NATIONAL SCIENCE FOUNDATION 2002 ENGINEERING SENIOR DESIGN PROJECTS TO AID PERSONS WITH DISABILITIES

Edited By
John D. Enderle
Brooke Hallowell

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FOREWORD

Welcome to the fourteenth annual issue of the National Science Foundation Engineering Senior Design Projects to Aid Persons with Disabilities. In 1988, the National Science Foundation (NSF) began a program to provide funds for student engineers at universities throughout the United States to construct custom designed devices and software for individuals with disabilities. Through the Bioengineering and Research to Aid the Disabled (BRAD) program of the Emerging Engineering Technologies Division of NSF[1], funds were awarded competitively to 16 universities to pay for supplies, equipment and fabrication costs for the design projects. A book entitled NSF 1989 Engineering Senior Design Projects to Aid the Disabled was published in 1989, describing the projects that were funded during the first year of this effort.

In 1989, the BRAD program of the Emerging Engineering Technologies Division of NSF increased the number of universities funded to 22. Following completion of the 1989-1990 design projects, a second book describing these projects, entitled NSF 1990 Engineering Senior Design Projects to Aid the Disabled, was published.

North Dakota State University (NDSU) Press published the following three issues. In NSF 1991 Engineering Senior Design Projects to Aid the Disabled almost 150 projects by students at 20 universities across the United States during the academic year 1990-91 were described. NSF 1992 Engineering Senior Design Projects to Aid the Disabled presented almost 150 projects carried out by students at 21 universities across the United States during the 1991-92 academic year. The fifth issue described 91 projects by students at 21 universities across the United States during the 1992-93 academic year.

Creative Learning Press, Inc. has published the succeeding volumes. NSF 1994 Engineering Senior Design Projects to Aid the Disabled, published in 1997, described 94 projects carried out by students at 19 universities during the academic 1993-94 year. NSF 1995 Engineering Senior Design Projects to Aid the Disabled, published in 1998, described 124 projects carried out by students at 19 universities during the 1994-95 academic year. NSF 1996 Engineering Senior Design Projects to Aid Persons with Disabilities, published in 1999, presented 93 projects carried out by students at 12 universities during the 1995-96 academic year. The ninth issue, NSF 1997 Engineering Senior Design Projects to Aid Persons with Disabilities, published in 2000, included 124 projects carried out by students at 19 universities during the 1996-97 academic year. NSF 1998 Engineering Senior Design Projects to Aid Persons with Disabilities, published in 2001, presented 118 projects carried out by students at 17 universities during the 1997-98 academic year. NSF 1999 Engineering Senior Design Projects to Aid Persons with Disabilities, published in 2001, presented 117 projects carried out by students at 17 universities during the 1998-99 academic year. NSF 2000 Engineering Senior Design Projects to Aid Persons with Disabilities, published in 2002, presented 127 projects carried out by students at 16 universities during the 1999-2000 academic year. In 2002, NSF 2001 Engineering Senior Design Projects to Aid Persons with Disabilities was published, presenting 134 projects carried out by students at 19 universities during the 2000-2001 academic year.

This book, funded by the NSF, describes and documents the NSF-supported senior design projects during the fourteenth year of this effort, 2001-2002. Each chapter, except for the first five, describes activity at a single university, and was written by the principal investigator(s) at that university, and revised by the editors of this publication. Individuals wishing more information on a particular design should contact the designated supervising principal investigator. An index is provided so that projects may be easily identified by topic. Chapters on best practices in design experiences, outcomes assessment, writing about and working with individuals who have disabilities are also included in this book.

It is hoped that this book will enhance the overall quality of future senior design projects directed

[1] In January of 1994, the Directorate for Engineering (ENG) was restructured. This program is now in the Division of Bioengineering and Environmental Systems, Biomedical Engineering & Research Aiding Persons with Disabilities Program.

toward persons with disabilities by providing examples of previous projects, and by motivating faculty at other universities to participate because of the potential benefits to students, schools, and communities. Moreover, the new technologies used in these projects will provide examples in a broad range of applications for new engineers. The ultimate goal of this publication and all the projects that were built under this initiative is to assist individuals with disabilities in reaching their maximum potential for enjoyable and productive lives.

This NSF program has brought together individuals with widely varied backgrounds. Through the richness of their interests, a wide variety of projects was completed and is in use. A number of different technologies were incorporated in the design projects to maximize the impact of each device on the individual for whom it was developed. A two-page project description format is generally used in this text. Each project is introduced with a nontechnical description, followed by a summary of impact that illustrates the effect of the project on an individual's life. A detailed technical description then follows. Photographs and drawings of the devices and other important components are incorporated throughout the manuscript.

Sincere thanks are extended to Dr. Allen Zelman, a former Program Director of the NSF BRAD program, for being the prime enthusiast behind this initiative. Additionally, thanks are extended to Drs. Peter G. Katona, Karen M. Mudry, Fred Bowman, Carol Lucas and Gil Devey, former and current NSF Program Directors of the Biomedical Engineering and Research to Aid Persons with Disabilities Programs, who have continued to support and expand the program.

We acknowledge and thank Mr. William Pruehsner for technical illustrations, and Ms. Julie Lundy for editorial assistance. We also acknowledge and thank Ms. Shari Valenta for the cover illustration and the artwork throughout the book, drawn from her observations at the Children's Hospital Accessibility Resource Center in Denver, Colorado.

The information in this publication is not restricted in any way. Individuals are encouraged to use the project descriptions in the creation of future design projects for persons with disabilities. The NSF and editors make no representations or warranties of any kind with respect to these design projects, and specifically disclaim any liability for any incidental or consequential damages arising from the use of this publication. Faculty members using the book as a guide should exercise good judgment when advising students.

Readers familiar with previous editions of this book will note that John Enderle moved from North Dakota State University to the University of Connecticut in 1995. With that move, annual publications also moved from NDSU Press to Creative Learning Press Inc. in 1997. During 1994, Enderle also served as NSF Program Director for the Biomedical Engineering & Research Aiding Persons with Disabilities Program while on a leave of absence from NDSU.

Brooke Hallowell is Associate Dean for Research and Sponsored Programs in the College of Health and Human Services and a faculty member in the School of Hearing, Speech and Language Sciences at Ohio University. Hallowell's primary area of expertise is in neurogenic communication disorders. She has a long history of collaboration with colleagues in biomedical engineering, in research, curriculum development, teaching, and assessment.

The editors welcome any suggestions as to how this review may be made more useful for subsequent yearly issues. Previous editions of this book are available for viewing at the web site for this project:

http://nsf-pad.bme.uconn.edu/.

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ENGINEERING SENIOR DESIGN PROJECTS TO AID PERSONS WITH DISABILITIES

CHAPTER 1
INTRODUCTION

John Enderle and Brooke Hallowell

Devices and software to aid persons with disabilities often require custom modification, are prohibitively expensive, or are nonexistent. Many persons with disabilities do not have access to custom modification of available devices and other benefits of current technology. Moreover, when available, personnel costs for engineering and support make the cost of custom modifications beyond the reach of the persons who need them.

In 1988, the National Science Foundation (NSF), through its Emerging Engineering Technologies Division, initiated a program to support student engineers at universities throughout the United States in designing and building devices for persons with disabilities. Since its inception, this NSF program (originally called Bioengineering and Research to Aid the Disabled) has enhanced educational opportunities for students and improved the quality of life for individuals with disabilities. Students and university faculty provide, through their Accreditation Board for Engineering and Technology (ABET) accredited senior design class, engineering time to design and build the device or software. The NSF provides funds, competitively awarded to universities for supplies, equipment and fabrication costs for the design projects.

Outside of the NSF program, students are typically involved in design projects that incorporate academic goals for solid curricular design experiences, but that do not necessarily enrich the quality of life for persons other than, perhaps, the students themselves. For instance, students might design and construct a stereo receiver, a robotic unit that performs a household chore, or a model racecar.

Under this NSF program, engineering design students are involved in projects that result in original devices, or custom modifications of devices, that improve the quality of life for persons with disabilities. The students have opportunities for practical and creative problem solving to address well-defined needs, and persons with disabilities receive the products of that process at no financial cost. Upon completion, each finished project becomes the property of the individual for whom it was designed.

The emphases of the program are to:

- Provide children and adults with disabilities student-engineered devices or software to improve their quality of life and provide greater self-sufficiency,
- Enhance the education of student engineers through the designing and building of a device or software that meets a real need, and
- Allow participating universities an opportunity for unique service to the local community.

Local schools, clinics, health centers, sheltered workshops, hospitals, and other community agencies participate in the effort by referring interested individuals to the program. A single student or a team of students specifically designs each project for an individual or a group of individuals with a similar need. Examples of projects completed in years past include a laser-pointing device for people who cannot use their hands, a speech aid, a behavior modification device, a hands-free automatic answering and hang-up telephone system, and an infrared beacon to help a blind person move around a room. The students participating in this program have been richly rewarded through their activity with persons with disabilities, and justly have experienced a unique sense of purpose and pride in their accomplishments.

The Current Book

This book describes the NSF supported senior design projects during the academic year 2001-2002. The purpose of this publication is threefold. First, it is to serve as a reference or handbook for future senior design projects. Students are exposed to this unique body of applied information on current technology in this and previous editions of this book. This provides an even broader education than typically experienced in an undergraduate curriculum, especially in the area of rehabilitation design. Many technological advances originate from work in the space, defense, entertainment and communications industry. Few of these advances have been applied to the rehabilitation field, making the contributions of this NSF program all the more important.

Secondly, it is hoped that this publication will serve to motivate students, graduate engineers and others to work more actively in rehabilitation. This will ideally lead to an increased technology and knowledge base to effectively address the needs of persons with disabilities.

Thirdly, through its initial four chapters, the publication provides an avenue for motivating and informing all involved in design projects concerning specific means of enhancing engineering education through design experiences.

This introduction provides background material on the book and elements of design experiences. The second chapter highlights specific aspects of some exemplary practices in design projects to aid persons with disabilities. The third chapter addresses assessment of outcomes related to design projects to aid persons with disabilities. The fourth chapter provides details on enhancing students' writing skills through the senior design experience. The fifth chapter addresses the importance of fostering relationships between students and individuals with disabilities.

After the five introductory chapters, 16 chapters follow, with each chapter devoted to one participating school. At the start of each chapter, the school and the principal investigator(s) are identified. Each project description is written using the following format. On the first page, the individuals involved with the project are identified, including the student(s), the professor(s) who supervised the project, and key professionals involved in the daily lives of the individual for whom the project has been developed. A brief nontechnical description of the project follows with a summary of how the project has improved a person's quality of life. A photograph of the device or the device modification is usually included. Next, a technical description of the device or device modification is given, with parts specified only if they are of such a special nature that the project could not otherwise be fabricated. An approximate cost of the project is provided, excluding personnel costs.

Most projects are described in two pages. However, the first or last project in each chapter is usually significantly longer and contains more analytic content. Individuals wishing more information on a particular design should contact the designated supervising principal investigator.

Some of the projects described are custom modifications of existing devices, modifications that would be prohibitively expensive were it not for the student engineers and this NSF program. Other projects are unique one-of-a-kind devices wholly designed and constructed by students for individuals with disabilities.

Engineering Design

As part of the accreditation process for university engineering programs, students are required to complete a minimum number of design credits in their course of study, typically at the senior level[2,3] Many call this the capstone course. Engineering design is a course or series of courses that brings together concepts and principles that students learn in their field of study. It involves the integration and extension of material learned throughout an academic program to achieve a specific design goal. Most often, the student is exposed to system-wide analysis, critique and evaluation. Design is an iterative decision-making process in which the

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[2] Accrediting Board for Engineering and Technology (1999). Accreditation Policy and Procedure Manual Effective for Evaluations for the 2000-2001 Accreditation Cycle. ABET: Baltimore, MD.

[3] Accrediting Board for Engineering and Technology (2000). Criteria for Accrediting Engineering Programs. ABET: Baltimore, MD.

student optimally applies previously learned material to meet a stated objective.

There are two basic approaches to teaching engineering design, the traditional or discipline-dependent approach, and the holistic approach. The traditional approach involves reducing a system or problem into separate discipline-defined components. This approach minimizes the essential nature of the system as a holistic or complete unit, and often leads participants to neglect the interactions that take place between the components. The traditional approach usually involves a sequential, iterative approach to the system or problem, and emphasizes simple cause-effect relationship.

A more holistic approach to engineering design is becoming increasingly feasible with the availability of powerful computers and engineering software packages, and the integration of systems theory, which addresses interrelationships among system components as well as human factors. Rather than partitioning a project based on discipline-defined components, designers partition the project according to the emergent properties of the problem.

A design course provides opportunities for problem solving relevant to large-scale, open-ended, complex, and sometimes ill-defined systems. The emphasis of design is not on learning new material. Typically, there are no required textbooks for the design course, and only a minimal number of lectures are presented to the student. Design is best described as an individual study course where the student:

- Selects the device or system to design,
- Writes specifications,
- Creates a paper design,
- Analyzes the paper design,
- Constructs the device,
- Evaluates the device,
- Documents the design project, and
- Presents the project to a client.

Project Selection

In a typical NSF design project, the student meets with the client (a person with a disability and/or a client coordinator) to assess needs and to help identify a useful project. Often, the student meets with many clients before finding a project for which his or her background is suitable.

After selecting a project, the student then writes a brief description of the project for approval by the faculty supervisor. Since feedback at this stage of the process is vitally important for a successful project, students usually meet with the client once again to review the project description.

Teams of students often undertake projects. One or more members of a team meet with one or more clients before selecting a project. After project selection, the project is partitioned by the team into logical parts, and each student is assigned one of these parts. Usually, a team leader is elected by the team to ensure that project goals and schedules are satisfied. A team of students generally carries out multiple projects.

Project selection is highly variable depending on the university and the local health care facilities. Some universities make use of existing technology to develop projects by accessing databases such as ABLEDATA. ABLEDATA includes information on types of assistive technology, consumer guides, manufacturer directories, commercially available devices, and one-of-a-kind customized devices. In total, this database has over 23,000 products from 2,600 manufacturers and is available from:

http://www.abledata.com

or

(800) 227-0216.

More information about this NSF program is available at:

http://nsf-pad.bme.uconn.edu

Specifications

One of the most important parts of the design process is determining the specifications, or requirements that the design project must fulfill. There are many different types of hardware and software specifications.

Prior to the design of a project, a statement as to how the device will function is required. Operational specifications are incorporated in determining the problem to be solved. Specifications are defined such that any competent engineer is able to design a device that will perform a given function. Specifications determine the device to be built, but do not provide information about how the device is built. If several engineers design a device from the same specifications, all of the designs would perform within the given tolerances and satisfy the requirements; however, each design would be different. Manufacturer's names are generally not stated in specifications, especially for electronic or microprocessor components, so that design choices for future projects are not constrained.

If the design project involves modifying an existing device, the modification is fully described in as much detail as possible in the specifications. Specific components of the device, such as microprocessors, LEDs, and electronic parts, are be described. Descriptive detail is appropriate because it defines the environment to which the design project must interface. However, the specifications for the modification should not provide detailed information about how the device is to be built.

Specifications are usually written in a report that qualitatively describes the project as completely as possible, and how the project will improve the life of an individual. It is also important to explain the motivation for carrying out the project. The following issues are addressed in the specifications:

- What will the finished device do?
- What is unusual about the device?

Specifications include a technical description of the device, and all of the facts and figures needed to complete the design project. The following are examples of important items included in technical specifications.

Electrical Parameters

Interfaces

Voltages

Impedances

Gains

Power output

Power input

Ranges

Current capabilities

Harmonic distortion

Stability

Accuracy

Precision

Power consumption

Mechanical Parameters

Size

Weight

Durability

Accuracy

Precision

Vibration

Environmental Parameters

Location

Temperature range

Moisture

Dust

Paper Design and Analysis

The next phase of the design is the generation of possible solutions to the problem based on the specifications, and selection of the optimal solution. This involves creating a paper design for each of the solutions and evaluating performance based on the specifications. Since design projects are open-ended, many solutions exist, solutions that often require a multidisciplinary system or holistic approach for a successful and useful product. This stage of the design process is typically the most challenging because of the creative aspect to generating problem solutions.

The specifications previously described are the criteria for selecting the best design solution. In many projects, some specifications are more important than others, and trade-offs between specifications may be necessary. In fact, it may be impossible to design a project that satisfies all of the design specifications. Specifications that involve some degree of flexibility are helpful in reducing the overall complexity, cost and effort in carrying out the project. Some specifications are absolute and cannot be relaxed.

Most projects are designed in a top-down approach similar to the approach of writing computer software by first starting with a flow chart. After the flow chart or block diagram is complete, the next step involves providing additional details to each block in the flow chart. This continues until sufficient detail exists to determine whether the design meets the specifications after evaluation.

To select the optimal design, it is necessary to analyze and evaluate the possible solutions. For ease in analysis, it is usually easiest to use computer software. For example, PSpice, a circuit analysis program, easily analyzes circuit problems. Other situations require that a potential design project solution be partially constructed or breadboarded for analysis and evaluation. After analysis of all possible solutions, the optimal design selected is the one that meets the specifications most closely.

Construction and Evaluation of the Device

After selecting the optimal design, the student then constructs the device. The best method of construction is to build the device module by module. By building the project in this fashion, the student is able to test each module for correct operation before adding it to the complete device. It is far easier to eliminate problems module by module than to build the entire project and then attempt to eliminate problems.

Design projects should be analyzed and constructed with safety as one of the highest priorities. Clearly, the design project that fails should fail in a safe manner, a fail-safe mode, without any dramatic and harmful outcomes to the client or those nearby. An example of a fail-safe mode of operation for an electrical device involves grounding the chassis, and using appropriate fuses; thus, if ever a 120-V line voltage short circuit to the chassis should develop, a fuse would blow and no harm to the client would occur. Devices should also be protected against runaway conditions during the operation of the device, and also during periods of rest. Failure of any critical components in a device should result in the complete shutdown of the device.

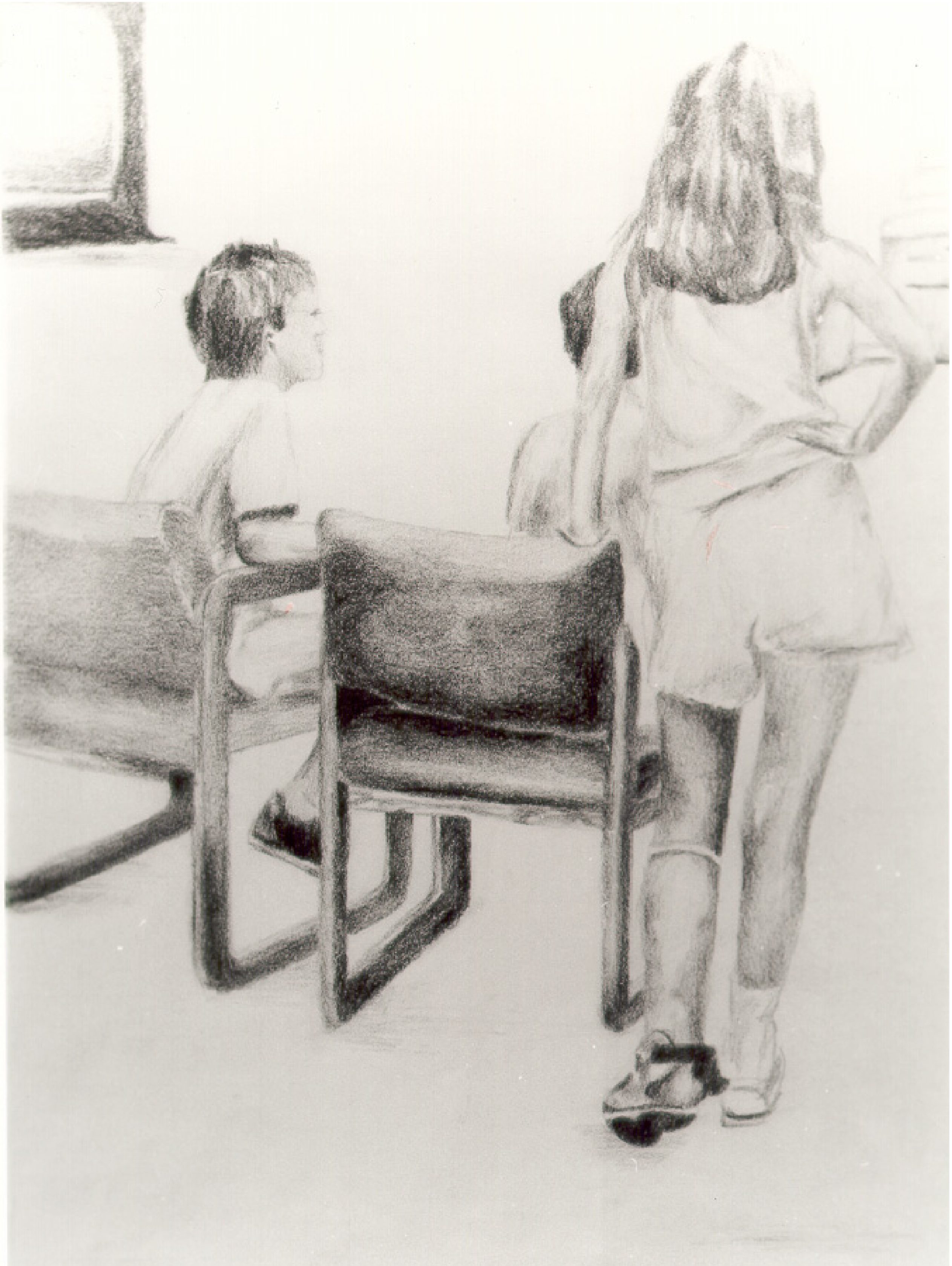
After the project has undergone laboratory testing, it is then tested in the field with the client. After the field test, modifications are made to the project, and then the project is given to the client. Ideally, the design project in use by the client should be periodically evaluated for performance and usefulness after the project is complete. Evaluation typically occurs, however, when the device no longer performs adequately for the client, and is returned to the university for repair or modification. If the repair or modification is simple, a university technician will handle the problem. If the repair or modification is more extensive, another design student is assigned to the project to handle the problem as part of his or her design course requirements.

Documentation

Throughout the design process, the student is required to document the optimal or best solution to the problem through a series of required written assignments. For the final report, documenting the design project involves integrating each of the required reports into a single final document. While this should be a simple exercise, it is often a most vexing and difficult endeavor. Many times during the final stages of the project, some specifications are changed, or extensive modifications to the ideal paper design are necessary.

Most universities require that the final report be professionally prepared using desktop publishing software. This requires that all circuit diagrams and mechanical drawings be professionally drawn. Illustrations are usually drawn with computer software, such as OrCAD or AutoCAD.

The two-page reports within this publication are not representative of the final reports submitted for design course credit, and in fact, are summaries of the final reports. A typical final report for a design project is approximately 30 pages in length, and includes extensive analysis supporting the operation of the design project. Usually, photographs of the device are not included in the final report since mechanical and electrical diagrams are more useful to the engineer to document the device.



CHAPTER 2
BEST PRACTICES IN SENIOR DESIGN

John Enderle and Brooke Hallowell

This chapter presents different approaches to the design course experience. For example, at Texas A&M University, the students work on many small design projects during the two-semester senior design course sequence. At North Dakota State University, students work on a single project during the two-semester senior design course sequence. At the University of Connecticut, students are involved in a WWW based approach and in distance learning, in a collaborative arrangement with Ohio University.

Duke University

The Devices for the Persons with Disabilities course is offered as an elective to seniors and graduate students through the Biomedical Engineering Department at Duke University. The course has been supported since September 1996 by a grant from the National Science Foundation, and is offered each fall. The course size is limited to 12 students and four to six projects to provide a team atmosphere and to ensure quality results.

The course involves design, construction and delivery of a custom assistive technology device, typically in one semester. At the start of the semester, students are given a list of descriptions for several possible projects that have been suggested by persons with disabilities and health care workers in the local community. Students individually rank order the list, and for their top three selections describe why they are interested and what skills they possess that will help them be successful. Projects are assigned to teams of one to three students based on these interests and expected project difficulty. Soon thereafter, students meet with the project's supervisor and client. The supervisor is a health care professional, typically a speech-language pathologist or occupational or physical therapist, who has worked with the client. Student teams then formulate a plan for the project, and present an oral and written Project Proposal to define the problem and their expected approach. In the written proposal, results of a patent and product search for ideas related to the student project are summarized and contrasted with the project.

Each student keeps an individual laboratory notebook for his or her project. Copies of recent entries are turned in to the course instructor for a weekly assessment of progress. During the semester, students meet regularly with the supervisor and/or client to insure that the project will be safe and meet the needs of the client. Three oral and written project reports are presented to demonstrate progress, to provide experience with engineering communications, and to allow a public forum for students to receive feedback from other students, supervisors, engineers, and health care professionals.

Course lectures focused on basic principles of engineering design, oral and written communication, and ethics. In addition, guest lectures cover topics such as an Overview of Assistive Technology, Universal Design, Ergonomics and Patent Issues. Field trips to a local assistive technology lending library, and to an annual Exposition of commercial assistive technology companies, provide further exposure to the field.

Students present their projects in near-final form at a public mock delivery two weeks before their final delivery, which provides a last chance to respond to external feedback. Final oral presentations include project demonstrations. Each project's final written report includes a quantitative analysis of the design, as well as complete mechanical drawings and schematics. At the end of the semester, students deliver their completed project to the client, along with a User's Manual that describes the operation, features, and specifications for the device.

For projects requiring work beyond one semester, students may continue working through the spring semester on an independent study basis. A full-time summer student provides service on projects already delivered.

University of Massachusetts-Lowell

The capstone design experience at University of Mass-Lowell is divided into two three-credit courses. These courses are taken in the last two semesters of undergraduate studies and for the most part involve the design of assistive technology devices and systems. The program costs are supported in part by a five-year grant from the National Science Foundation. Additional funding comes from corporate and individual donations to the assistive technology program at University of Mass-Lowell. Both courses are presented in each semester of a traditional academic year. The combined enrollment averages between 40 and 50 each semester.

The major objective of the first course is for each student to define a major design to be accomplished prior to graduation and ideally within the timeframe of the second course. The process for choosing a design project begins immediately. However, there are other activities that take place concurrently with the search for a project. The most significant of these is a team effort to generate a business plan for securing venture capital or other forms of financing to support corporate development of a product orientated towards the disadvantaged community. The instructor chooses a number of students to serve as CEOs of their company. The remaining students must present oral and written resumes and submit to interviews.

The CEO of each company must then hire his/her employees and the teams are thus formed. Each team is expected to do the following.

- Determine a product, name the company, and generate a market analysis.
- Determine the process for company name registration, determine the patent process, generate a cost analysis for an employee benefit package, generate information on such terms as FICA, FUTA, SS, 941, MC, IRA, SRA, i9, and other terms relative to payroll deductions and state and federal reporting requirements.
- Students must meet with patent attorneys, real estate agents, and members of the business community, bankers and a venture capitalist.
- Students must fully understand the cost of insurance and meet with insurance agents to discuss health and life insurance for employees and liability insurance costs for the company. Students are required to explore OSHA requirements relative to setting up development laboratories. Students are expected to generate much of the above required information using direct person-to-person contact and the vast amount of information on the www.

The teams are also required to understand the elements of scheduling and must produce a Gant chart indicating the tasks and allotted times to take their product through development and make ready for manufacture. A cost analysis of the process is required, and students are expected to understand the real cost of development, with overhead items clearly indicated.

Much of the subject material described above is covered in daily classroom discussions and with guest speakers. During the process of generating the team business plan, each team is required to present two oral reports to the class. The first is a company report describing their company, assigned tasks, their product, and a rationale for choosing their product.

The second is a final report that is essentially a presentation of the company business plan. Technical oral and written reports are essential components of the first course. Two lectures are presented on the techniques of oral presentations and written reports are reviewed by the college technical writing consultants. All oral presentation must be made using PowerPoint or other advanced creative tools.

Early in the course, potential capstone projects are presented; students are required to review current and past projects. In some semesters, potential clients address the class. Representatives from agencies have presented their desires and individuals in wheelchairs have presented their requests to the class. Students are required to begin the process of choosing a project by meeting with potential clients and accessing the problem, defining the needs, and making a decision as to whether or not they want the associated project. In some cases, students interview and discuss as many as three or four potential projects before finding one they feel confident in accomplishing. If the project is too complex for a single student, a team is formed. The decision to form a team is made by the instructor only after in depth discussions with potential team members. Individual responsibilities must be identified as part of a team approach to a design. Once a project has been chosen, the student must begin the process of generating a written technical proposal. This document must indicate clearly answers to the following questions:

- What are the project and its technical specifications?
- Why is the project necessary?
- What technical approach is going be used to accomplish the project?
- How much time is necessary?
- How much will the project cost?

The final activity in this first course is the oral presentation of the proposal.

The second course is concerned with the design of the project chosen and presented in the first course. In the process of accomplishing the design, students must present a total of five written progress reports, have outside contacts with a minimum of five different persons, and generate at least three publications or public presentations concerning their project. Finally, they demonstrate their project to the faculty, write a final comprehensive technical report, and deliver the project to their client.

Texas A&M University Engineering

The objective of the NSF program at Texas A&M University is to provide senior bioengineering students an experience in the design and development of rehabilitation devices and equipment to meet explicit client needs identified at several off-campus rehabilitation and education facilities. Texas A&M has participated in the NSF program for six years. The students meet with therapists and/or special education teachers for problem definition under faculty supervision. This program provides significant "real world" design experiences, emphasizing completion of a finished product. Moreover, the program brings needed technical expertise that would otherwise not be available to not-for-profit rehabilitation service providers. Additional benefits to the participating students include a heightened appreciation of the problems of persons with disabilities, motivation toward rehabilitation engineering as a career path, and recognition of the need for more long-term research to address the problems for which today's designs are only an incomplete solution.

Texas A&M University's program involves a two-course capstone design sequence, BIEN 441 and 442. BIEN 441 is offered during the fall and summer semesters, and BIEN 442 is offered during the spring semester. The inclusion of the summer term allows a full year of ongoing design activities. Students are allowed to select a rehabilitation design project, or another general bioengineering design project.

The faculty at Texas A&M University involved with the rehabilitation design course have worked in collaboration with the local school districts, community rehabilitation centers, residential units of the Texas Department of Mental Health and Mental Retardation (MHMR), community outreach programs of Texas MHMR, and individual clients of the Texas Rehabilitation Commission and the Texas Commission for the Blind.

Appropriate design projects are identified in group meetings between the staff of the collaborating agency, the faculty, and the participating undergraduate students enrolled in the design class. In addition, one student is employed in the design laboratory during the summer to provide logistical support, as well as pursue his or her own project. Each student is required to participate in the project definition session, which adds to the overall design experience. The meetings take place at the beginning of each semester, and periodically thereafter as projects are completed and new ones identified.

The needs expressed by the collaborating agencies often result in projects that vary in complexity and required duration. To meet the broad spectrum of needs, simpler projects are accommodated by requiring rapid completion, at which point the students move on to another project. More difficult projects involve one or more semesters, or even a year's effort; these projects are the ones that typically require more substantial quantitative and related engineering analysis. Projects are carried out by individual students or a team of two.

Following the project definition, the students proceed through the formal design process of brainstorming, clarification of specifications, preliminary design, review with the collaborating agency, design execution and safety analysis, documentation, prerelease design review, and delivery and implementation in the field. The execution phase of the design includes identifying and purchasing necessary components and materials, arranging for any fabrication services that may be necessary, and obtaining photography for their project reports.

Throughout each phase of the project, the faculty supervises the work, as well as the teaching assistants assigned to the rehabilitation engineering laboratory. These teaching assistants are paid with university funds. The students also have continued access to the agency staff for clarification or revision of project definitions, and review of preliminary designs. The latter is an important aspect of meeting real needs with useful devices. In addition to individual and team progress, the rehabilitation engineering group meets as a group to discuss design ideas and project progress, and to plan further visits to the agencies.

One challenging aspect of having students be responsible for projects that are eagerly anticipated by the intended recipient is the variable quality of student work, and the inappropriateness of sending inadequate projects into the field. This potential problem is resolved at Texas A&M University by continuous project review, and by requiring that the project be revised and reworked until they meet faculty approval.

At the end of each academic year, the faculty and the personnel from each collaborating agency assess which types of projects met with the greatest success in achieving useful delivered devices. This review has provided ongoing guidance in the selection of future projects. The faculty members also maintain continuous contact with agency personnel with respect to ongoing and past projects that require repair or modification. In some instances, repairs are assigned as short-term projects to currently participating students. This provides excellent lessons in the importance of adequate documentation.

Feedback from participating students is gathered each semester using the Texas A&M University student "oppinionaire" form as well as personal discussion. The objective of the reviews is to obtain students' assessment of the educational value of the rehabilitation design program, the adequacy of the resources and supervision, and any suggestions for improving the process.

North Dakota State University

North Dakota State University (NDSU) has participated in this program for six years. All senior electrical engineering students at NDSU are required to complete a two-semester senior design project as part of their study. These students are partitioned into faculty-supervised teams of four to six students. Each team designs and builds a device for a particular disabled individual within eastern North Dakota or western Minnesota.

During the early stages of NDSU's participation in projects to aid persons with disabilities, a major effort was undertaken to develop a complete and workable interface between the NDSU electrical engineering department and the community of persons with disabilities to identify potential projects. These organizations are the Fargo Public School System, NDSU Student Services and the Anne Carlson School. NDSU students visit potential clients or their supervisors to identify possible design projects at one of the cooperating organizations. All of the senior design students visit one of these organizations at least once. After the site visit, the students write a report on at least one potential design project, and each team selects a project to aid a particular individual.

The process of a design project is implemented in two parts. During the first semester of the senior year, each team writes a report describing the project to aid an individual. Each report consists of an introduction to the project establishing the need for the project. The body of the report describes the device; a complete and detailed engineering analysis is included to establish that the device has the potential to work. Almost all of the NDSU projects involve an electronic circuit. Typically, devices that involve an electrical circuit are analyzed using PSpice, or another software analysis program. Extensive testing is undertaken on subsystem components using breadboard circuit layouts to ensure a reasonable degree of success before writing the report. Circuits are drawn for the report using

OrCAD, a CAD program. The OrCAD drawings are also used in the second phase of design, which allows the students to bring a circuit from the schematic to a printed circuit board with relative ease.

During the second semester of the senior year, each team builds the device to aid an individual. This first involves breadboarding the entire circuit to establish the viability of the design. After verification, the students build a printed circuit board(s) using OrCAD, and then finish the construction of the project using the fabrication facility in the electrical engineering department. The device is then fully tested, and after approval by the senior design faculty advisor, the device is given to the client. Each of the student design teams receives feedback throughout the year from the client or client coordinator to ensure that the design meets its intended goal.

Each design team provides an oral presentation during regularly held seminars in the department. In the past, local TV stations have filmed the demonstration of the senior design projects, and broadcast the tape on their news show. This media exposure usually results in viewers contacting the electrical engineering department with requests for projects to improve the life of another individual, further expanding the impact of the program.

Design facilities are provided in three separate laboratories for analysis, prototyping, testing, printed circuit board layout, fabrication, and redesign/development. The first laboratory is a room for team meetings during the initial stages of the design. Data books and other resources are available in this room.

There are also 12 workstations available for teams to test their designs, and verify that the design parameters have been met. These workstations consist of a power supply, waveform generator, oscilloscope, breadboard, and a collection of hand tools.

The second laboratory contains Intel computers for analysis, desktop publishing and microprocessor testing. The computers all have analysis, CAD and desktop publishing capabilities so that students may easily bring their design projects from the idea to implementation stage. Analysis software supported includes Microsoft EXCEL and Lotus 123 spreadsheets, PSpice, MATLAB, MATHCAD, and VisSim. Desktop publishing supported includes Microsoft Word for Windows, Aldus PageMaker, and technical illustration software via AutoCAD and OrCAD. A scanner with image enhancement software and a high-resolution printer are also available in the laboratory.

The third laboratory is used by the teams for fabrication. Six workstations exist for breadboard testing, soldering, and finish work involving printed circuit boards. Sufficient countertop space exists so that teams may leave their projects in a secure location for ease in work.

The electrical engineering department maintains a relatively complete inventory of electronic components necessary for design projects, and when not in stock, has the ability to order parts with minimal delay. The department also has a teaching assistant assigned to this course on a year round basis, and an electronics technician available for help in the analysis and construction of the design project.

There were many projects constructed at NDSU (and probably at many other universities) that proved to be unsafe or otherwise unusable for the intended individual, despite the best efforts of the student teams under the supervision of the faculty advisors. These projects are not officially documented.

University of Connecticut

In August 1998 the Department of Electrical & Systems Engineering (ESE) at the University of Connecticut (UConn), in collaboration with the School of Hearing, Speech and Language Sciences at Ohio University, received a five-year NSF grant for senior design experiences to aid persons with disabilities. This NSF project was a pronounced change from previous design experiences at UConn that involved industry sponsored projects carried out by a team of student engineers. The new Biomedical Engineering Program at UConn has now replaced the ESE Dept. in this effort.

To provide effective communication between the sponsor and the student teams, a WWW based approach was implemented.[4] Under the new

[4] Enderle, J.D., Browne, A.F., and Hallowell, B. (1998). A WEB Based Approach in Biomedical

scenario, students work individually on a project and are divided into teams for weekly meetings. The purpose of the team is to provide student derived technical support at weekly meetings. Teams also form throughout the semester based on needs to solve technical problems. After the problem is solved the team dissolves and new teams are formed.

Each year, 25 projects are carried out by the students at UConn. Five of the 25 projects are completed through collaboration with personnel at Ohio University using varied means of communication currently seen in industry, including video conferencing, the WWW, telephone, e-mail, postal mailings, and videotapes.

Senior design consists of two required courses, Design I and II. Design I is a three-credit hour course in which students are introduced to a variety of subjects. These include: working on teams, design process, planning and scheduling (time-lines), technical report writing, proposal writing, oral presentations, ethics in design, safety, liability, impact of economic constraints, environmental considerations, manufacturing and marketing. Each student in Design I:

- Selects a project to aid a disabled individual after interviewing a person with disabilities,
- Drafts specifications,
- Prepares a project proposal,
- Selects an optimal solution and carries out a feasibility study,
- Specifies components, conducts a cost analysis and creates a time-line, and
- Creates a paper design with extensive modeling and computer analysis.

Design II is a three-credit hour course following Design I. This course requires students to implement a design by completing a working model of the final product. Prototype testing of the paper design typically requires modification to meet specifications. These modifications undergo proof of design using commercial software programs commonly used in industry. Each student in Design II:

- Constructs and tests a prototype using modular components as appropriate;
- Conducts system integration and testing;
- Assembles a final product and field-tests the device;
- Writes a final project report;
- Presents an oral report using PowerPoint on Senior Design Day; and
- Gives the device to the client after a waiver is signed.

Course descriptions, student project homepages and additional resources are located at http://design.bme.uconn.edu/.

The first phase of the on-campus projects involves creating a database of persons with disabilities and then linking the student with a person with a disability. The A.J. Pappanikou Center provided a database with almost 60 contacts and a short description of the disabilities in MS Access. The involvement of the Center was essential for the success of the program. The A.J. Pappanikou Center is Connecticut's University Affiliated Program (UAP) for disabilities studies. As such, relationships have been established with the Connecticut community of persons affected by disabilities, including families, caregivers, advocacy and support groups and, of course, persons with disabilities themselves. The Center serves as the link between the person in need of the device and the Design course staff. The Center has established ongoing relationships with Connecticut's Regional Educational Service Centers, the Birth to Three Network, the Connecticut Tech Act Project, and the Department of Mental Retardation. Through these contacts, the Center facilitates the interaction between the ESE students, the client coordinators (professionals providing support services, such as the speech-language pathologists, physical and occupational therapists), individuals with disabilities (clients), and clients' families.

The next phase of the course involves students' selection of projects. Using the on-campus database,

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Engineering Design Education. Biomedical Sciences Instrumentation, 34, pp. 281-286.

each student selects two clients to interview. The student and a UConn staff member meet with the client and/or client coordinator to identify a project that would improve the quality of life for the client. After the interview, the student writes a brief description for each project. Almost all of the clients interviewed have multiple projects. Project descriptions include: contact information (client, client coordinator, and student name) and a short paragraph describing the problem. These reports are collected, sorted by topic area, and put into a Project Notebook. In the future, these projects will be stored in a database accessible from the course server for ease in communication.

Each student then selects a project from a client that he or she has visited, or from the Project Notebook. If the project selected was from the Project Notebook, the student visits the client to further refine the project. Because some projects do not involve a full academic year to complete, some students work on multiple projects. Students submit a project statement that describes the problem, including a statement of need, basic preliminary requirements, basic limitations, other data accumulated, and important unresolved questions.

Specific projects at Ohio University are established via distance communication with the co-principal investigator, who consults with a wide array of service providers and potential clients in the Athens, Ohio region.

The stages of specification, project proposal, paper design and analysis, construction and evaluation, and documentation are carried out as described earlier in the overview of engineering design.

To facilitate working with sponsors, a WWW based approach is used for reporting the progress on projects. Students are responsible for creating their own WWW sites that support both html and pdf formats with the following elements:

- Introduction for the layperson,
- Resume,
- Weekly reports,
- Project statement,
- Specifications,
- Proposal, and
- Final Report.

Team Work

Student learning styles differ among team members. Gender, cultural factors, personality type, intelligence, previous educational background, academic achievement, and previous experience in teams may influence the strengths and weaknesses that individuals bring to team membership. Research pertaining to differences in cognitive style characterized by field dependence versus independence helps to shed light on individual differences among team members and how those differences may affect team interactions[5,6]. There is strong empirical evidence in numerous disciplines suggesting that students may benefit from explicit training to compensate for or enhance the cognitive style with which they enter an educational experience, such as a senior design course.[7,8,9]

Research on effective teamwork suggests that key variables that should be attended to for optimal team performance include:

- Explicit sharing of the group's purpose among all team members,
- Concerted orientation to a common task,

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[5] Tinajero, C., & Paramo, M.F., Field dependence-independence and academic achievement: A re-examination of their relationship. *British Journal of Educational Psychology, 67*, 1997, 2: 199-212.

[6] Witkin, H.A., & Goodenough, D.R., *Cognitive Styles: Essence and Origins.* International Universities Press, Inc., NY, 1981.

[7] Deming, W. *Out of the crisis: quality, productivity, and competitive position*. Cambridge, Massachusetts: Cambridge University Press, 1986.

[8] Katzenbach, J. & Smith, D. *The wisdom of teams: creating the high-performance organization.* Boston, Massachusetts: Harvard Business School Press, 1993.

[9] Larson, C. & LaFasto, F. *Teamwork: what must go right, what can go wrong.* Newbury Park, California: SAGE Publications, 1989.

- Positive rapport among team members,
- Responsiveness to change,
- Effective conflict management,
- Effective time management, and
- Reception and use of ongoing constructive feedback.

According to the literature on cooperative learning in academic contexts,[10,11] the two most essential determiners for success in teamwork are positive interdependence and individual accountability. Positive interdependence, or effective synergy among team members, leads to a final project or design that is better than any of the individual team members may have created alone. Individual accountability, or an equal sharing of workload, ensures that no team member is overburdened and also that every team member has equal learning opportunity and hands-on experience.

Because students are motivated to work and learn according the way they expect to be assessed, grading of specific teamwork skills of teams and of individual students inspires teams' and individuals' investment in targeted learning outcomes associated with teamwork. Teamwork assessment instruments have been developed in numerous academic disciplines and can be readily adapted for use in engineering design projects.

Clearly targeting and assessing teamwork qualities may help to alleviate conflicts among team members. In general, most team members are dedicated to the goals of the project and excel beyond all expectations. When there is a breakdown in team synergy, instructors may sometimes be effective in facilitating conflict resolution.

Timeline development by the team is usually vital to success, eliminates most management issues, and allows the instructor to monitor the activities by student team members. For this to be a success, activities for each week need to be documented for each team member, with best success when there are five to 10 activities per team member each week. When each team member knows what specific steps must be accomplished there is a greater chance of success in completing the project.

History of Teams in Senior Design at UConn

Projects Before the NSF Program

Before the NSF sponsored program, senior design was sponsored by local industry. During these years, all of the students were partitioned into four-member teams whereby student names were selected at random to choose a particular sponsored project. The projects were complex. Team members were challenged to achieve success. All of the students met each week at a team meeting with the instructor. During the first semester, lectures on teaming and communication skills were given, as well as team skills training. No time-lines were used and general project goals were discussed throughout the two semesters. A teaching assistant was used in the course as an assistant coach to help the students in whatever manner was necessary. In general, multidisciplinary teams were not formed since the student backgrounds were not the criteria used to select team members.

Procrastination, a lack of enthusiasm and poor planning were common themes among the students. Most teams encountered significant difficulties in completing projects on time. Conflict among team members was more frequent than desired, and in some extreme encounters, physical violence was threatened during lab sessions. Many students complained that the projects were far too difficult, scheduling of team meetings was too challenging, they did not have the proper background, they had difficulty communicating ideas and plans among team members, and they did not have enough time with outside activities and courses. A peer evaluation was used without success.

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[10] Cottell, P.G. & Millis, B.J., Complex cooperative learning structures for college and university courses. In To improve the Academy: Resources for students, faculty, and institutional development. Stillwater, OK: New Forums Press, 1994.

[11] Jaques, D. Learning in groups, 2nd edition. Guilford, Surrey, England: Society for Research into Higher Education, 1991.

NSF Projects Year 1
During year one of the NSF senior design program, students worked individually on a project and were divided into teams for weekly meetings. The level of project difficulty was higher than previous years. The purpose of the team was to provide student-derived technical support at weekly team meetings. Students were also exposed to communication skills training during the weekly team meetings, and received feedback on their presentations. In addition, timelines were used for the first time, which resulted in greater harmony and success. The course improved relative to previous years. Many students continued working on their projects after the semester ended.

Throughout the year, students also divided themselves into dynamic teams apart from their regular teams based on needs. For example, students implementing a motor control project gathered together to discuss various alternatives and help each other. These same students would then join other dynamic teams in which a different technology need was evident. Dynamic teams were formed and ended during the semester. Both the regular team and dynamic teams were very important in the success of the projects.

Overall, students were enthusiastic about the working environment and the approach. Although students seemed content with being concerned only with their individual accomplishments, completing a project according to specifications and on time, this approach lacked the important and enriching multidisciplinary team experience that is desired by industry.

NSF Projects Year 2
During the second year of the NSF senior design program, seven students worked in two- and three-person team projects, and the remaining students in the class worked in teams oriented around a client; that is, a single client would have three students working on individual projects, projects that required integration in the same way a music system required integration of speakers, a receiver, an amplifier, CD player, etc. In general, when teams were formed, the instructor would facilitate the team's multidisciplinary nature. Two teams involved mechanical engineering students and electrical engineering students. The others were confined by the homogeneity of the remaining students. All of the students met each week at a team meeting with the same expectations as previously described, including oral and written reports. Dynamic teaming occurred often throughout the semester.

While the team interaction was a significantly improved relative to previous semesters, the process was not ideal. Senior Design is an extremely challenging set of courses. Including additional skill development with the expectation of success in a demanding project does not always appear to be reasonable. A far better approach would be to introduce team skills much earlier in the curriculum, even as early as the freshman year. Introducing teamwork concepts and skills earlier and throughout the curriculum would ensure that an improved focus on the project itself during the senior design experience.

Timelines
At the beginning of the second semester, the student is required to update the timeline to conform to typical project management routines wherein the student focuses on concurrent activities and maps areas where project downtimes can be minimized. This updated timeline is posted on a student project web page and a hard copy is also attached to the student's workbench that allows the course professor or instructor to gage project progress. This allows the instructor to determine over the "larger picture" if the student is falling behind at a rate that will delay completion of the project within the required due dates.

Also during the second semester, the student is required to report via the web on a weekly basis project progress. Included in this report are sections of their timeline that focus on the week just past and on the week ahead. During these meetings the instructor can discuss progress or the lack thereof, but more importantly the instructor can take mental note of how the student is proceeding on a week-by-week basis.

Theory

The Senior Design Lab utilizes what is perhaps the most easily understood project-planning tool: the timeline. The timeline, or Gantt chart, displays each task as a horizontal line that shows the starting and ending date for each task within a project and how it relates to others.

The relation of one task to another is the central part of a timeline. The student lists tasks and assigns durations to them. The student then "links" these tasks together. Linking is done in the order of what needs to happen first before something else can happen. These links are known as dependencies. An example of this is a construction project. The foundation must be poured before you can start to erect the walls. Once all dependencies are determined, the end date of the project can be determined. This line of linked dependencies is also known as the critical path.

The critical path, the series of tasks in a project that must be completed on time for the overall project to stay on time, can be examined and revised to advance the project completion date. If after linking tasks the timeline does not result in the required or desired completion date, it is recast. For example, sequential activities may be arranged to run in parallel, that is, concurrently to the critical path whenever this is practicable. An example of this is performing certain types of design work on sub-assembly B while injection mold parts are being manufactured for item A, which is in the critical path. In the case of the Senior Design Lab, the student would schedule report writing or familiarization of certain software packages or equipment concurrently with parts delivery or parts construction. Parallel planning prevents downtime – time is utilized to its fullest since work is always underway. The project completion date is also advanced when assigned durations of critical path tasks are altered. An example of a timeline showing concurrent tasks is shown in Figure 2.1.

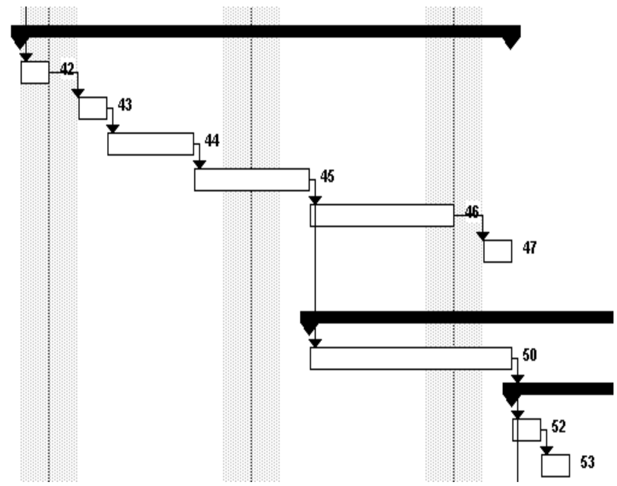

Figure 2.1. Shown above is a section of a typical timeline. The rectangular boxes represent certain tasks to be completed. These singular tasks are grouped into larger tasks, represented by thick black lines. The tasks are numbered to correspond to a task list that is not shown. The thin lines that descend from task to task are the links. Notice that task 42 must be completed before task 43 can be started. Also, task 45 must be completed before task 46 and 50 can be started. However, task 46 and 50 are concurrent, along with task 47, and can therefore be completed at the same time. No link from task 47 shows that it is out of the critical path.

It is the planning and mapping of concurrent tasks that make the timeline a project-planning tool. In the modern working world time is a most valuable resource. With the timeline, by using time loading (resource management) a project manager schedules people and resources to operate at their most efficient manner. For example, optimum time loading keeps a machining center from being overloaded one day and then having zero work the next day. The timeline schedules "full time busy" for people and equipment allowing for maximum pay-off and efficiency. In the machining center example, less than optimum time-loading would delay any tasks that require usage of the center because a greater number of tasks are assigned than can be accomplished in the amount of time scheduled. Tasks would slide, resulting in delayed projects. The same idea of time loading is also applied to personnel resources. Less than optimal time loading could result in absurd schedules that require employees to work excessive hours to maintain project schedules.

A timeline also allows for updates in the project plan should a task require more time than expected or if a design methodology turns out to be unsatisfactory with the result of new tasks being added. These extra times or new tasks that outline the new design track are logged into the timeline with the project completion date being altered. From this information, the project manager can either alter durations of simpler tasks or make certain tasks parallel to place the new completion date within requirements.

The timeline also acts as a communication tool. Team members or advisors can see how delays will affect the completion date or other tasks in the project. Project progress is also tracked with a timeline. The project manager can see if the tasks are completed on time or measure the delay if one is present. Alterations to amount of resources or time spent on tasks are implemented to bring the project plan back on schedule. Alterations are also made by removing certain tasks out of the critical path and placing them into a parallel path, if practical.

One major advantage of successful project planning using the timeline is the elimination of uncertainty. A detailed timeline has all project tasks thought out and listed. This minimizes the risk of missing an important task. A thoughtfully linked timeline also allows the manager to see what tasks must be completed before its dependent task can start. If schedule lag is noticed, more resources can be placed on the higher tasks.

Method

Discussed below is a method in which a timeline can be drawn. The Senior Design Lab utilizes Microsoft Project for project planning. Aspects such as assigning work times, workday durations, etc. are determined at this time but are beyond the scope of this chapter.

Tasks are first listed in major groups. Major groupings are anything that is convenient to the project. Major groups consist of the design and/or manufacture of major components, design type (EE or ME or programming), departmental tasks, or any number of related tasks. After the major groups are listed, they are broken down into sub-tasks. If the major group is a certain type of component, say an electro-mechanical device, then related electrical or mechanical engineering tasks required to design or build the item in the major group are listed as sub-groups. In the sub-groups the singular tasks themselves are delineated. All of the aforementioned groups, sub-groups, and tasks are listed on the left side of the timeline without regard to start, completion, or duration times. It is in this exercise where the project planner lists all of the steps required to complete a project. This task list should be detailed as highly as possible – higher detail allowing the project manager to follow the plan with greater ease.

The desired detail is determined by the requirements of the project. Some projects require week-by-week detail; other projects require that all resource movements be planned. It is also useful to schedule design reviews and re-engineering time if a design or component does not meet initial specifications as set out at project inception. Testing of designs or component parts should also be scheduled.

The second step followed in timeline drawing is the assignment of task duration. The project planner assigns time duration to each task, usually in increments of days or fractions thereof. If, for example, a task is the manufacture of a PC Board (without soldering of components), the planner may assign a half-day to that task. All durations are assigned without regard to linking.

The next step is task linking. Here the planner determines the order in which tasks must be completed. Microsoft Project allows linking with simple keyboard commands. The planner links all tasks together, with a final completion date being noted. It is in this step where the planner must make certain decisions in order to schedule a satisfactory completion date. Tasks may be altered with respect to their duration or scheduled as concurrent items. The critical path is also delineated during the linking exercise. Once a satisfactory completion date has been scheduled due to these alterations, the planner can then publish his/her timeline and proceed to follow their work plan.

Weekly Schedule

Weekly activities in Design I consist of lectures, student presentations and a team meeting with the instructor. Technical and non-technical issues that impact the design project are discussed during team meetings. Students also meet with clients/coordinators at scheduled times to report on progress.

Each student is expected to provide an oral progress report on his or her activity at the weekly team meeting with the instructor, and record weekly progress in a bound notebook and on the WWW site. Weekly report structure for the WWW includes: project identity, work completed during the past week, current work within the last day, future work, status review and at least one graphic. The client and/or client coordinator uses the WWW reports to keep up with project so that they can provide input on the progress. Weekly activities in Design II include team meetings with the course instructor, oral and written progress reports, and construction of the project. As before, the WEB is used to report project progress and communicate with the sponsors. For the past two years, the student projects have been presented at the annual Northeast Biomedical Engineering Conference.

Other Engineering Design Experiences

Experiences at other universities participating in this NSF program combine many of the design program elements presented here. Still, each university's program is unique. In addition to the design process elements already described, the program at the State University of New York at Buffalo, under the direction of Dr. Joseph Mollendorf, requires that each student go through the preliminary stages of a patent application. Naturally, projects worthy of a patent application are actually submitted. Thus far, a patent was issued for a "Four-Limb Exercising Attachment for Wheelchairs" and another patent has been allowed for a "Cervical Orthosis."

CHAPTER 3
IMPROVING "MEANINGFUL" EDUCATIONAL OUTCOMES ASSESSMENT THROUGH DESIGN PROJECT EXPERIENCES

Brooke Hallowell

Of particular interest to persons interested in the engineering education are the increasingly outcomes focused standards of the Accrediting Board for Engineering and Technology (ABET).[12] This chapter is offered as an introduction to the ways in which improved foci on educational outcomes may lead to: (a) improvements in the learning of engineering students, especially those engaged in design projects to aid persons with disabilities, and consequently, (b) improved knowledge, design and technology to benefit individuals in need.

Brief History

As part of a movement for greater accountability in higher education, U.S. colleges and universities are experiencing an intensified focus on the assessment of students' educational outcomes. The impetus for outcomes assessment has come most recently from accrediting agencies. All regional accrediting agencies receive their authority by approval from the Council for Higher Education Accreditation (CHEA), which assumed this function from the Council on Recognition of Postsecondary Accreditation (CORPA) in 1996. The inclusion of outcomes assessment standards as part of accreditation by any of these bodies, such as North Central, Middle States, or Southern Associations of Colleges and Schools, and professional accrediting bodies, including ABET, is mandated by CHEA, and thus is a requirement for all regional as well as professional accreditation. Consequently, candidates for accreditation are required to demonstrate plans for assessing educational outcomes, and evidence that assessment results have led to improved of teaching and learning and, ultimately, better preparation for entering the professions. Accrediting bodies have thus revised criteria standards for accreditation with greater focus on the "output" that students can demonstrate and less on the "input" they are said to receive.[13]

"Meaningful" Assessment Practices

Because much of the demand for outcomes assessment effort is perceived, at the level of instructors, as a bureaucratic chore thrust upon them by administrators and requiring detailed and time-consuming documentation, there is a tendency for many faculty members to avoid exploration of effective assessment practices. Likewise, many directors of academic departments engage in outcomes assessment primarily so that they may submit assessment documentation to meet bureaucratic requirements. Thus, there is a tendency in many academic units to engage in assessment practices that are not truly "meaningful".

[12] Accrediting Board for Engineering and Technology (2000). Criteria for Accrediting Engineering Programs. ABET: Baltimore, MD.

[13] Hallowell, B. & Lund, N. (1998). Fostering program improvements through a focus on educational outcomes. In Council of Graduate Programs in Communication Sciences and Disorders, Proceedings of the nineteenth annual conference on graduate education, 32-56.

Although what constitutes an "ideal" outcomes assessment program is largely dependent on the particular program and institution in which that program is to be implemented, there are at least some generalities we might make about what constitutes a "meaningful" program. For example:

> An outcomes assessment program perceived by faculty and administrators as an imposition of bureaucratic control over what they do, remote from any practical implications... would not be considered “meaningful.” Meaningful programs, rather, are designed to enhance our educational missions in specific, practical, measurable ways, with the goals of improving the effectiveness of training and education in our disciplines. They also involve all of a program's faculty and students, not just administrators or designated report writers. Furthermore, the results of meaningful assessment programs are actually used to foster real modifications in a training program.[14]

Outcomes Associated with Engineering Design Projects

Despite the NSF's solid commitment to engineering design project experiences and widespread enthusiasm about this experiential approach to learning and service, there is a lack of documented solid empirical support for the efficacy and validity of design project experiences and the specific aspects of implementing those experiences. Concerted efforts to improve learning, assessment methods and data collection concerning pedagogic efficacy of engineering design project experiences will enhance student learning while benefiting the community of persons with disabilities.

Agreeing on Terms

There is great variability in the terminology used to discuss educational outcomes. How we develop and use assessments matters much more than our agreement on the definitions of each of the terms we might use to talk about assessment issues. Still, for the sake of establishing common ground, a few key terms are highlighted here.

Formative and Summative Outcomes

Formative outcomes indices are those that can be used to shape the experiences and learning opportunities of the very students who are being assessed. Some examples are surveys of faculty regarding current students' design involvement, on-site supervisors' evaluations, computer programming proficiency evaluations, and classroom assessment techniques.[15] The results of such assessments may be used to characterize program or instructor strengths and weaknesses, as well as to foster changes in the experiences of those very students who have been assessed.

Summative outcomes measures are those used to characterize programs (or college divisions, or even whole institutions) by using assessments intended to capture information about the final products of our programs. Examples are student exit surveys, surveys of graduates inquiring about salaries, employment, and job satisfaction, and surveys of employers of our graduates.

The reason the distinction between these two types of assessment is important is that, although formative assessments tend to be the ones that most interest our faculty and students and the ones that drive their daily academic experiences, the outcomes indices on which most administrators focus to monitor institutional quality are those involving summative outcomes. It is important that each of academic unit strive for an appropriate mix of both formative and summative assessments.

Cognitive/Affective/Performative Outcome Distinctions

To stimulate our clear articulation of the specific outcomes targeted within any program, it is helpful to have a way to characterize different types of outcomes. Although the exact terms vary from context to context, targeted educational outcomes are commonly characterized as belonging to one of three domains: cognitive, affective, and

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14 Hallowell, B. (1996). Innovative Models of Curriculum/Instruction: Measuring Educational Outcomes. In Council of Graduate Programs in Communication Sciences and Disorders, Proceedings of the Seventeenth Annual Conference on Graduate Education, 37-44.

15 Angelo, T. A., & Cross, K. P. (1993). Classroom assessment techniques: A handbook for college teachers. San Francisco: Jossey-Bass.

performative. Cognitive outcomes are those relating to intellectual mastery, or mastery of knowledge in specific topic areas. Most of our course-specific objectives relating to a specific knowledge base fall into this category. Performance outcomes are those relating to a student's or graduate's accomplishment of a behavioral task. Affective outcomes relate to personal qualities and values that students ideally gain from their experiences during a particular educational and training program. Examples are appreciation of various racial, ethnic, or linguistic backgrounds of individuals, awareness of biasing factors in the design process, and sensitivity to ethical issues and potential conflicts of interest in professional engineering contexts.

The distinction among these three domains of targeted educational outcomes is helpful in highlighting areas of learning that we often proclaim to be important, but that we do not assess very well. Generally, we are better at assessing our targeted outcomes in the cognitive area, for example, with in-class tests and papers, than we are with assessing the affective areas of multicultural sensitivity, appreciation for collaborative teamwork, and ethics. Often, our assessment of performative outcomes is focused primarily on students' design experiences, even though our academic programs often have articulated learning goals in the performative domain that might not apply only to design projects.

Faculty Motivation

A critical step in developing a meaningful educational outcomes program is to address directly pervasive issues of faculty motivation. Faculty resistance is probably due in large part to the perception that outcomes assessment involves the use of educational and psychometric jargon to describe program indices that are not relevant to the everyday activities of faculty members and students. By including faculty, and perhaps student representatives, in discussions of what characterizes a meaningful assessment scheme to match the missions and needs of individual programs, and by agreeing to develop outcomes assessment practices from the bottom up, rather than in response to top-down demands from administrators and accrediting agencies, current skeptics on our faculties are more likely to engage in assessment efforts.

Additional factors that might give faculty the incentive to get involved in enriching assessment practices include: Consideration of outcomes assessment work as part of annual merit reviews:

- provision of materials, such as sample instruments, or resources, such as internet sites
- to simplify the assessment instrument design process
- demonstrate means by which certain assessments, such as student exit or employer surveys

These assessment practices may be used to [a] program's advantage in negotiations with ... administration (for example, to help justify funds for new equipment, facilities, or salaries for faculty and supervisory positions); and notice and reward curricular modifications and explorations of innovative teaching methods initiated by the faculty in response to program assessments.[14]

With the recent enhanced focus on educational outcomes in accreditation standards of ABET, and with all regional accrediting agencies in the Unites States now requiring extensive outcomes assessment plans for all academic units, it is increasingly important that we share assessment ideas and methods among academic programs. It is also important that we ensure that our assessment efforts are truly meaningful, relevant and useful to our students and faculty.

An Invitation To Collaborate In Using Assessment To Improve Design Projects

Readers of this book are invited to join in collaborative efforts to improve student learning, and design products through improved meaningful assessment practices associated with NSF-sponsored design projects to aid persons with disabilities. Future annual publications on the NSF-sponsored engineering design projects to aid persons with disabilities will include input from students, faculty, supervisors, and consumers on ways to enhance associated educational outcomes in specific ways. The editors of this book look forward to input from the engineering education community for dissemination of further information to that end.

ABET's requirements for the engineering design experiences in particular[16] provides direction in areas that are essential to assess in order to monitor the value of engineering design project experiences. For example, the following are considered "fundamental elements" of the design process: "the establishment of objectives and criteria, synthesis, analysis, construction, testing, and evaluation" (p. 11). Furthermore, according to ABET, specific targeted outcomes associated with engineering design projects should include: development of student creativity, use of open-ended problems, development and use of modern design theory and methodology, formulation of design problem statements and specifications, consideration of alternative solutions, feasibility considerations, production processes, concurrent engineering design, and detailed system descriptions. The accrediting board additionally stipulates that it is essential to include a variety of realistic constraints, such as economic factors, safety, reliability, aesthetics, ethics, and social impact. ABET's most recent, revised list of similar targeted educational outcomes is presented in the Appendix to this chapter. We encourage educators, students and consumers to consider the following questions:

- Are there outcomes, in addition to those specified by ABET, that we target in our roles as facilitators of design projects?
- Do the design projects of each of the students in NSF-sponsored programs incorporate all of these features?
- How may we best characterize evidence that students engaged in Projects to Aid Persons with Disabilities effectively attain desired outcomes?
- Are there ways in which students' performances within any of these areas might be more validly assessed?
- How might improved formative assessment of students throughout the design experience be used to improve their learning in each of these areas?

Readers interested in addressing such questions are encouraged to send comments to the editors of this book. The editors of this book are particularly interested in disseminating, through future publications, specific assessment instruments that readers find effective in evaluating targeted educational outcomes in NSF-sponsored engineering design projects.

Basic terminology related to pertinent assessment issues was presented earlier in this chapter. Brief descriptions of cognitive, performative, and affective types of outcomes provided here, along with lists of example types of assessments that might be shared among those involved in engineering design projects.

Cognitive outcomes are those relating to intellectual mastery, or mastery of knowledge in specific topic areas. Some examples of these measures are:

- Comprehensive exams,
- Items embedded in course exams,
- Pre-post tests to assess "value added",
- Design portfolios,
- Student self evaluation of learning during a design experience,
- Alumni surveys, and
- Employer surveys.

Performative outcomes are those relating to a student's or graduate's accomplishment of a behavioral task. Some performance measures include:

- Evaluation of graduates' overall design experience,
- Mastery of design procedures or skills expected for all graduates,
- Student evaluation of final designs, or of design components,
- Surveys of faculty regarding student design competence,

[16] Accrediting Board for Engineering and Technology (2000). Criteria for Accrediting Engineering Programs. ABET: Baltimore, MD.

- Evaluation of writing samples,
- Evaluation of presentations,
- Evaluation of collaborative learning and team-based approaches,
- Evaluation of problem-based learning,
- Employer surveys, and
- Peer evaluation; e.g., of leadership or group participation.

Affective outcomes relate to personal qualities and values that students ideally gain from their educational experiences. These may include:

- Student journal reviews,
- Supervisors' evaluations of students' interactions with persons with disabilities,
- Evaluations of culturally-sensitive reports,
- Surveys of attitudes or satisfaction with design experiences,
- Interviews with students, and
- Peers', supervisors', and employers' evaluations.

We welcome contributions of relevant formative and summative assessment instruments, reports on assessment results, and descriptions of assessment programs and pedagogical innovations that appear to be effective in enhancing design projects to aid persons with disabilities.

Please send queries or submissions for consideration to:

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APPENDIX: Desired Educational Outcomes as Articulated in ABET's New "Engineering Criteria 2000" (Criterion 3, Program Outcomes and Assessment)[17]

Engineering programs must demonstrate that their graduates have:

(a) An ability to apply knowledge of mathematics, science, and engineering

(b) An ability to design and conduct experiments, as well as to analyze and interpret data

(c) An ability to design a system, component, or process to meet desired needs

(d) An ability to function on multi-disciplinary teams

(e) An ability to identify, formulate, and solve engineering problems

(f) An understanding of professional and ethical responsibility

(g) An ability to communicate effectively

(h) The broad education necessary to understand the impact of engineering solutions in a global and societal context

(i) A recognition of the need for, and an ability to engage in life-long learning

(j) A knowledge of contemporary issues

(k) An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

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[17] Accrediting Board for Engineering and Technology (2000). Criteria for Accrediting Engineering Programs. ABET: Baltimore, MD (p. 38-39).

CHAPTER 4
USING NSF-SPONSORED PROJECTS TO ENRICH STUDENTS' WRITTEN COMMUNICATION SKILLS

Brooke Hallowell

Based on numerous anecdotes offered inside and outside of engineering, age-old stereotypes that engineers lack communication skills may have some basis in fact. However, current work environments for most new graduates in a host of professional biomedical engineering contexts place such heavy expectations for, and demands on, excellence in oral and written communication that engineers' lack of communication skills can no longer be tolerated as a trade-off for their strengths in science and mathematics. Evolving requirements for communication with interdisciplinary team members, clients, patients, consumers, employers, and the public require that educators of engineers work hard to ensure that students reach a standard of excellence in communication before they enter the workforce. This chapter is offered to provide specific guidance on principles and resources for enriching written communication skills in biomedical engineering students through their NSF-sponsored design project experiences.

A Formative Focus

As discussed in the previous chapter, a formative focus on academic assessment allows educators to use assessment strategies that directly influence students who are still within their reach. A solid approach to formative assessment of writing skills involves repeated feedback to students throughout educational programs, with faculty collaboration in reinforcing expectations for written work, use of specific and effective writing evaluation criteria, and means of enhancing outcomes deemed important for regional and ABET accreditation[18]. Given that most students in the NSF-sponsored Senior Design Projects to Aid Persons with Disabilities programs are already in their fourth year of college-level study, it is critical to recognize that previous formative writing instruction is essential to their continued development of writing skills during the senior year. Model strategies for improving writing presented here in light of senior design projects may also be implemented at earlier stages of undergraduate learning.

Clarifying Evaluation Criteria

Student learning is directly shaped by how students think they will be assessed. Regardless of the lofty goals of excellence instructors might set forth in course syllabi and lectures, if specific performance criteria are not articulated clearly and assessed directly, then students are unlikely to reach for those same goals. To enhance writing skills effectively through the senior design experience, specific evaluation criteria for writing quality must be established at the start of the senior design experience. Clear expectations should be established for all written work, including related progress reports, web page content, and final reports. Although the examples provided here are oriented toward writing for annual NSF publications, the basic assessment process is ideally applied to other areas of written work.

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[18] Engineering Criteria 2000 (Criterion 3, Program Outcomes and Assessment) Accrediting Board for Engineering and Technology (2000). Criteria for Accrediting Engineering Programs. ABET: Baltimore, MD (p. 38-39).

Elements of Writing to be Assessed

What aspects of writing quality are important in writing about senior design projects? The list of specific ideal aspects probably varies widely among instructors. Still, consideration of guidelines already proposed may help to streamline the development of finely tuned assessment instruments to shape and evaluate student writing. Each year, the editors of this annual publication on senior design projects send guidelines for manuscript publication to principal investigators on NSF-sponsored Engineering Senior Design Projects to Aid Persons with Disabilities grants. Those guidelines form the basis for the elements of writing on which writing projects may be evaluated.

A sample grading form, based on the most recent version of those guidelines at the time of this publication, may be found in Appendix A. Explicit writing criteria are specified, and a means for explicit scoring according to those criteria is provided. Instructors may use such a form to evaluate drafts and final project reports. Specific item descriptions and the relative weighting of the value of performance in specific areas may be modified according to instructor preferences. Application of such scoring systems to student course grades will ensure greater student accountability for meeting explicit writing standards.

General categories for analyzing writing performance for project reports include: A) form and formatting, B) accompanying images, C) grammar, spelling, punctuation, and style, D) overall content, and E) content within specific sections.

Form and formatting concerns are related primarily to students' following of explicit instructions regarding page limitation, spacing, margins, font size, indentations, and headings. Items related to images include the type, quality, relevance and formatting of photographs and drawings used to illustrate reports. Issues of grammar, spelling, punctuation, and style may be largely addressed through adherence to specific conventions for each of these areas. Thorough proofreading and use of computerized checks for spelling and grammar, although frequently recommended by instructors, are not as likely to be carried out by students who are not expecting to be assessed for performance in these important areas.

Areas of overall content evaluation for senior design reports include aspects of writing that are often among the most problematic for undergraduate engineers. One such area is that of using appropriate language when referring to individuals with disabilities. Reports submitted for NSF publications often include terms and descriptions that may be considered offensive by many, such that the editors of this annual publication often engage in extensive rewriting of sections including client descriptions. It is most likely that students engaged in projects for persons with disabilities are wholeheartedly supportive of their clients, and use such terms out of naiveté rather than any ill intent. Still, the words we use to communicate about other people powerfully influences readers' perceptions of them, especially in cases in which readers may be unfamiliar with the types of conditions those people are experiencing. Using appropriate language is of paramount importance to our joint mission of enabling individuals to live fully and with maximum independence. It is thus critical that instructors provide clear instruction and modeling for appropriate language use in writing about disabilities. In cases where instructors may have outdated training concerning language use in this arena, it is critical that they seek training regarding sensitivity in language use themselves.

Basic guidelines for writing with sensitivity about persons with disabilities are summarized briefly in Appendix B. Using person-first language, avoiding language that suggests that individuals with disabilities are "victims" or "sufferers", and avoiding words with negative connotations are three key components to appropriate language use.

Evaluation of content within specific sections of senior design project reports will help students focus on drafting and appropriately revising and editing reports. By discussing and evaluating specific criteria - such as the use of laypersons' terms in a project description, effective description of the motivation for a particular design approach, and the use of clear, concise technical language to describe a device modification such that others would be able to replicate the design - instructors may help students further hone their writing and revision skills.

A Hierarchy of Revision Levels

Constructive feedback through multiple revisions of written work is critical to the development of writing excellence. Even for the accomplished writer, a series of drafts with a progressive evolution toward a polished product is essential. It is thus important that instructors allow time for revision phases for all writing assignments throughout the senior design experience.

Three basic levels of writing revision proposed by some authors include global, organizational, and polishing revision[19]. Global revision involves a general overhaul of a document. Macro-level feedback to students about their general flow of ideas and adherence to assignment guidelines helps to shape an initially-submitted draft into a version more suitable for organizational revision. Organizational revision requires reshaping and reworking of the text. Helpful feedback to students at this level may involve revising of macro-level issues not corrected since the initial draft, and/or a focus on new micro-level issues of coherence, clarity, relevance, and word choice. Polishing revision entails attention on such flaws as grammatical errors, misspellings, and misuse of punctuation, and to specific formatting rules for the assignment. Finding patterns of errors and providing constructive feedback about those patterns may help individuals or teams of students learn efficient strategies for improving their written work.

Structured Critical Peer Evaluation

As many instructors require several forms of written assignments within project design courses, including the final reports required for submission to the NSF-sponsored annual publication, is impractical or impossible for many instructors to handle providing evaluation and feedback at three levels of revision for each written assignment. One means of promoting students' experience with critical reflection on writing is to implement assignments of structured critical evaluation of writing using reader-response strategies, with students as editors for other students' work. Students (as individuals or on teams) may be given a basic or detailed rubric for evaluating other students' written work, and explicit guidelines for providing structured constructive comments following critical evaluation.

Resources and Support

Numerous excellent texts are available to promote and provide structure and guidance for the development of essential writing skills in engineering students. Some sample recommended texts are listed in Appendix C. Comments and suggestions from instructors who have developed model writing programs for engineering design courses at any level of study are welcome to submit those to the editors of this book, to be considered for future publication.

It is the profound hope of the editors of this book that future improvements in reports submitted for NSF-sponsored publications will reflect instructors' increasingly greater attention to the quality of student-generated writing. With continuously enhanced attention to the development of engineering students' writing through improved foci on writing skills and strategic assessment of written work, all with interest in design projects for persons with disabilities will benefit.

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[19] **Ohio University Center for Writing Excellence Teaching Handouts [on-line] (2002). Available at: http://www.ohiou.edu/writing/3_Ls_of_Revision.htm**

APPENDIX A: Sample Evaluation Form for Project Reports Prepared for Annual NSF Publications on Senior Design Projects to Aid Persons with Disabilities

Item evaluated	Score/ Possible Score
A. Form and formatting	
Does not exceed two pages (unless authorized by instructor)	/2
10 point size type throughout the manuscript	/2
Margin settings: top =1", bottom=1", right=1", and left=1"	/2
Title limited to 50 characters on each line (if longer than 50 characters, then skips two lines and continues, with a blank line between title text lines)	/1
Text single spaced	/2
No indenting of paragraphs	/1
Blank line inserted between paragraphs	/1
Identifying information includes: project title, student name, name of client coordinator(s), supervising professor(s), university address	/2
Appropriate headings provided for Introduction, Summary of impact, and Technical description sections	/2
Total points for form and formatting	**/15**
B. Images	
Photographs in black and white, not color	/1
Photographs are hard copies of photo prints, not digital	/1
Line art done with a laser printer or drawn professionally by pen with India (black) ink	/2
Images clearly complement the written report content	/2
Photographs or line art attached to report by paperclip	/1
Photographs or line art numbered on back to accompany report	/1
Figure headings inserted within the text with title capitalization, excluding words such as "drawing of" or "photograph of"	/2
Total points for images	**/10**

C. Grammar, spelling, punctuation, and style	
Consistent tenses throughout each section of the report	/2
Grammatical accuracy, including appropriate subject-verb agreement	/2
Spelling accuracy	/2
Appropriate punctuation	/2
Abbreviations and symbols used consistently throughout (For example, " or in. throughout for "inch;" excludes apostrophe for plural on abbreviations, such as "BMEs"or "PCs"	/2
Uses the word "or" rather than a slash (/) (For example, "He or she can do it without assistance.")	/1
Numbers one through 9 spelled out in text; number representations for 10 and higher presented in digit form (except in series of numbers below and above 10, or in measurement lists)	/1
In lists, items numbered, with commas between them (for example: "The device was designed to be: 1) safe, 2) lightweight, and 3) reasonably priced.")	/1
Consistent punctuation of enumerated and bulleted lists throughout the report	/2
Total points for grammar, spelling, punctuation, and style	**/15**

D. Overall content	
Excludes extensive tutorials on specific disabilities	/2
Demonstrates appropriate language regarding individuals with disabilities	/3
Avoids redundancy of content among sections	/3
Demonstrates clear and logical flow of ideas	/3
Excludes use of proper names of clients	/3
Citation and reference provided for any direct quote from published material	/1
Total points for overall content	**/15**

E. Section content	
Introduction	
Includes a brief description of the project in laypersons' terms	/4
Includes problem addressed, approach taken, motivation for the approach, a summary of usual or existing solutions, and problems with these solutions	/4
Summary of impact	
Includes a brief description of how this project has improved the quality of life of a person with a disability	/5
Includes a quoted statement from an educational or health care specialist who supervises the client, or from a significant other	/2
Includes a description of the project's usefulness and overall design evaluation	/5
Technical description	
Clear, concise technical description of the device or device modification such that others would be able to replicate the design	/10
Detailed parts lists included only if parts are of such a special nature that the project could not be fabricated without the exact identity of the part	/2
Text refers to circuit and/or mechanical drawing of the device	/3
Includes analysis of design effectiveness	/5
Concludes with approximate cost of the project, including parts and supplies (not just the NSF's contribution) and excluding personnel costs	/5
Total points for section content	**/45**

Evaluation Summary

A. Total points for form and formatting	**/15**
B. Total points for images	**/10**
C. Total points for grammar, spelling, punctuation, style	**/15**
D. Total points for overall content	**/15**
E. Total points for section content	**/45**
TOTAL POINTS	**/100**

APPENDIX B: A Summary of Guidelines for Writing about Persons with Disabilities

The World Health Organization (WHO) has launched word-wide efforts to modify the ways in which we refer to persons with disabilities. The WHO emphasizes that disablement is not considered an attribute of an individual, but rather the complex interactions of conditions involving a person in the context of his or her social environment. One classification scheme proposed by the WHO, the International Classification of Impairments, Disabilities and Handicaps (ICIDH) employs the general terms "impairment", "disability", and "handicap", while a more recent scheme, the ICIDH-2, employs the terms "impairment", "activity", and "participation", to refer to the various contextual aspects of disabling conditions one might experience. 20 Health care professionals and researchers throughout the world are following suit by de-emphasizing the reference to individuals according to medically-based diagnostic categories, focusing instead on their holistic functional concerns and what might be done to address them. Readers of this book are encouraged to join in this important movement. General guidelines are presented here.

Recognize the importance of currency and context in referring to individuals with disabilities

There are always variances in the terms that particular consumers or readers prefer, and that it is essential to keep current regarding changes in accepted terminology.

[20] World Health Organization (1999). ICIDH-2: International Classification of Impairments, Activities and Participation: A manual of dimensions of disablement and health [on-line]. Available: http://www.who.int/msa/mnh/ems/icidh/introduction.htm

Refer to "disabilities"

Although the very term "disability" may be considered offensive to some (with its inherent focus on a lack of ability), it is currently preferred over the term "handicap" in reference to persons with physical, cognitive, and/or psychological challenges or "disabilities".

Use person-first language.

Person-first language helps emphasize the importance of the individuals mentioned rather than their disabilities. For example, it is appropriate to refer to a "person with a disability" instead of "disabled person," and to say "a child with cerebral palsy" instead of "a cerebral palsied child.

Avoid using condition labels as nouns

Many words conveying information about specific disabilities exist in both noun and adjectival forms, yet should primarily be used only as adjectives, or even better, modified into nouns corresponding to conditions, as in the person-first language examples given above. For example, it is not appropriate to call an individual with aphasia "an aphasic." Although the term "an aphasic individual" would be preferred to the use of "an aphasic" as a noun, such labeling may convey a lack of respect for, and sensitivity toward, individuals who have aphasia.[21] A more appropriate term would be "person with aphasia." Likewise, it is not appropriate to call an individual with paraplegia "a paraplegic," or to call persons with disabilities "the disabled."

Avoid Language of Victimization

Do not use language suggesting that clients are "victims" or people who "suffer" from various

[21] Brookshire, R.H. (1992). An introduction to neurogenic communications disorders. St. Louis: Mosby – Year Book.

forms of disability. For example, say, "the client had a stroke" rather than "the client is a stroke victim." Say, "She uses a wheelchair," rather than "she is confined to a wheelchair." Say "her leg was amputated…" instead of, "the client suffered an amputation of the leg."

Avoid Words with Negative Connotations

Words that evoke derogatory connotations should be avoided. These include such words and phrases as affliction, crazy, crippled, defective, deformed, dumb, insane, invalid, lame, maimed, mute, retard, and withered.

Encourage Others in Appropriate Language Use

By modeling appropriate language in writing about persons with disabilities, authors take an important step in helping others to improve in this area. It is also important to help others learn to implement guidelines such as these directly through course work and other educational experiences. Likewise, polite and constructive corrections of others using inaccurate language helps encourage more positive communication as well as more enabling positive societal attitudes, widening the arena for empowering persons with disabilities.

CHAPTER 5
CONNECTING STUDENTS WITH PERSONS WHO HAVE DISABILITIES

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[22] Portions of "The Engineering Perspective" were presented at the 40th Annual Rocky Mountain Bioengineering Symposium, April 2003, Biloxi, MS (Barrett, 2003)

INTRODUCTION

For many students, participation in the National Science Foundation (NSF) projects to aid persons with disabilities is a unique experience. Often it is their first opportunity to work with individuals with disabilities. As such, not only must they meet the academic requirements of their senior design project, but in order to be successful, they must also learn about disability and related issues. Only when students are able to combine their scientific knowledge with an understanding of other related humanistic factors will they be able to make significant contributions to the field. Therefore, it is imperative for engineering programs participating in the NSF projects to ensure that students have the opportunity to gain the necessary awareness and social competencies needed. Specifically, students need to have a basic understanding of philosophical attitudes toward disability as well as an understanding of assistive technology and how to communicate effectively with persons with disabilities. This awareness and understanding will not only enable students to have a more meaningful experience, but will also ensure a more meaningful experience for the individuals with whom they will be working.

Students must also understand the engineering aspects of their project. The engineering aspects may be viewed from two different levels: the programmatic aspects of the project and the engineering details of their specific project. At the program level, projects must be properly scoped for difficulty and required expertise. At the individual project level the projects must meet specific requirements but also must be safe and reliable. Senior design faculty as well as participating students have the joint responsibility of insuring these engineering aspects are met.

In this chapter we will discuss these diverse yet related aspects of National Science Foundation engineering senior design projects to aid persons with disabilities. We will first examine the social constructs of disability, followed by the proper language of disability. We will then investigate assistive technology and universal design principles. This chapter will conclude with a discussion of the engineering aspects for a successful design experience.

Models of Disability

There are three predominant social constructs of disability. These models define the source or problem of disability, who holds the onus, and the ways that best address the related issues. The oldest model is the moral model, which posits that disability is caused by moral lapse or sin. It explains disability as a supernatural phenomena or act of god that serves as punishment and represents the consequences of perceived wrongdoing. It brings shame to the individual and in cultures that emphasize family and/or groups over the individual, the shame spreads to the family and/or group. The person and/or family carry the blame for causing the disability. In a tenuously more auspicious interpretation of the moral model, disability is perceived as a test of faith, i.e. "God only gives us what we can bear" or as a mystical experience in which one sense may be impaired but others are heightened and the adversity of the disability provides increased emotional and spiritual strength often recognized by the belief "with the grace of God he/she overcame the disability."

Given the limitations of the moral model, the medical model began to emerge in the mid- 1800s as a result of developing science and improved humanistic medicine. In this model, disability is recognized as a medical problem that resides within the individual. It is a dysfunction, defect, or abnormality that needs to be fixed. The ambition is to restore normality and cure the individual. It is a paternalistic model that expects an individual to assume the role of a victim or sick person and avail themselves to medical professionals and services. The individual is a passive participant. However, as medicine and professionals have advanced in their knowledge and understanding, this model has given way to a more person centered version, often referred to as the rehabilitation model, in which disability is analyzed in terms of function and limitations. In this paradigm, a more holistic approach is taken. The individual is a more active participant and his or her goals are the basis for therapeutic intervention. The emphasis is on functioning within one's environments and a variety of factors are assessed in terms of barriers and or facilitators to increased functioning. This model recognizes disability as the corollary of interaction between the individual and the environment. The individual is recognized as a client and the emphasis is based on assisting the individual in adjusting or adapting. It is important to note that, although this model derives from a systems approach, the primary issues of disability are still attributed to the individual.

In the last 30 years, another model has emerged, the social model of disability, which is also referred to as a minority group model and/or independent living model. Its genesis resides within the disability rights movement and proclaims that disability is a social construction. Specifically, the problem of disability is not within the individual, but within the environment and systems with which the individual must interact. The barriers that prevent individuals with disabilities from participating fully and equally within society include prejudice, discrimination, inaccessible environments, inadequate support, and economic dependence.

While it is beyond the scope of this chapter to view these constructs in detail, an awareness of these models enables one to examine their own beliefs and attitudes toward disability. It also helps students understand that they will encounter both professionals and persons with disabilities whose beliefs are rooted in any one (or combination of) these identified constructs. Although it may not be readily evident, these beliefs will impact how students approach their projects, their ability to see beyond the disability and consider other related factors, and their ability to establish meaningful relationships with the individuals they are trying to assist. Therefore, it is highly recommended that all engineering programs establish collaborative partnerships with other disability professionals in order to provide students with an awareness of disability issues. Potential partners include other programs within the university, especially those with disability studies programs, state assistive technology projects, and independent living centers.

Language of Disability

Terminology and phrases used to describe many people (those with and without disabilities) have changed over time. Many words and phrases are embedded in the social constructs and ideologies of our history and the changes in terminology reflect the paradigm shifts that have occurred over time. For example, the terms Native American or African American have changed with the Zeitgeist and no longer reflect the often derogatory words or phrases that preceded them. Although there is often disdain for those that advocate political correctness, it is important to realize that words and expressions can be very powerful and they do in fact communicate attitudes, perceptions, feelings, and stereotypes. They can be oppressive or empowering. The changes in language that have occurred represent an acceptance of diversity and a respect for differences which ultimately impact social change. As professionals and educators, we are in fact, agents of change, and it is our responsibility to recognize the power of language and to use it befittingly in our conversations, discussions and writings.

In regard to disability, the use of person first language (i.e. always putting the person before the disability) recognizes the person first and foremost as a unique individual. In contrast, referring to someone by his or her disability defines them by a single attribute and limits the ability to distinguish who they are as a person from the disability, which in fact they may consider to be a very minute characteristic. For example, the statement "The stroke victim's name is Joe" conjures up a very different image from "Joe is a great musician who had a stroke last year", or "she can't ski; she is paralyzed and confined to a wheelchair" versus "she loves to ski and uses a sit ski device because she has paraplegia and is a wheelchair user." Putting the person before the disability demonstrates respect and acknowledges the person for who they are, not for what they do or do not have. Although it may seem awkward when one first begins to use person first language, it will become natural over time, it will demonstrate respect, and it will have a positive societal impact. For general guidelines on person first language, a keyword internet search will reveal many resources. For guidelines on writing, see Chapter 4.

Assistive Technology and Universal Design

Assistive Technology is a general term that describes any piece of equipment or device that may be used by a person with a disability to perform specific tasks and to improve or maintain functional capabilities, thus providing a greater degree of independence, inclusion, and/or community integration. It can help redefine what is possible for people with a wide range of cognitive, physical, or sensory disabilities. AT can be simple or complex, and can include off the shelf items as well as special design. Devices become AT through their application. This technology may range from very low-cost, low-tech adaptations (such as a battery interrupter to make a toy switch accessible) to high-tech, very expensive devices (such as a powered mobility equipment and environmental controllers).

Assistive Technology can include cognitive aids, aids to assist with walking, dressing, and other activities of daily living, aids to augment hearing or vision, adaptive recreation devices, augmentative communication aids, and alternate computer access. Services related to Assistive Technology may include evaluation for appropriate equipment and systems, assistance with purchasing or leasing devices, and selecting, defining, fitting, adapting, applying, maintaining, repairing, or replacement of equipment and systems. In addition, services could include training and technical assistance for individuals and their families, and/or other professionals. Assistive Technology may be used at home, in the workplace, in the classroom and in the community to provide creative solutions in assisting individuals as they go about their activities of living, learning, working, and playing.

Universal Design (UD) refers to a concept or philosophy for designing and delivering products and services that are usable by people with the widest possible range of functional capabilities. This includes products and services that are directly usable (without requiring assistive technology) and products and services that are made usable with assistive technology.

As noted earlier, the social model of disability focuses on the environment as the most significant barrier preventing people with disabilities from full contribution to all aspects of society. As such, the concepts of universal design have significant potential for remedy (see reference section for resources specific to universal design). The basic premise of universal design is to create access, in terms of the mass marketplace as well as community and information environments, for as many people as possible, regardless of age, size, or ability.

It is estimated that approximately thirty million people have a disability or functional limitation due to injury, illness or aging (Vanderheidin, 1990). With the advances in modern medicine and the emerging inroads in health promotion and disease prevention, people are living longer. Nearly everyone will experience some type of functional limitation during the course of a lifetime. Given such broad prevalence of disability in the general population, the need for universal design becomes self-evident.

The underlying principles of universal design are available for review at www.design.ncsu.edu, The Center for Universal design, North Carolina State University. Those basic principles provide the philosophical interface between functional limitations/disability and best practices in design. In fact, universal design principles can oftentimes simplify the adaptation or even eliminate the need for specialized design created specifically for the individual person. Conversely, when prototype devices are necessary, if they adhere to principles of UD, it is much more likely that the device will also be able to be adopted by others and that the technology will be able to be transferred to other applications. When assistive technology is necessary to support access and/or use of the built environment, products, or information, the understanding that any design must first and foremost respect personal dignity and enhance independence without stigmatizing the individual is critical. This is clearly a quality of life issue for everyone. Working with an individual who has disabilities to develop assistive technology requires the engineer to actively collaborate, respecting the right of each person to self-determination and self-control (Shapiro, 1993).

In general, the areas of functional limitation most amenable to benefit from the concepts of universal design (and assistive technology where necessary) are in the broad categories of: communication, mobility, sensory, manipulation, and cognition including memory. All design should consider and address varying human abilities across each of these domains. The goal of universal design is to eliminate, as much as possible, the need for assistive technologies because the focus of all design is inclusive rather than restrictive. Historically, designs were often based on the young, able-bodied male. With the advent of UD, designers are redefining the user to include as many people as possible with the widest range of abilities.

There are many examples of how assistive technologies have been adopted by the general population. For example, at one time the use of closed captioning was limited to individuals who were hard of hearing or deaf. Today, captioning can be seen on televisions located in public places such as restaurants, airports, and sports bars. Captioning in also used by many people in their own homes when one person wishes to watch TV while another does not. Other examples include ramps, curb cuts and automatic door openers. Initially designed for individuals who were wheelchair users, it was quickly realized they also benefited delivery personnel, people with strollers, people with temporary injuries, cyclists, etc. In addition, many items related to computer access such as voice recognition, are now employed in a variety of computer and telecommunication applications. When UD principles are employed, the whole environment, in the broadest sense becomes more humane and maximizes the potential contribution of everyone, not just those with disabilities.

As senior design students explore their options for projects, an awareness of disability issues, existing assistive technologies and universal design principles will ensure that their projects incorporate state-of- the-art practices. A list of valuable resources is included at the end of this chapter.

The Engineering Perspective

To provide for a successful Engineering Senior Design Projects to Aid Persons with Disabilities Program, projects must be successful at both the program level and the individual project level. In this section we discuss aspects of a successful program and use the University of Wyoming's program as a case study.

- To be successful at the academic program level, a program must successfully address the following aspects:
- Provide a team approach between assistive technology professionals and engineering participants,
- Receive appropriate publicity within assistive technology channels,
- Provide projects that have been properly scoped for difficulty, student team size, and required student expertise, and
- Have mechanisms in place to address the safety aspects of each project and the legal aspects of the program.

In order to address these needs, the College of Engineering partnered with four other programs to identify the specific needs of the individual. Specifically, the college joined with the Wyoming Institute for Disabilities (WIND) assistive technology program, Wyoming New Options in Technology (WYNOT) and their Sports and Outdoor Assistive Recreation (SOAR) project along with the university's Special Education program.

With this assembled team of professionals, we assigned specific duties to the team members. The WYNOT Project Director served as the coordinator with the community to identify specific assistive technology needs. This was accomplished using a short project application to identify the desired assistive device and the special needs of the individual. Project proposals were initiated by the individual with a disability, his/her family members, caregivers, teachers, or any of the service agencies in the state of Wyoming. WYNOT was also the key player in the promotion of the Biomedical Engineering Program and Research to Aid Persons with Disabilities (BME/RAPD). Marketing included featured articles in the WYNOT newsletter, posting of project information on the WYNOT website, development of a project website, (http://wwweng.uwyo.edu/electrical/faculty/barrett/assist/), public service announcements, and statewide and nationwide press releases.

The WYNOT project director and the engineering PI met on a regular basis to evaluate the suitability of the submitted projects. Specifically, each requested projected was reviewed to ensure it was sufficiently challenging for a year long senior design project. Also, the required engineering expertise was scoped for each project. Once a project was determined to be of suitable scope for an undergraduate design project, the PI coordinated with the appropriate engineering department(s) to publicize the project in the senior design course. This process is illustrated in Figure 5.1. Overall, an individual with a disability was linked with a student engineering team to provide a prototype custom designed assistive device specific to his/her needs.

Since these projects involve the use of human subjects, students were required to complete an Institutional Review Board (IRB) study prior to initiating a specific project. These studies were completed and submitted to the IRB per federal and university guidelines. Furthermore, projects were delivered to the recipients only after extensive testing. At that time the recipient or their legal guardian signed a "Hold Harmless" agreement. This agreement was reviewed and approved by the university's legal office.

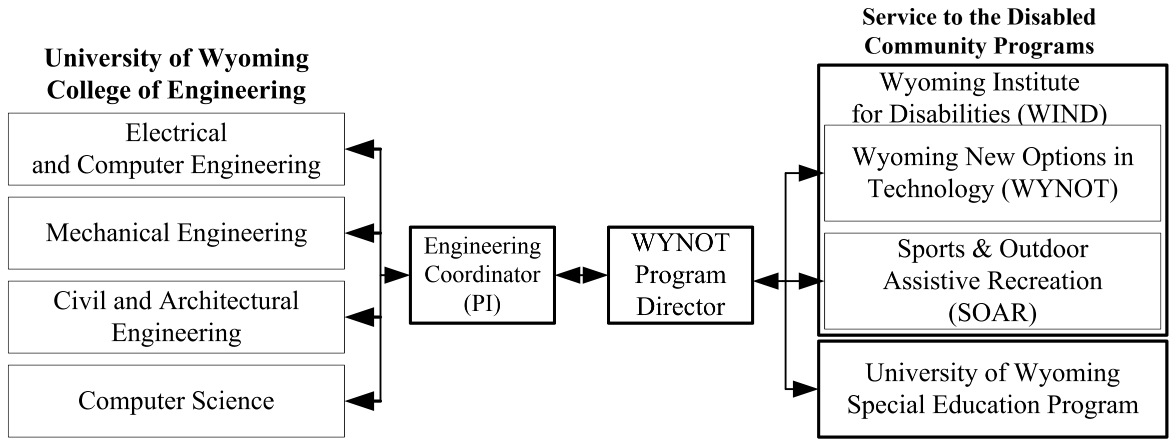

Figure 5.1. Program Flow for Undergraduate Design Projects to Aid Wyoming Persons with Disabilities (Barrett, 2003).

At the individual project level, students must:

- Be educated on assistive technology awareness,
- Be committed to delivering a completed, quality project,
- Be aware of available expertise to assist with the technical aspects of the project,
- Work closely with the individual who will be using the project, and
- Provide adequate time in the project schedule for testing and remanufacture if required.

To assist the students in developing these aspects of the project, the PI met with each senior design course at the beginning of the semester. The PI reviewed the purpose of the program, described potential projects, and also emphasized the importance of delivering a completed project. Students were encouraged to meet individually with the PI if they wanted more information about a specific project. At these follow-up meetings, the students were given all available information about the project and a point of contact to obtain more information from the requesting assistive technology agency or individual. Students were encouraged to contact these individuals to begin developing a relationship between the project user and designer.

Many of the projects were interdisciplinary in nature typically involving both mechanical and electrical engineering students. Faculty advisors for the senior design courses set up several "get acquainted" sessions at the local pizza parlor for students to get to know each other and also to review potential projects.

WYNOT also provided training to the engineering students regarding assistive devices and services. This training was provided to all students in the senior design course regardless if they were participating in the assistive technology program. This provided disability awareness to the state's next generation of engineers.

Expected Benefits

It is a challenge to get a program of this type initiated; however, the potential benefits far outweigh these challenges. Here is a list of potential benefits:

- Provide engineering students multi-disciplinary, meaningful, community service design projects,
- Provide persons with disabilities assistive devices to empower them to achieve the maximum individual growth and development and afford them the opportunity to participate in all aspects of life as they choose,
- Provide engineering students education and awareness on the special needs and challenges of persons with disabilities, and

- Provide undergraduate engineering students exposure to the biomedical field of engineering.

This quote from a student who participated in the program best sums up the expected benefit,

"As an undergraduate student in the college of engineering, this project personally affected my life in many ways. It not only challenged me to think creatively and to be able to come up with an original design, but it also allowed me to see at a young age how the work I do can better other lives. I am proud to have been a part of this project and to know that something that I helped design and build is allowing people from around the state of Wyoming to be educated about disabilities (Barnes, 2003)."

Resources

Resources on Disability:

The Family Village is a website maintained by the Waisman Center at the University of Wisconsin-Madison,
http://www.familyvillage.wisc.edu/index.htmlx
The Library section allows individuals to search for specific diagnoses or general information on numerous disabilities.

The ILRU (Independent Living Research Utilization) http://www.ilru.org/ilru.html program is a national center for information, training, research, and technical assistance in independent living. The directory link provides contact information for all Independent Living Centers in the country and US territories.

Resources on Assistive Technology:

The National Institute on Disability Rehabilitation and Research,
http://www.ed.gov/offices/OSERS/NIDRR/
funds the state Assistive Technology projects as well as Rehabilitation Engineering Research Centers (RERC). The state projects are excellent resources on a variety of AT issues and the RERC's conduct programs of advanced research of an engineering or technical nature in order to develop and test new engineering solutions to problems of disability. Information on these centers is available through the NIDRR website by searching their project directory for Rehabilitation Engineering Research Centers. These centers specialize in a variety of areas including mobility, communication, hearing, vision, spinal cord injury, recreation, prosthetics and orthotics, and wireless technologies to name just a few. These are excellent resources to learn more on state-of-the-art engineering projects to assist individuals with disabilities.

Another valuable source is the Rehabilitation Engineering and Assistive Technology Society of North America (RESNA) http://www.resna.org/. This is a transdisciplinary organization that promotes research, development, education, advocacy and the provision of technology for individuals with disabilities. In addition, by using the technical assistance project link on the home page, one can then locate all of the state assistive technology projects and obtain contact information for their particular state or territory.

For specific product information, http://www.assistivetech.net/ as well as http://www.abledata.com/Site_2/welcome.htm are excellent resources.

Resources on Universal Design:

The Center for Universal Design, North Carolina State University, http://www.design.ncsu.edu/cud.

The Trace Research and Development Center, University of Wisconsin-Madison, http://www.trace.wisc.edu.

The Center for Inclusive Design and Environmental Access (IDEA), University at Buffalo, New York, www.ap.buffalo.edu/idea.

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CHAPTER 6
ARIZONA STATE UNIVERSITY

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THE GRIPPING SYSTEM

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INTRODUCTION

The Gripping System for golf clubs provides a larger circumference at the golf club grip for people who are unable to tightly grasp the small, standard handle of a golf club. Because of an injury, the client is unable to tightly close the fingers of his right hand around objects that are small diameter. Therefore, the client cannot securely grasp a standard golf club. He needs a device that securely attaches to the butt end of a standard golf grip, providing a large diameter surface which would be easily gripped, and could be quickly removed and placed on any of his golf clubs.

SUMMARY OF IMPACT

The Gripping System is a single piece of specially shaped plastic that enlarges the circumference of golf clubs at the grip. The Gripping System attaches to any golf clubs having a standard circular grip. Changing the grip of the putter to a similar grip would enable him to use it while putting, too, although this may be unnecessary. The Gripping System is fast, convenient, secure and inexpensive. Also, the Gripping System allows the client to maintain a relatively natural golf swing. The placement of the hands on the club handle and the Gripping System remains consistent with the traditional golf gripping method, although its bulk requires a slight repositioning of the left hand (Figures 6.1, 6.2).

TECHNICAL DESCRIPTION

The Gripping System holds onto the golf club while the bulk of the device creates a larger handle for the client to grasp. The Gripping System is a C-shaped piece, machined from a block of Teflon (Figure 6.3). The Gripping System is made from a 2 inch x 3 inch x 2 inch block of Teflon. While many plastics would have worked, the Teflon met the requirements needed for strength, light weight, and the right balance of flexibility and stiffness.

Figure 6.1. The Gripping System.

The design of the Gripping System makes attachment and removal easy. The Teflon piece is milled out with a taper to match the existing taper found in the shafts and grips of standard golf clubs. The slot is sized to allow a golf club shaft to easily pass through it. The user simply puts the shaft through the slot, and then slides the piece up the handle until it jams securely at the top of the grip. To enhance gripping security, the outer portion of the Gripping System has grooves cut into it to match the grasp of the client's fingers. The grooves add comfort and confidence when grasping the club.

Figure 6.2. The Gripping System Attaches to a Standard Club while Maintaining a Typical Golf Grip.

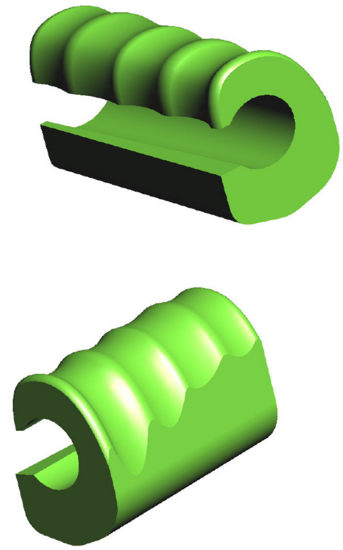

Figure 6.3. The Gripping System is a C-Shaped Piece Cut from a Block of Teflon.

The dimensions for the Gripping System were initially determined using a piece of clay. The clay was wrapped around a golf club, and the circumference of the clay mold was increased until the client could securely grasp the club. This mold was then used to design the Gripping System with the optimal dimensions. While this prototype was machined, it is likely that a production piece could be molded to reduce costs.

The cost of materials is $5. At a reduced rate of $10 per hour for labor, the final prototype device was manufactured in three hours for $30. At typical labor rates of $68 per hour, the total cost is estimated at $35.

SPLIT-HOOK PROSTHESIS FOR LOCAL PRODUCTION IN DEVELOPING NATIONS

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INTRODUCTION

The popular voluntary opening, split-hook terminal device provides amputees with a strong and versatile artificial hand. However, the high price of these devices makes them unattainable to many citizens in developing nations. Even if a modern aluminum split hook could be imported, specialized repair parts would inevitably be needed. Rural, remote environments pose particular problems for roller bearings, which wear quickly in the presence of sand and grit. Additionally, heli-arc or TIG welding facilities for repairing aluminum parts are scarce.

A possible solution is to carve functional split-hook prostheses out of native hardwoods. Inexpensive but high quality prostheses would enable the amputee population in developing countries to work and perform daily tasks. This project investigated the possibility of manufacturing a split-hook terminal device out of wood which would combine the beauty of wood with the functionality of aluminum. At issue were questions of strength, redesign necessary to support useful loads, and simplicity of production (without requiring expensive parts or complex machinery).

SUMMARY OF IMPACT

A prosthesis for poor citizens of developing nations must be inexpensive but durable enough to withstand heavy use in manual labor, both indoors and outdoors. The populations at risk for losing a limb are generally engaged in manual labor. In these difficult economic and labor conditions, the loss of a limb can mean a drastic decrease in one's ability to provide income through labor. A split-hook prosthesis improves the functionality of the amputated limb. The split-hook also provides a level of functionality that cannot be achieved with a simple hook by giving the user the ability to grasp objects between the hooks (Figure 6.4). The ability to grasp increases functionality and is important to perform useful work and the tasks of daily living. Taking advantage of local resources, such as the presence of both hardwoods and the local woodcarving labor force will allow the devices to be produced at affordable prices. It will also provide possible new markets for woodcarvers.

Figure 6.4. Split-Hook Prosthesis with Grasping Ability.

TECHNICAL DESCRIPTION

The basic mechanics of the wooden split-hook prosthesis are similar to those of modern, commercially available, voluntary-opening aluminum split-hook prosthesis. One hook attaches to a cuff on the amputated limb with a bolt. A second hook, which rests on top of and curves with the other hook, is attached to the first hook by a bearing. This allows the hooks to open and close, enabling the user to grasp objects similar as if between the hooked middle and forefingers. The hooks are closed, and held shut, by an elastic band wrapped around their shafts, near, but on the distal side of the bearing. In commercial split hooks, the hooks are opened by an actuating cable, which is attached to the upper, moving hook, and controlled by a shoulder harness. The wooden split hook is opened using the contralateral hand or an object such as the edge of a table surface.

The wooden split-hook incorporates design changes to optimize it for simplicity and wood construction (Figure 6.5). The hooks are broader than they are thick, and do not extend as far from their shafts as the hooks on a commercial metal prosthesis would. The shafts of the hooks are also much thicker than those on a metal split-hook. These two modifications are necessary to minimize the bending stresses placed upon the hooks while supporting a useful load, here defined as the weight of a five pound bucket. The shafts of the hooks are also much thicker than those on a metal split-hook. The bearing, which the hooks pivot on, is made of a simple brass tube, with its ends hammered and flared to hold it in place. Washers protect the wooden hooks from being worn by the rough edges of the axel and assist in keeping the movement of the bearing free.

The wooden split-hook is constructed of ebony wood. Ebony wood was chosen because it is both a material available to woodcarvers in many developing nations and was the densest, hardest wood available for purchase.

The cost of materials for this prototype is approximately $40. Most of this cost is incurred in purchasing the wood, which, as an exotic species, is expensive. The cost would be significantly lower for a tradesman in a country where ebony is a native wood.

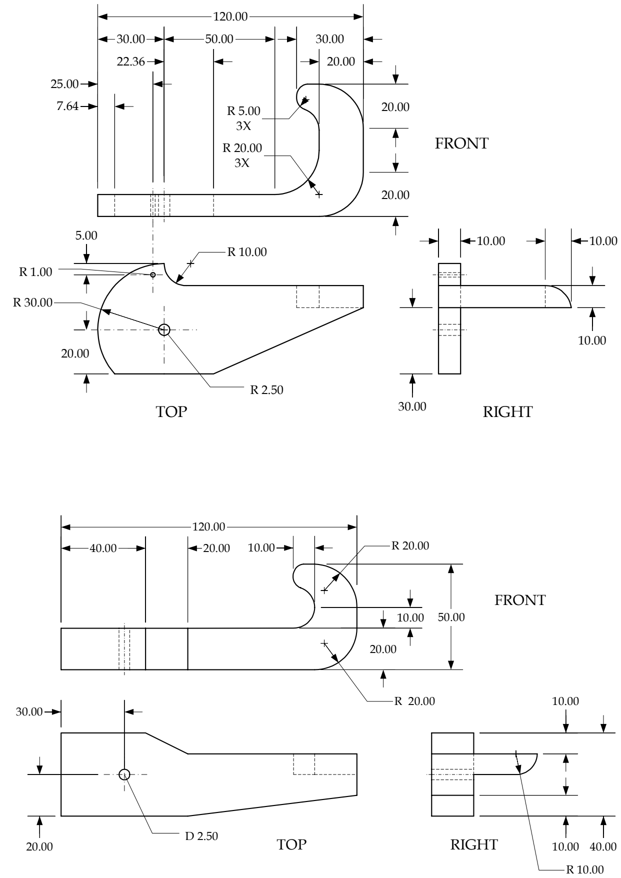

Figure 6.5. Wooden Split-Hook Design.

FISHING REEL ASSIST DEVICE

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INTRODUCTION

Persons with limited use of muscles in one hand and arm often find the sport of fishing difficult. These individuals typically use their stronger hand to hold the fishing rod, and their weaker hand to grasp and turn the reel handle. The client loves to fish in both fresh and saltwater, but has difficulty holding onto the handle of the reel and is unable to reel the line in quickly and powerfully enough to land a large fish.

The Fishing Reel Assist Device (FRAD) assists individuals who have trouble grasping and turning the handle of levelwind (revolving spool) fishing reels. The client's brain injury caused atrophy, weakening, and contractures of the right elbow, wrist, and fingers.The client cannot easily open the fingers, or grasp the reel handles. Currently, there are no devices that could enable a client to perform normal fishing motions and assist him while reeling in the fishing line. The specific need is to assist in grasping and releasing the handle. To fulfill this need, two devices were made. One device was for freshwater fishing reels and the other device was for saltwater fishing reels, which have different handle designs and functional requirements (Figure 6.6).

Figure 6.6. The Freshwater and Saltwater Fishing Reel Assist Devices.

SUMMARY OF IMPACT

The design criteria for the Fishing Reel Assist Device are defined by the client's physical capabilities. The FRAD is designed to be safe, versatile, and easy to use. Safety is a large concern, particularly while big-game fishing in saltwater. Therefore, both the freshwater FRAD and the saltwater FRAD devices can be quickly released even while under tension. Freshwater fishing reels have a variety of handle designs. Therefore, the freshwater FRAD includes an adjustable clamp, which allows the client to use a variety of freshwater fishing reels. The saltwater reel handles most often employ a T-shaped handle, and are built to crank against 50 to 80 pound line tensions with gear ratios of about three to five. These reels are very expensive, so the FRAD had to be built in such a way that it attached securely without damaging the reel handles. Because both versions of the FRAD are safe, versatile, and easy to use, the client can now safely enjoy a variety of recreational fishing activities.

TECHNICAL DESCRIPTION

The main components of the freshwater device consist of commercially available Pro Tec Wrist Braces ($14.99 US) interfaced to two aluminum plates. The aluminum pieces were anodized with a 0.001-inch hard black coating for corrosion resistance. While not absolutely required for freshwater use, anodizing the aluminum pieces improve the appearance greatly. One aluminum plate (1.4 by 6.9 by 1/8-inch) has a swiveling T-shaped latch and is mounted onto a wrist brace. The other aluminum plate (1.4 by 4.3 by 1/8-inch) has an adjustable clamp mounted onto it and a slot that allows for the T-shaped latch to securely fasten the two plates together. After the two aluminum plates are assembled and fastened together, the user can easily and securely grasp various fishing reel handles to reel in the fishing line.

To use the device, the client places the wrist brace on the right hand and attaches the aluminum plates with the clamp to the wrist brace. To reel in the line, the client presses the device onto the fishing reel handle (Figure 6.7) and uses his shoulder and elbow motion to reel the line in. The freshwater FRAD allows the user to cast a fishing rod with the stronger, more functional hand, and reel in the fishing line with the weaker hand.

The saltwater FRAD has a similar, but stronger design with modifications to grasp a T-handle (Figure 6.8). An aluminum plate (1.4 by 5 by 1/8-inch), with a hard black anodized coating, is mounted onto an arm brace. However, the saltwater device differs in that a milled aluminum part in the shape of a "c" or a claw (2.25 by 1.59 by 1/4-inch), with a 3/8-inch slit through the center, is mounted onto the aluminum plate. This device works similarly to the freshwater FRAD. However, instead of pressing the FRAD onto the reel handles, the saltwater FRAD easily *hooks* onto the saltwater fishing reel handles. The slit in the center of the claw is placed over the handle of the saltwater fishing pole, and with a slight twist of the user's arm, the claw grasps the handle. The saltwater FRAD allows the user to cast a fishing rod with the functional hand, and reel in the fishing line with the weaker grasping hand.

The total cost of the freshwater FRAD is $58.28, including the wrist brace and anodizing. The total cost of the saltwater FRAD is $61.98, including the wrist brace and anodizing.

Figure 6.7. The Freshwater FRAD Attached to a Fishing Reel Handle.

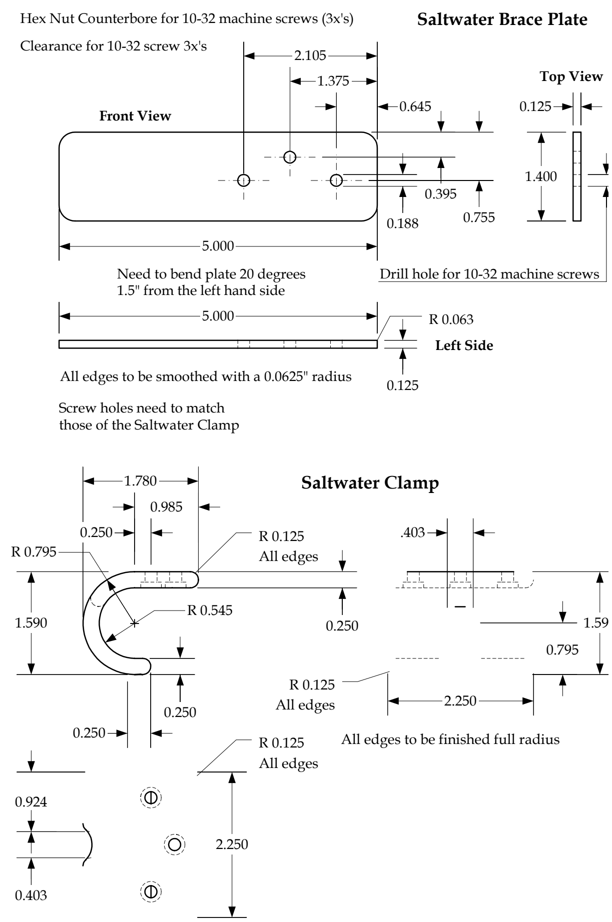

Figure 6.8. Design of the Saltwater FRAD, Including Brace Plate (top) and Clamp (bottom).

ROWING MACHINE FOR AN INDIVIDUAL WITH PARAPLEGIA

Designers: Erin M. Gaekel, Jessica W. McFarland, Melissa Shellabarger, and Chad Thompson
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INTRODUCTION

Individuals with paraplegia lack motor control and sensation in the lower extremities and are unable to provide the lower extremity force and motions (plantar/dorsiflexion, knee/hip extension, and knee/hip flexion) necessary to operate a traditional rowing machine. However, certain aspects of the rowing motion, namely the large hip and knee motions, might be beneficial to individuals with paraplegia who wish to mitigate the effects of lower extremity immobilization. Upper extremity exercise, besides providing upper extremity muscle toning and cardiovascular benefits, can be used to drive the lower extremities throughout their range of motion. Regular range of motion exercises are thought to decrease muscle spasticity and improve circulation in the paralyzed extremities.

The Paraplegic Rowing Machine (PRM) is designed and constructed as an exercise machine for individuals with paraplegia (Figure 6.9). The PRM uses the force produced by the user's arms to move the user's legs through a range of motion. The rowing machine is designed for a specific individual, but can be adjusted to accommodate different users.

SUMMARY OF IMPACT

Individuals with paraplegia must mobilize and bear weight on (or "load") their legs to prevent muscle atrophy and bone degeneration. Regular exercise also prevents declines in circulation and cardiovascular fitness. Traditionally, individuals with paraplegia load their legs by static standing with standing frames and help from others. Individuals with paraplegia also participate in exercise programs. Spasticity is another common problem that occurs after a spinal cord injury. An exercise machine that would allow a paralyzed individual to exercise independently would improve convenience, reduce costs, and increase independence.

Figure 6.9. Rowing Machine for an Individual with Paraplegia.

The Paraplegic Rowing Machine is designed to help provide independent and regular exercise for the client. Not only can individuals with paraplegia use the PRM independently, but the PRM also helps to improve circulation, upper body strength, and cardiovascular fitness.

TECHNICAL DESCRIPTION

The PRM coordinates the movements between the arms and the legs in an ergonomically proportional manner, thus allowing for a full arm motion without causing an over-extension in the legs. The PRM consists of two independent, rigid, steel frames. The seat is positioned on one frame and the feet slide on foot rests mounted to the other frame. A flywheel (with fan blades) and two springs provide resistance for the arms. The user transfers to the swivel seat, swivels, and locks the seat in the forward facing position. He then manually lifts one leg over the center bar of the main frame, places each foot on a footrest and straps the feet in place. The user then grasps the rowing handle and pulls it to drive the flywheel via the chain and sprocket mechanism. Another chain and gear system attaches the flywheel using two small pulleys. These pulleys rotate as the user pulls the handle, causing the footrests to move forward and backward. This motion flexes and extends the legs. Together, the PRM and user create a cyclic leg movement and a rowing motion is mimicked.

Material selection involves many important topics such as: cost, time, functionality, safety, and availability. The base of the rowing machine is constructed of steel. Plastic coated aircraft cables, bicycle gears, and a bicycle chain are used in the gear system. The footrests are constructed from Plexiglas. Guide blocks, slide rails, and steel connecting rods are used in one frame to allow the feet to slide. Also, the PRM design as built was limited by material and component availability. For example, spring loaded pulleys would have been ideal for the return mechanism, but were unavailable. Therefore, simple pulleys were used with extension springs.

The total cost of materials for the rowing machine was approximately $1283.

REHABILITATIVE DRINKING AIDS FOR PATIENTS WITH TRAUMATIC BRAIN INJURY

Designers: Aaron Ashby, Song Paek, and Abdullah Abshawalkeh
Client Coordinators: Barbara Brillhart, ASU Professor of Nursing Rehabilitation, ASU; Catherine Quiroz, OT, VA Tucson
Supervising Professors: Dr. Gary Yamaguchi and Dr. Vincent Pizziconi
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INTRODUCTION

Individuals with traumatic brain injuries (TBI) often need to relearn how to swallow when drinking from a cup. Some patients have difficulty holding a cup due to strength limitations and/or tremor, and need a straw. However, simply providing a straw does not solve the problem, as it often provides an uncontrolled, open passageway for fluids to be quickly aspirated if the user has not regained the proper muscular control to swallow liquids. Various exercises are used to train the tongue and muscles of the throat to prevent aspiration of liquids. A rehabilitative drinking cup that could control the flow of liquids to the throat was initially suggested as a means of assisting in this training. Requirements for such a device were to deliver a small, fixed amount of fluid at a time, with a mandatory rest (no suction) interval in between. Other requirements included adjustability (by the caregiver) of fluid amounts delivered, easy cleaning,

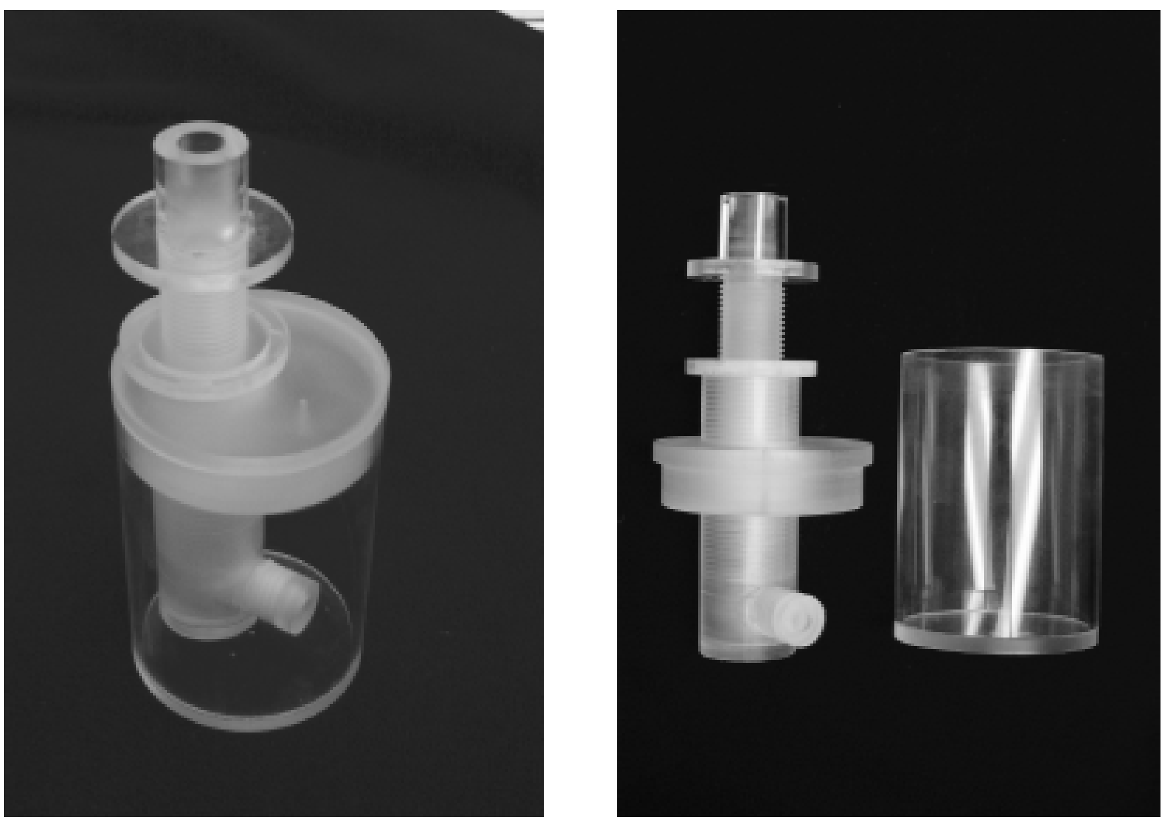

Figure 6.10. Rehabilitative Drinking Cup Prototype.

readily manufactured, and fail-safe.

SUMMARY OF IMPACT

The particular individual for whom this device was designed was an elderly stroke patient, who was in speech-language pathology and physical therapy to relearn the ability to swallow. Unfortunately, she suffered another stroke midway through the year, and did not survive. We believe that the drinking cups would have been of great assistance to her, and continued the projects in the belief that they would help others in a similar predicament.

TECHNICAL DESCRIPTION

All three devices (Figures 6.10, 6.11 and 6.12) incorporate a lid, a straw and double checkvalve, and a cup to accomplish the task of holding a liquid and metering its flow. The basic components of these devices are the straw and double ball/checkvalve arrangements, which utilize some form of modification from an earlier device by Toth and Yamaguchi (NSF 1999 Engineering Senior Design Projects to Aid Persons with Disabilities, pp. 36-37). One checkvalve is used to prevent fluid within the straw from flowing backward (back into the cup). This is necessary to prevent frustration, as the user might have exerted a great deal of effort to fill the straw with fluid in the first place, only to gain a single sip. With the first checkvalve in place, the straw need be filled only once. The second checkvalve closes after the measured amount of fluid is delivered, and maintains its closed state until suction from the mouth is completely released. This is necessary to allow the user time to swallow the measured amount of fluid, and importantly prevents the user from potentially aspirating the entire cupful of liquid. As in the earlier device, the second checkvalve is most commonly made using a freely moving ball and seal. If the ball is only slightly denser than the fluid, it will move upward

Figure 6.11. Rehabilitative Drinking Cup.

with the fluid during fluid delivery, block the flow when the measured amount of fluid is delivered, and sink downward within the straw when suction is released. As it sinks, the ball releases its block on fluid motion, and resets itself in the time it takes to sink to the level of the first checkvalve. Polypropylene balls were found to be good for this purpose, and allowed the user to take another sip after an interval of about 10 seconds.

The cost of materials for the drinking cups was nominal. Each of them was constructed using plastics for material costs of approximately $30 each. The most expensive was $31.10, primarily because the cup was large and required a large block of acrylic to be purchased.

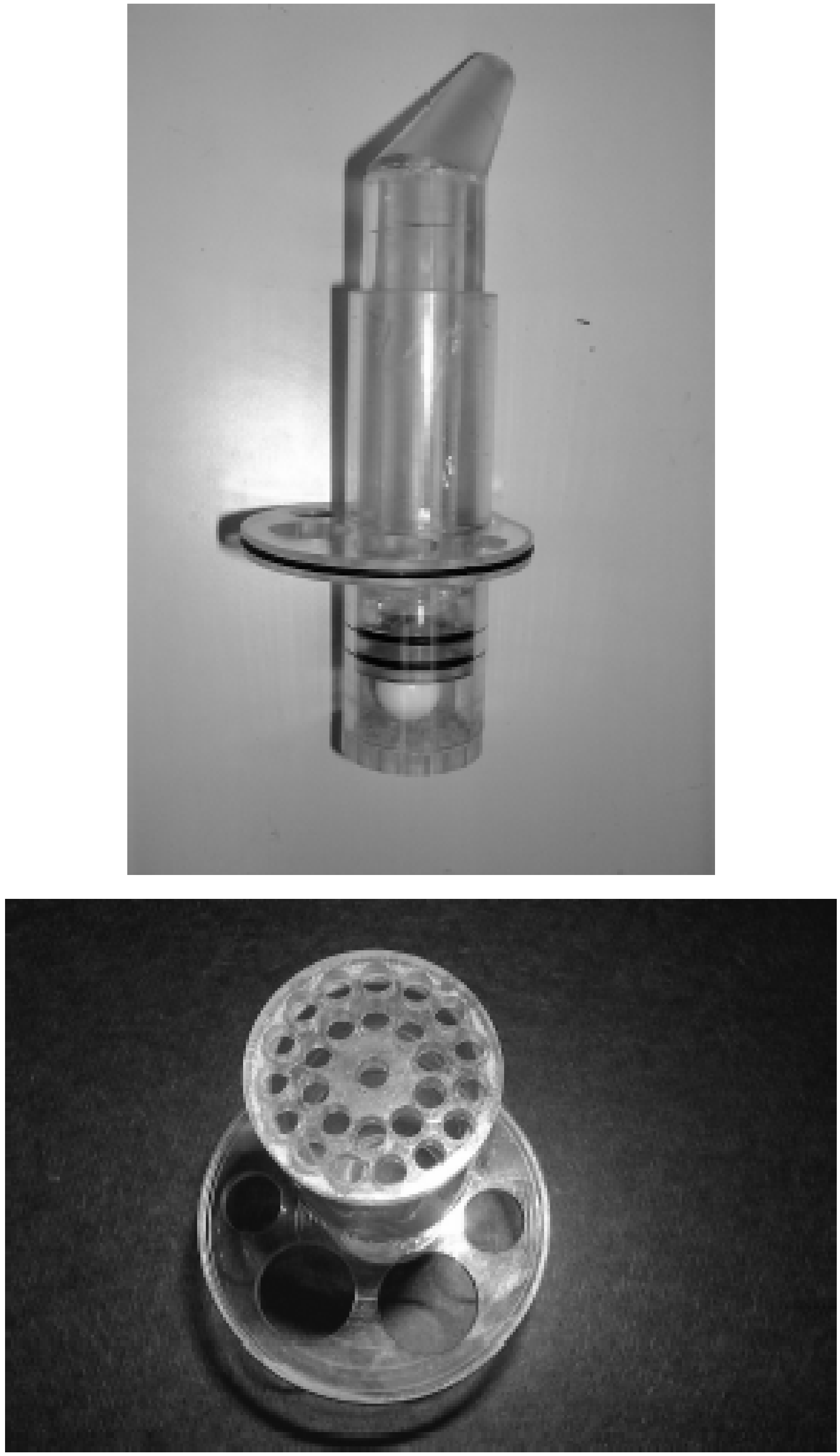

Figure 6.12. Working Portion of the Rehabilitative Drinking Cup.

CHAPTER 7
DUKE UNIVERSITY

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CUSTOM WALKER WITH ROTATIONAL HIP SUPPORT

Designers: Clark O'Niell, Graeme Waitzkin
Client Coordinator: Eliza Bankert
Supervising Professor: Larry Bohs
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INTRODUCTION

The client was a young child with athetoid cerebral palsy who used a walker for ambulation. She had outgrown her walker, and no commercial walkers fit her specialized needs. The goal of our project was to provide a custom walker that the client could use for both gait training and quotidian ambulation. We developed a custom walker with a rotational hip support, sling seat, and armrests that could accommodate her narrow shoulders. The walker facilitated increased mobility and independence.

SUMMARY OF IMPACT

The custom walker has been well accepted by the client. The large tires allow her to traverse terrains that she was unable to navigate before, thus enabling her to attend activities such as a sibling's soccer game. The rotational hip support, suggested by her therapist, appears to improve her gait while walking. The client's mother commented, "[She] has never had a walker that suits her like this one… Do you know what it means to go where you want to instead of where your mother chooses to push you in your chair?"

TECHNICAL DESCRIPTION

Fig. 7.1 shows the custom walker. The walker is based on an adapted commercial frame, Busy Bee (Ottobock), which has been tested for safety and reliability. Custom armrests, a sling seat, and rotational hip support are added to a steel top bar that attaches to the commercial frame. The armrests are adjusted to a relatively narrow lateral position to accommodate the client's torso. The hip support is mounted on the rear of the top bar. For structural testing, the total dead load was assumed to be 60 pounds which is the estimated maximum weight of the client. Modeling indicated that at this load the steel would not yield, and the deformations would be infinitesimally small.

Figure 7.1. Custom Walker with Rotational Hip Support.

The hip support, which is constructed from the hip belt of a backpacking frame pack, opens in the front and is closed with a plastic clip. A heat-molded polyethylene panel inside the belt provides rigidity and flexibility. The belt attaches to a slotted back plate (see Fig. 7.2) to allow vertical adjustment. The rear end of the back plate has a threaded coupling that attaches to a boat rail antenna mount, which provides simple rotational adjustment using a single knob. The antenna mount can be adjusted horizontally on the top bar to re-center the client after the hip rotation angle is changed. The walker also has an easily removable sling seat, which is shown in Fig. 7.3.

Custom armrests are constructed from bicycle handgrips, metal, foam, molded polyethylene and neoprene because the armrests on the original frame were too large. The couplings that attach the arm support to the frame clamp to the top bar, so they can be adjusted in angular and fore-aft position.

The cost of parts for the custom walker was $335, not including the Busy Bee frame.

Figure 7.3 Custom Walker in Use.

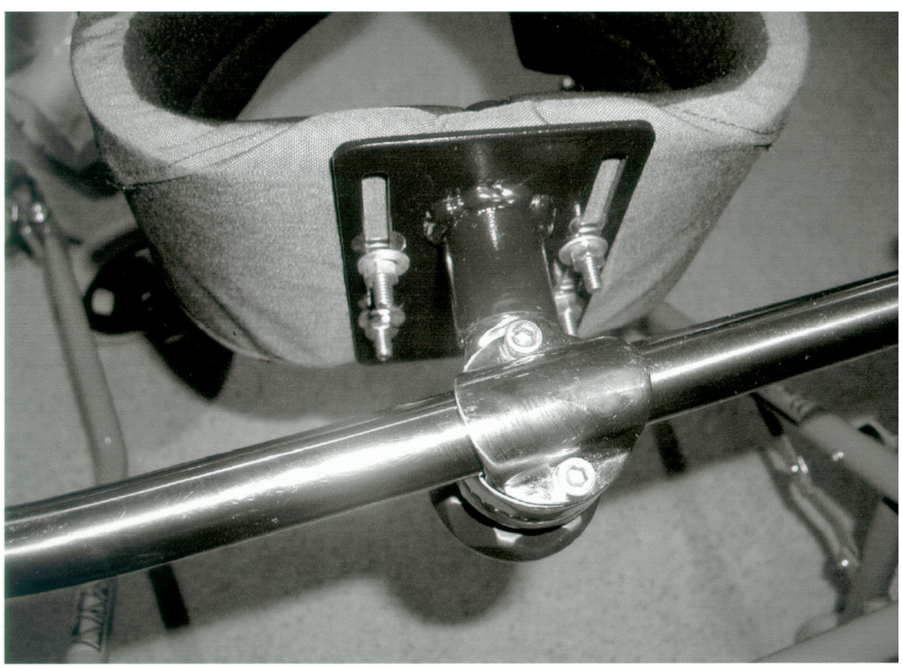

Figure 7.2. Slotted Back Plate and Rotational Hip Support.

COUNTER FOR INDIVIDUALS WITH VISUAL AND MOBILITY IMPAIRMENTS

Designers: Larry Sandell, Erin Sparnon
Client Coordinators: Antonia Pedroza, Judy Stroupe
Supervising Professor: Larry Bohs
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INTRODUCTION

A local non-profit corporation employs adults with cognitive and physical disabilities to perform tasks such as counting objects for shipping and assembly. The current counting aid is too small to be operated easily or independently by many employees. The goal of this project was to provide five digital counting aids that would be easy to increment, read, and reset. Specific objectives were to build discrete, durable, portable, safe, and rechargeable counting devices. A counting unit was designed that included a large LED display for the count, a large ergonomic button to increment the count, an input jack for external switches, and a small enclosure. The design also supported a rechargeable battery source. Five units were assembled and delivered to the client.

SUMMARY OF IMPACT

The counters have increased the number of employees able to perform tasks and increased the productivity of some employees. Employees with poor vision and limited manual strength and dexterity can use the counting aids because they are easy to read and increment. Because the devices can be reset independently, employees do not need to wait for a work coach to reset their counting aids before starting the next task. This enables employees to perform more counting tasks per work day. A client coordinator remarked, "The students seemed determined to make the products as user-friendly as possible. I was very impressed with the durability and weight of the [counters] because it was something I asked for specifically".

TECHNICAL DESCRIPTION

A photograph of a counter is shown in Fig. 7.4. Commercially available enclosures were utilized for the counters to save machine and assembly time. The enclosure is made of aluminum with an angled

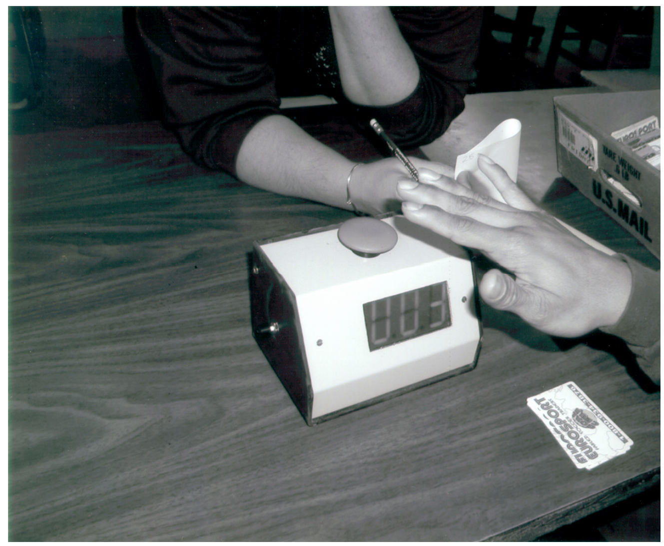

Figure 7.4 The Counter in Use.

display face. Five enclosures were machined and each can accommodate buttons, switches, jacks and the LED display. The edges of the enclosures are filed to remove sharp edges, the exteriors are coated with protective Plasti-Dip, and rubber feet have been added to increase traction and durability.

The LED display, which consists of three 1.5 inch digits, rests on the 60-degree sloped panel of the counter housing. The red increment button is mounted in the middle of the top of the device, and the two black reset buttons protrude from the middle of each side. The increment button can be actuated with very little force applied at many angles, and has a long mechanical life (five million cycles). The reset buttons also require little force to actuate, but must be held on for about three seconds to prevent accidental resetting.

The back of the device contains an on-off switch, an external input jack and a battery recharger jack. The on-off switch is a two inch tall rocker switch, and the external input jack is a small metal jack that accepts one-eighth inch male plugs. This jack allows any desired switch to be used to increment the counter. The LED display is protected from the exterior by Lucite and backed by a nylon panel. This panel is secured by bolts connecting to the enclosure on both sides of the LED display, and supports the circuit board via standoffs. The battery pack is also well secured, immobilized by nylon ties bolted to the enclosure's base.

The electronic circuitry (see Fig. 7.5) is based on a counter chip (MM74C925) that receives input from the increment and reset buttons and displays the current count by driving an LED display that is quickly lit digit-by-digit to save power consumption. A seven-segment display with one and one-half inch digits, which uses low-power LEDs to backlight each segment, provides a large display while saving battery life. The common anode LED display interfaces to the counter chip, a common cathode display, by inverting the driver output with NPN transistors. The input increment signal is debounced using an RC circuit and Schmitt trigger. A high-capacity NiMH battery pack and charger from Radio Shack powers the counter. In empirical tests, the counter ran for an average of 54 hours per charge, indicating that it will need recharging only once each work week.

The cost of parts for each of the five counters was approximately $105.

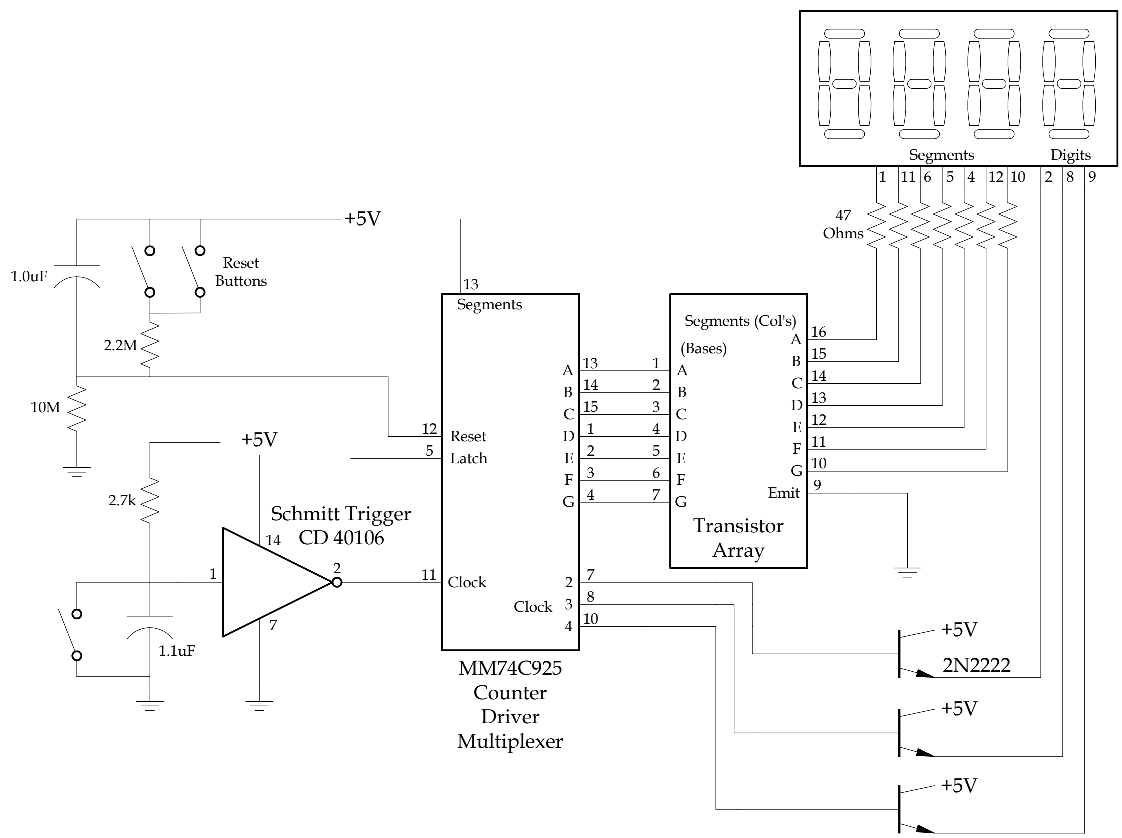

Figure 7.5. Counter Schematic.

DRESSING SUPPORT SYSTEM

Designers: Sarah Park, Ronald Lee
Client Coordinators: Amy Loesch, Kristi Duke
Supervising Professor: Larry Bohs
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INTRODUCTION

The client, a 9-year-old girl with spastic diplegic cerebral palsy, had difficulty putting on pants, shoes, and socks without outside help. We designed a device to increase her independence while dressing.

SUMMARY OF IMPACT

The device enables the client to dress faster and with less effort. This increases her self-esteem and independence. After five months of use, the client's father said: "The dressing chair… has worked out very well. It's well designed, it looks nice, and she uses it every morning. It helps her to be independent, and that makes our lives easier, too".

TECHNICAL DESCRIPTION

Fig. 7.6 shows the client using the device, which consists of a chair, parallel bars, a shoe/clothes rack, and a platform. Additional features include a shoehorn, no-slip foam covers on the bars, a cushioned backrest, and height-adjustability for both the chair and parallel bars.

A kneeling chair is used as the main structure because it is height-adjustable and has a natural forward and downward incline. The downward incline of the seat helps the client maintain her balance by shifting her center of gravity forward.

The steel parallel bar structure is designed for simplicity, safety, and height adjustability. A plywood platform with dimensions 42 inches by 39 inches by ¾ inch is used as the base for the design to prevent tipping. The edges of the platform are beveled at 45 degrees to prevent tripping. A one and one-half inch trapezoidal wooden step is included below the chair to also prevent tripping. The height of the parallel bars adjusts using ball detents on the inner tubes and a series of holes in the outer tubes.

Figure 7.6. Client Using the Dressing Device.

The parallel bars are connected to the chair at its front leg with 90-degree elbow joints, forming a single stable unit. In addition, a crossbar is connected between the rear vertical members of the parallel bar structure to minimize shearing motion and increase stability. The bottom, horizontal members of the parallel bar structure are bolted to the plywood base.

A shoe/clothes rack attaches to the side of the bar structure. A shoehorn attaches to the structure with a Velcro, as shown on the left vertical bar in Fig. 7.7. The structure includes a padded back support, which was an important safety feature included through discussions with the coordinator. Black, non-slip foam attached to both side bars provides additional comfort and grip.

The cost of parts for the project was approximately $300.

Figure 7.7. Dressing Support System.

RETRACTABLE HEAD POINTER

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Supervising Professors: Richard Goldberg, Kevin Caves
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INTRODUCTION

This client has cerebral palsy, no use of his right arm, and only limited use of his left arm. His job involves moving, sorting, and otherwise manipulating small, light objects such as sheets of paper, plastic tags, and pens. Currently, this is accomplished with his left arm and considerable difficulty. Because he has good head control, a cap-mounted pointer was designed to assist him in performing his job. In contrast to most commercial products, this device uses a small and relatively unobtrusive mounting system. An electric motor, mounted to the client's wheelchair, extends and retracts the pointer. The user controls the telescoping pointer using a single lever switch.

SUMMARY OF IMPACT

After two months of use one of the client's supervisors remarks, "The head pointer allows an individual who is really interested in working do more jobs. The head pointer allows this person to work with paper, something he was not able to do before without destroying the paper." His other supervisor comments, "The head pointer has enabled a gentleman to perform his work independently and the smile on his face says it all."

TECHNICAL DESCRIPTION

The Retractable Head Pointer, shown in Fig. 7.8, uses a commercial automotive power antenna for both the motor and the pointer. The motor uses 12V power from the client's wheelchair battery. To allow for a full range of relative motion, a length of vinyl tubing is inserted between the motor and the antenna, housing the motor-to-antenna controlling cable. The tubing is attached with compression fittings to the motor on one end and to the antenna on the other end. This allows the tubing to be removed and replaced easily.

The original motor control circuitry is removed, leaving only a DC motor whose direction of rotation

Figure 7.8. Retractable Head Pointer, Motor and Control Box with Switch.

is easily controlled. This control is accomplished by varying the polarity of the voltages of the power leads using a SPDT switch with a long lever. The circuit uses two DPST relays to isolate the switch itself from the motor current, which can reach 1.5A. A 2A fuse between the control circuit and the battery provides short circuit protection.

Fig. 7.9 shows the pointer mounted to a user and the wheelchair. Two modified binder clips attach the pointer to the client's hat. The clip attached to the bill of the cap uses a piece of heat-shrink tubing, while the clip at the back of the hat holds an eye bolt that extends slightly outward. The positioning of the attachment points provides optimal position of the pointer relative to the head. Padding at the rear attachment point maximizes comfort. A spring mechanism connects the motor to the wheelchair to improve range of motion (see Fig. 7.8).

Electrical connectors attach at three points: the battery, the control box, and the motor. To ensure that no chance for confusion exists, each point uses a different type of plug and jack; interlocks within the connectors prevent misconnection. The battery cable connects to the main cable via an axial two-lead jack. The main cable plugs into the control box with a six-lead plug. Finally, the control cable connects to the motor with a four-lead plug. All connectors are easy-off, protecting the components from accidental jerks.

The pointer tip consists of a piece of soft rubber cut in a cross shape and wrapped around the end of the antenna. The rubber is held in place with a cable tie. This design provides excellent friction for moving sheets of paper and for other manipulation, and is very inexpensive and easy to replace.

The cost of parts for the project was $120.

Figure 7.9. Retractable Head Pointer in Use.

TASK CUEING TIMER

Designers: Jeff Heyman, Dave Alspector
Client Coordinators: Greg Beck, Jennifer Bell, Gina Chapman
Supervising Professor: Larry Bohs
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INTRODUCTION

A man with autism relied on supervisors to enforce task durations and schedule. A device was designed to limit this supervision. The Task Cueing Timer (TCT) uses visual, auditory, and tactile stimuli to cue him to start and stop a task. A progression of colored, blinking lights helps him to anticipate the end of his activities. Start, Finish, and Reward windows provide additional visual cueing. An audible buzzer and vibrating wristband also help to signal the end of a task. It is hoped that the TCT will help the client better understand his task beginnings, their completions, and his next activity, and thereby give him more independence in his daily routine.

SUMMARY OF IMPACT

In addition to his autism, the client also is affected by deafness and visual impairments, seeing primarily with his left eye. This combination of disabilities makes the goal of improving his independence a challenge. The TCT was designed with careful input from the client's three therapists, as well as his mother, to provide signals and stimuli that would most attract and interest him. After five months of use, the client's supervisor commented: "It has been going well. I would consider us very much still in the teaching phase of its use. (The client) loves the lights and will attend to it for a certain period of time, but not always the time set. He sometimes puts his head down while it is on, and misses some of the lights moving along towards 'finished'… The vibration device has come in handy. He will look up when the device starts to vibrate, whereupon we show him the 'break is finished' or whatever the next card happens to be and he then begins to process the transition. So as of yet he does not understand that when the timer goes off, he should transition, but with the continued pairing, I think the association could be made. The teaching process is a long one, but advantages have been noticed.

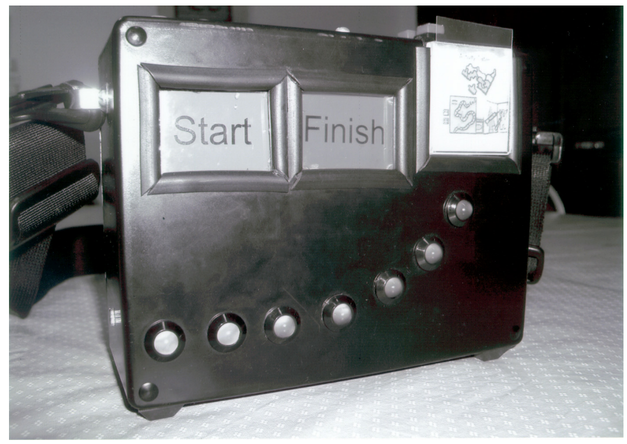

Figure 7.10. Task Cueing Timer.

TECHNICAL DESCRIPTION

The TCT consists of two main parts. The first part is the user interface, mounted on the top of the enclosure, which allows the supervisor to set the time duration and cueing mechanisms of the TCT. The second part includes the visual stimuli of the front display and the additional audible and tactile cues.

The user interface comprises an LCD display, three cue toggle switches, four momentary pushbuttons for setting the time duration, and a power switch. The four-digit LCD display can be set in increments of one or five minutes using two of the pushbuttons. The other two buttons are for "start/stop" and "reset". The cue switches toggle to select any combination of visual, audible, or tactile stimuli. Timer accuracy was tested and confirmed to be accurate to within one second for periods up to 60 minutes.

The front of the TCT is shown in Fig. 7.10. The visual stimuli include a string of large LEDs that slowly approach the "reward window", changing from green to red as time progresses. At the start, the first green LED on the left blinks for a period of time, then stays on. Then the next green LED blinks and stays on, and so on. At task completion, an illuminated slide in the reward window (upper right) cues the client to his next activity. The client is familiar with these slides, and thus the design allows easy incorporation into his routines. Illuminated start and finish windows reinforce the beginning and ending of the time durations. If the audible cue is selected, a buzzer sounds to signal the completion of a task. If the tactile cue is selected, a vibrating wristband activates upon task completion.

Fig. 7.11 shows the electrical schematic for the hardware involved in cueing. The PIC 16F84 processor controls all cues through its output ports. The signals are either fed through 555 timer circuitry, or through an inverter to drive blinking or continuous activation, respectively. Complete connections are shown for the first 555 timer, enclosed with a dashed box. All pins found on the left side of PIC16F84 are shared by a second PIC processor, which controls a Maxim LCD driver, and a Varitronix four-digit LCD display, as shown in Fig. 7.12. An adjustable stand allows the TCT to be positioned at an appropriate viewing angle, either on a table top or over the back of a chair, and a carrying strap provides portability. Rechargeable NiMH batteries provide long battery life and low maintenance. Battery life testing confirmed at least eight hours of use before recharging. The batteries are charged via an external charger, which plugs into the TCT when it is not being used.

The cost of parts for the project was approximately $220.

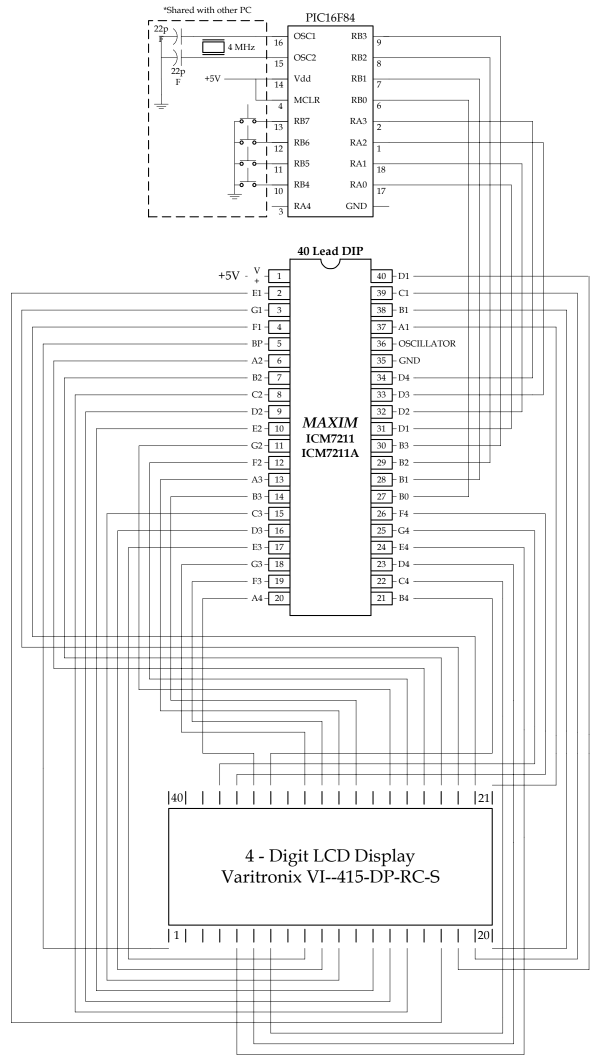

Figure 7.11. Schematic of the Cueing Hardware.

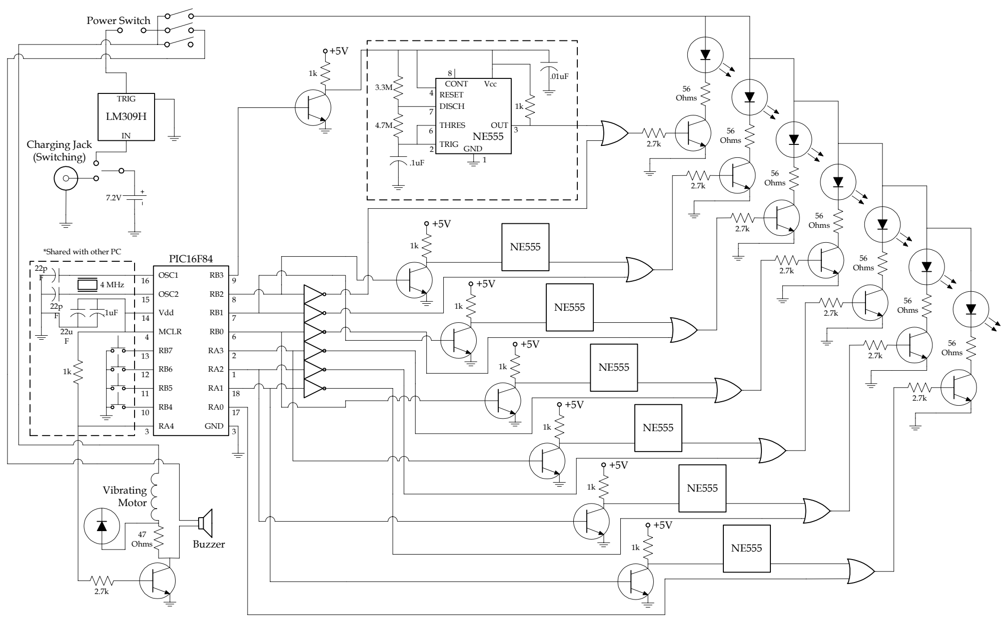

Figure 7.12. Schematic of the LCD Display Hardware.

AUDIBLE COUNTER

Designers: Luke Palmer, Jeffrey Earhart
Client Coordinators: Antonia Pedroza, Judy Stroupe
Supervising Professor: Larry Bohs
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INTRODUCTION

An agency provides employment to people with a variety of disabilities, including cerebral palsy, mental retardation, and visual and mobility impairments. The employees are paid to complete basic tasks that often involve counting an assigned number of objects for placement in supply kits or papers for work packets. The counters used currently are small and difficult to increment and reset; therefore, they are not suitable for many employees. The goal of this project was to design a counter that could receive input from a variety of external switching devices and output the count with both a large visual display and spoken numbers. Specific objectives included: usable by employees with a variety of disabilities, adaptable to needs of new employees, easy to use, portable, unobtrusive, rechargeable, and able to accept a wide range of input devices. A base unit was designed with multiple input ports to which either a commercial switch or two custom-designed motion-sensing switches could be connected. Audio and visual outputs of the count are available, and the design allowed for simple addition of other input devices

SUMMARY OF IMPACT

Workers at the agency are paid by the amount of work they accomplish, rather than the amount of time they are on the job. Employees often say that they do not earn as much money as they would like. The audible counter allows some employees to perform jobs not previously possible, and helps others improve their efficiency, allowing them to earn more money. After two months of use, the assistant director, commented, "The audible counter was brilliant and the students exceeded my expectations for that counter. The consumers enjoy the continuous feedback it provides and it therefore works as an incentive to stay on task for longer periods of time". A supervisor added "The audible counter has allowed several of our employees to become independent in work in which they previously depended on their supervisor. "

TECHNICAL DESCRIPTION

The audible counter, shown in Fig. 7.13, consists of the counter unit, three interchangeable inputs (a foot pedal, an ultrasonic motion sensor, and a passive infrared sensor), and a Plexiglas storage container that doubles as a stand for the counter unit.

The device is powered by six internal AA NiMH batteries, which require a specialized charging circuit that monitors both the voltage and temperature of the batteries during each charge cycle. These batteries will power the device for approximately one work week under moderate use and can be recharged in two to three hours. A high-efficiency switching regulator delivers power to the audio amplifier and also the PIC microcontroller, which controls the overall system.

The foot-pedal, visible at the bottom of Fig. 7.13, is made of a metallic case with a textured, rubber top. This commercial pedal is normally used with an electronic keyboard, and it connects to the counter unit with a ¼ inch plug. The custom-built ultrasound motion sensor (stored in the container at the top left of Fig. 7.13) is a black rectangular box with two metallic cylinders coming out of the front. One is the transmitter and the other is the receiver. Passing a hand or other object in front of these transducers triggers an increment signal. This device terminates in a four-pin plug. The passive infrared device (stored in the upper right of Fig. 7.13) is a small black box with a plastic dome centered on the top face. Passing a hand in front of this device also increments the count; it uses the same connector as the ultrasound sensor.

A double-sided printed circuit board, fabricated using iron-on methods, contains the electronic circuit. This board minimizes total size, provides good product durability, and accommodates the two surface mount IC's used in the device.

The front of the device (Fig. 7.13) contains two LCD displays. The smaller display, showing "07", indicates the goal count for a worker to reach before starting a new batch. This display, 1.5 inches tall, helps those employees who do not understand the concept of numbers to detect their completion of a task by matching the current count display to the static goal display. The larger display ("03") is the current count, displayed in large four inch LCD's. Beneath the smaller display is the speaker, which voices the current count upon each increment.

The audio output uses an ISD voice record/playback chip with on-board memory, in which computer-generated sampled numbers are stored. A differential audio amplifier, chosen due to its efficiency and high output power for low supply voltages, drives the speaker. The audible counter also has a volume control and an automatically switching headphone output.

The cost of parts for the audible counter was $193.

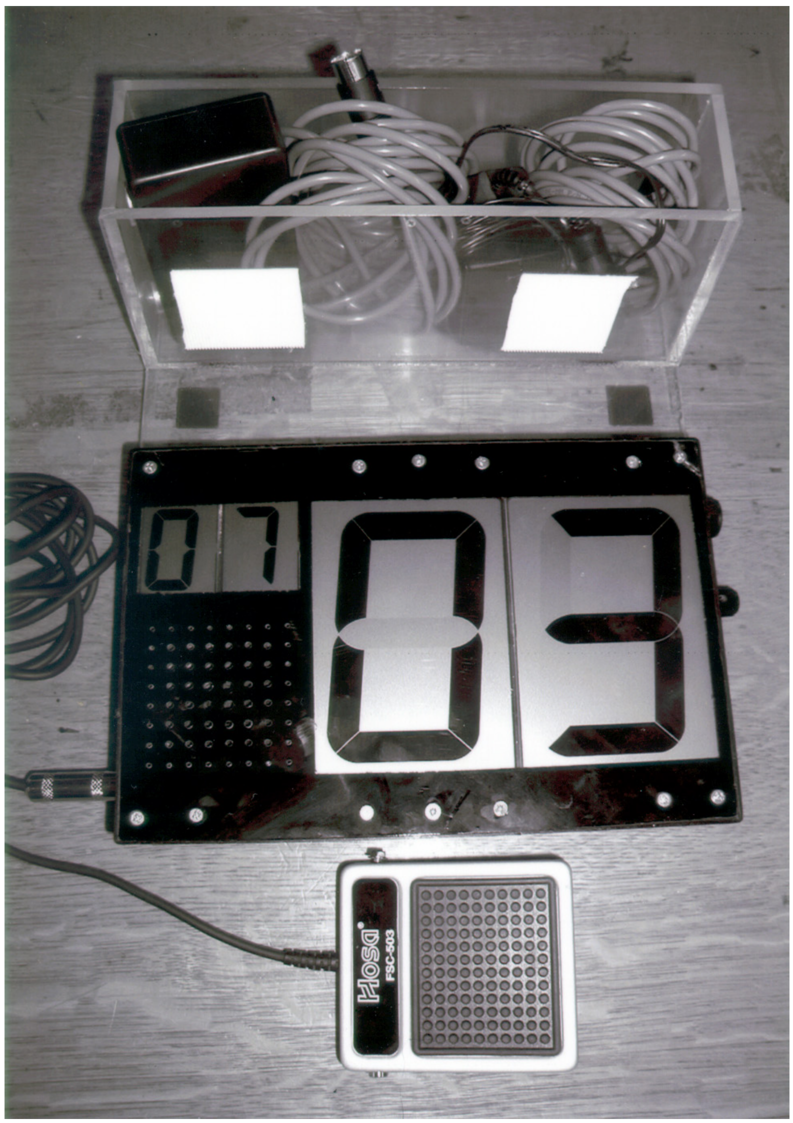

Figure 7.13. The Audible Counter.

STRETCH AND EXERCISE STATION

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Supervising Professor: Larry Bohs
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INTRODUCTION

A client, a nine-year old girl, has a form of cerebral palsy that affects only her legs and causes spasms and stiffness. The goal of this project was to provide her with a stretching and exercise machine that would improve her strength and flexibility and aid in her self-sufficiency. This was accomplished by modifying an existing weight bench to meet our client's specific needs. The completed station provides four exercises and can be used daily with only minimal assistance from an adult caregiver. Two passive stretches are supported, a hamstring stretch and an abductor stretch, as well as two active exercises, a quadriceps extension and a hip raise.

SUMMARY OF IMPACT

The client's cerebral palsy causes both of her legs to spasm and stiffen. Physical therapy focusing on leg stretches and exercises is the current intervention employed. Our client's physical therapist makes weekly visits to assist with stretches and exercises; however, these activities now can now be performed daily. The client's physical therapist says that, "The stretching and exercise station has allowed [the client] to be an active participant in her therapy. She is able to invent her own exercises and enjoys being somewhat in charge of her stretching activities." She also states that the device helps "improve the client's level of independence and cooperation in that part of treatment which is not always fun."

TECHNICAL DESCRIPTION

Fig. 7.14 shows the completed design, which involves modifying a commercial weight bench. The factory lat tower is modified to provide a hamstring stretch by changing the angle of the tower and adding a ratcheted leg lifting mechanism. A pulley system provides a 2:1 mechanical advantage and allows the client to easily raise her leg to a secure position. Safety bars on both sides of the bench seat, coated with rubber, allow the client to traverse the length of the bench without involving her legs. The bars also act as handholds during exercise and help with mounting and dismounting from the bench seat.

An abductor wedge was designed for placement between our client's legs during the abductor stretch. This wedge positions her legs at an appropriate angle for maximizing the benefits of the stretch. A bracket was placed on the bottom of the wedge so that it can be mounted on the vertical lat tower bar and act as a cushion to prevent the client from accidentally bumping her head on the bar during other exercises (see Fig. 7.14).

The original arm curl support was modified to serve as an incentive tray. The incentive tray holds any item with the use of industrial Velcro and guide pins. Fig. 7.15 shows the client doing an abductor stretch with a keyboard attached.

The leg exercise L-bar, which is used for the quadriceps extension and hip raise, was modified with additional position holes. These holes allow the foam support pad bars to be placed in multiple configurations allowing the device to grow as our client grows. A quick release pin was also added so the L-bar can easily be removed when not in use. Finally, a wheel is added at the base of the lat tower so the bench can be moved easily, and industrial felt pads are placed on the bench feet to protect floor surfaces.

The cost of parts for the project was approximately $400.

Figure 7.14. Exercise and Stretching Device Station.

Figure 7.15. A Client Preparing for an Abductor Stretch.

ASSISTIVE WORK CHAIR

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Supervising Professors: Kevin Caves, Richard Goldberg
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INTRODUCTION

A client with autism is employed in an office setting where she sits in a standard office chair. The seat is too high for her because she is less than three feet tall. She currently clambers into the seat, but this is inconvenient and potentially dangerous. A device was built that consists of a set of steps that extend and retract from a base under the chair. This allows the client to step safely and comfortably into her seat. Retraction of the steps is necessary for aesthetics, unobtrusiveness, and safety in a crowded environment. The device couples the extension and retraction of the steps to the rotational swivel of the chair and does not require electrical power.

SUMMARY OF IMPACT

The assistive work chair has provided a safe and simple method for the client to sit in her chair. One of the client's supervisor's says, "The work chair has made [the client] much more comfortable in her work environment and her production has increased." Another supervisor added, "The chair is a dream come true, it is the chair we have been wishing for since the consumer started working (here)... The consumer can now rest her feet and work more comfortably."

TECHNICAL DESCRIPTION

The assistive work chair is a standard office chair with a mechanically retractable step. Fig. 7.16 shows the work chair with the steps extended. The rotation of the seat is coupled with the retraction or extension of the steps. In its default position, the steps are retracted into the base under the chair.

Figure 7.16. Assistive Work Chair.

When the seat is rotated 90 degrees (as in Fig. 7.16), the seat locks into position and the steps extend outward, allowing the user to mount or dismount.

The steps are made of ¾ inch solid red oak, which provides a good combination of strength and weight efficiency. The steps weigh approximately 11 pounds. The base is made of plywood because it does not need to withstand any direct stress. The steps are connected to the base via 24 inch drawer slides rated for loads of 100 pounds. The drawer slides have friction-reducing ball bearings that enable the steps to slide in and out under their own weight when tilted. The slides' sole connection to the base is by a pivot rod, allowing them to tilt freely up and down about the pivot. The default position of the slides is back-end tilted down as shown in Fig. 7.17a. This tilt is maintained by a spring of sufficient strength to pull down the back ends of the slides. When the drawer slides are tilted at this angle, gravity retracts the steps down into the base.

When the user wants to extend the steps, the seat is swiveled until it is aligned with the steps as in Fig. 7.16. A torque arm rotates with the seat, which pulls up on the back end of the drawer slides via a rope and pulley. This rope overcomes the counteracting spring force and reverses the tilt of the slides as shown in Fig. 7.17b. Gravity then extends the steps out of the base, allowing the user to step onto or off the chair. The seat is lightly locked into this position by a cabinet door latch (not pictured) whose spring-loaded jaws clamp onto the torque rod. This lock prevents the chair from swiveling while the user is mounting or dismounting.

When the steps are no longer needed, the seat is jogged out of its lock and rotated to its original position. This slacks the rope holding up the drawer slides. The spring is strong enough to force the drawer slides to tilt down again, enabling gravity to retract the steps back into the base.

The cost of parts for the device was $108.

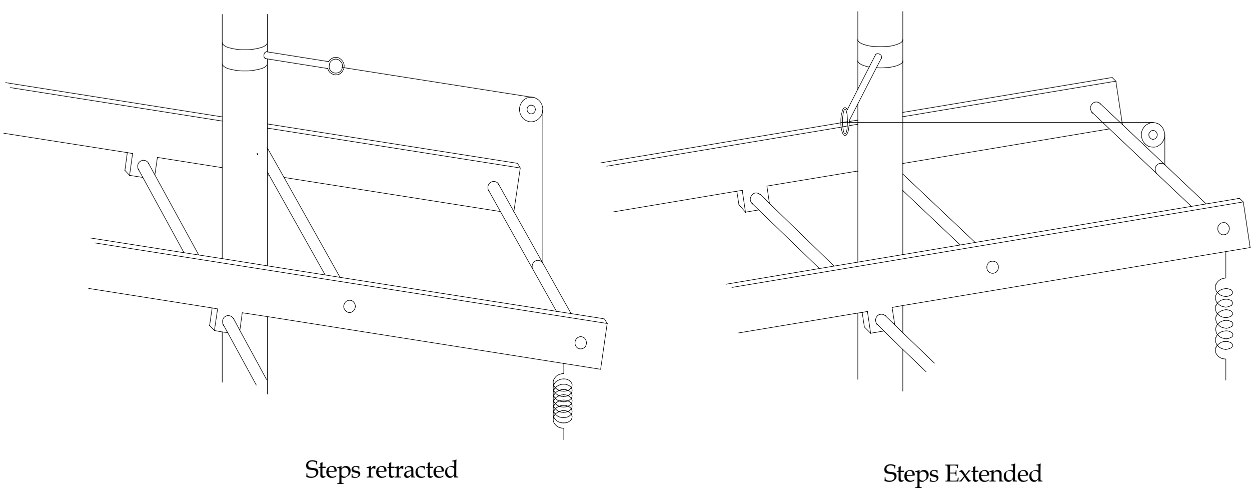

Figure 7.17. Step Control Mechanism.

CHAPTER 8
MICHIGAN TECHNOLOGICAL UNIVERSITY

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INTERACTIVE AQUARIUM

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Supervising Professor: Dr. Debra Wright
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INTRODUCTION

Children with disabilities typically have short attention spans, so teaching methods for them must be dynamic to stimulate the students' visual, tactile and auditory senses. Computer games, bubble columns, stereos and water toys are some examples of devices that assist in teaching students with disabilities (Tidmarsh, 2001). An interactive way to teach students cause-and-effect relationships is by the use of play tools that demonstrate these relationships. A client requested a device that would teach cause-and-effect relationships and social skills with switches in an aquatic environment. Students with multiple physical and cognitive disabilities intend to use the device. To meet these objectives, the Interactive Aquarium (IA) was developed.

SUMMARY OF IMPACT

The client has reacted positively to the addition of the IA to her classroom. It is an effective tool for teaching cause-and-effect relationships and provides an additional tool to develop these relationships in an entertaining manner. The IA is mounted on casters, which makes it easy to move to new locations, and is small enough to be used throughout the classroom. Virtually every student in the classroom will benefit from the use of this new device.

TECHNICAL DESCRIPTION

The IA is brightly colored and has four effects to get and keep the students' attention. The effects utilize visual and auditory stimuli: 1) a mobile of sea creatures, 2) an array of bubbles, 3) multicolored light shining into the water and 4) sound via a

mounted on the IA and can then learn the effects caused by their actions.

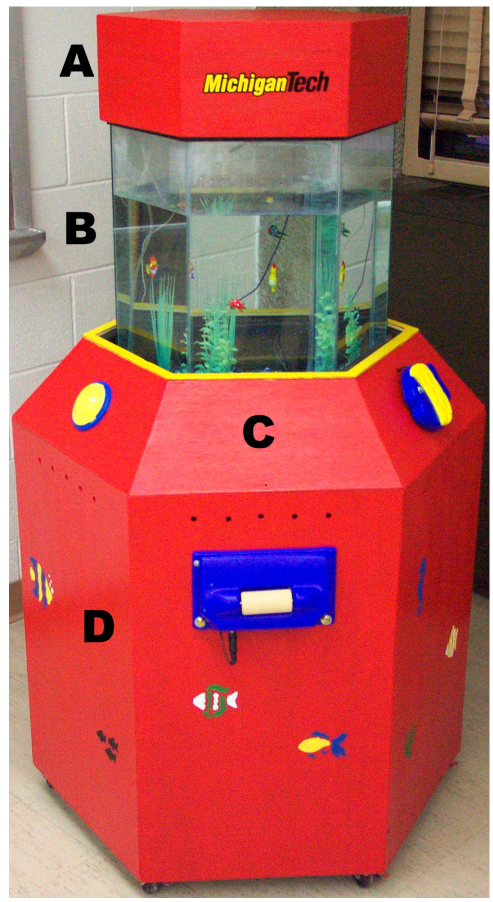

Figure 8.1. Interactive Aquarium.: (A) Lid Housing Motor and Bubbler; (B) Tank Containing Seaweed and Glass Fish Hanging in Water; (C) Two Switches Mounted on Crown of Stand; (D) Third Switch Mounted on Base of Stand.

cassette player. The students activate the effects by switches

The central attraction of the IA is a hexagonal 20-gallon aquarium. The aquarium sits concentrically on a frame built from steel tubing. The shortest measure across the cross-section of the stand is 26 inches and its height is 31 inches. Each corner of the hexagonal frame has two vertical members. Two steel tubes run across both the top and the bottom of the frame for shelf support. A four-inch crown surrounds the base of the tank, provides an aesthetically pleasing transition from the wider base to the narrower tank, and provides a sloped surface to attach switches. The steel frame of the stand and crown is encased by ¼" inch thick Luann panels. Built into the "back" side of the stand is a door with child safety lock for access to the interior of the frame. The controls and effects are held within the frame. The base of the frame sits upon six swiveling, locking caster wheels placed at each corner. Except for a single power cord extending through a 1 ½ inch hole cut into the base, the IA is entirely self-contained within the frame, tank and custom made wooden lid.

Three switches operate the four effects. The first switch operates a mobile of sea creatures. A small A/C motor and bubbler sit on Plexiglas on top of the tank. A custom made wooden lid encases the Plexiglas top, motor and bubbler. The mobile of sea creatures is attached to the motor and suspended in the water. A switch that is hard wired to the motor activates the mobile.

A second switch operates the bubbler and lights. The bubbler on top of the tank has two ¼ inch diameter plastic tubes that leave the bubbler, pass through holes in the Plexiglas and connect at the bottom of the aquarium to two bubble diffusers. The light fixture is mounted under the tank and shines light up into the tank. The light fixture has a 10W halogen lamp with a semitransparent color wheel rotating above it to change the color of the light illuminating the water. The bubbler and lights are powered by the PowerLink 3® (AbleNet, Inc.), and the switch is inserted into the PowerLink 3®. The PowerLink 3® has two inputs for switches, and each switch operates two electrical outlets. A third switch is connected through the PowerLink 3® to operate the final effect, a tape player hidden in the base.

The cost of is about $650 for materials.

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Tipton, Debbie. "Teaching Children with Disabilities,"Internet: kyky.essortment.com/teachingchildre_rdba.htm, November 26, 2001.

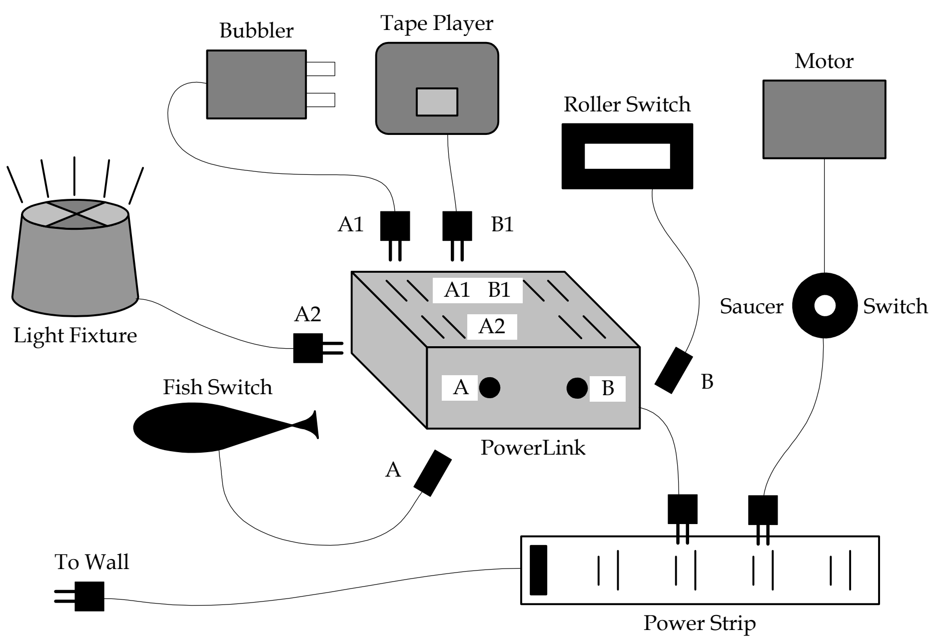

Figure 8.2. Schematic of Wiring Links between Causes (Switches) and Effects.

MULTI-SENSORY ENVIRONMENT

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INTRODUCTION

The multi-sensory environment was designed to provide stimulation to children who are severely multiply impaired (SMI). These students have both cognitive and physical disabilities. The structure will do this by providing the children with a dark and quiet environment to use their sensory devices. The environment incorporates visual, auditory, and tactile stimuli. These stimuli will help the children by engaging them in physical activities and help them to develop an understanding of cause and effect relationships. The environment will be used in a school.

SUMMARY OF IMPACT

The teacher who is primarily overseeing use of the device has expressed enthusiasm and delight at the addition of the Multi-Sensory Environment to her classroom. The students have all had an opportunity to experience the sensory room in "stimulation" mode, where numerous lights, sounds and aromas fill the room. All eight students demonstrated an awareness of the new and improved environment. Teachers have observed differences in facial expression, body movements, and behavior. Aside from being "aware", students who generally hang their heads while in their wheelchairs held their heads in a neutral position and looked around the room for up to seven minutes.

An experience with one specific student who has very little motor control due to severe spastic cerebral palsy was especially dramatic. In "stimulation" mode, the student was noticeably less spastic, and worked to maintain proper head position when he was in the environment. He also used the room in the "relaxation" mode with quiet music playing on the radio during his range of motion exercises. When finished, he stayed in the room for another 20 minutes and nearly fell asleep – a rare and significant occurrence for this particular student.

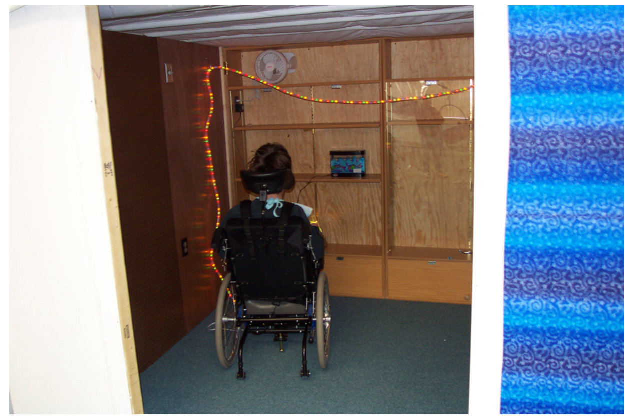

Figure 8.3: Student Inside Muliti-Sensory Structure at CCISD.

Future uses of the Multi-Sensory Environment will involve: 1) making more switches accessible to more students, 2) utilizing the room for small group activities, and 3) decorating the room for seasonal activities.

TECHNICAL DESCRIPTION

The structure is designed to create a quiet and dark environment that is temporary, so material selection is important.

The structure is made primarily of pine studs and Luan plywood. The frame is designed so that it will be portable and easy to assemble by separating into smaller sections when the pins in the hinges are removed. These smaller sections are two bookshelves, two sidewalls, two front walls, and the roof/door assembly. The bookshelves are adjustable to accommodate a variety of sensory devices. Acoustic foam is installed between the sheets of Luan and pegboard to absorb sound. The smooth plywood exterior acts as a barrier to reflect the sound waves on the exterior. Pegboard is used on the front panel of each sidewall to provide an easy way to attach tactile devices and switches.

The roof is made of fabric typically used as drapery lining to block out all light. The door is made of vinyl so it would be easy to clean. The roof is supported by electrical conduit to provide rigidity and is lined with foam to absorb sound. The door is also lined with foam. The roof and door are attached to the structure by fitting the holes in the conduit over wooden pegs and attaching the Velcro along each overhanging flap to ensure that there are no large gaps for sound or light to pass through undamped.

The structure has six power outlets used to power the sensory devices. The outlets are wired through a timer switch, which will shut off the power to the structure and turn on a safety light if the child is left unattended for more than 15 minutes.

Light levels are reduced by 93.7% with the door open and 99.2% when the door is sealed using the Velcro. The sound levels are reduced from 76.3 to 59.8 dBA in the reverberation chamber using a white noise generator. A sound test was also performed in the classroom in the afternoon, when noise levels are typically higher. In the test, there was an improvement of 12 dBA from the outside of the structure, measured at 59.5 dBA, to the inside of the structure, measured at 47.5 dBA. This drop corresponds to a subjective sound level change from a restaurant or department store, to the noise level of an average conversation (Lord et al, 1987).

Safety is an especially important issue with this project, because the structure is intended for students with multiple disabilities. Plexiglas sheets with latches cover each bookshelf so the devices on the bookshelf are not accessible to the students. All outlets are covered with safety plugs. The oxygen and temperature levels are also monitored with two adults in the room for one hour to ensure that ventilation is adequate. Redundant hinges are used to lock the panels in place for stability of the structure.

Figure 8.4: Outside of Multi-Sensory Structure with Door Closed.

The total cost for the structure was approximately $1200.

REFERENCES

Lord, Gatley, and Evensen. Noise Control for Engineers. Florida: Krieger Publishing Company, 1987.

ONE-ARM DRIVE SYSTEM FOR A WHEELED STANDER

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INTRODUCTION

A wheeled stander, which operates much like a standard wheelchair, is a device that allows individuals with little or no lower extremity control to be in an upright position. Wheeled standers can be physiologically and psychologically beneficial for individuals with cerebral palsy. However, many persons with cerebral palsy lack bilateral control of their upper extremities. A user cannot propel and control a wheeled stander without using both arms. The task presented was to design a one-arm drive system for a wheeled stander, to be used by a child.

The one-arm drive systems used on wheelchairs are not feasible for use on a wheeled stander because the axle would interfere with the user's body placement. A new design was required to preserve the full functionality of the wheeled stander. The design solution must allow the user to steer and propel the stander efficiently. It is to be a simple retrofit to existing standing walkers, requiring little or no modification of current devices. It should readily adapt for either left-hand or right-hand propulsion. The design will broaden the market for wheeled standers and enable a greater number of people to benefit from the advantages of a stander.

SUMMARY OF IMPACT

Many children with cerebral palsy experience life looking up from a wheelchair. Wheeled standers open their worlds to experiences and perspectives others take for granted. Past clients have stated that something as simple as seeing what is up on their kitchen countertops, being able to wash dishes at the sink, or seeing how "tall" they are compared to their peers can be very significant. Until now, the design of the wheeled standers did not accommodate the needs of many children who have asymmetrical upper extremity involvement. With this design modification, independent mobility in a standing position can be a reality. For people who spend much of their time in a wheelchair, the physiological and psychological benefits of using a wheeled stander are important. This device could enable a larger number of people to experience the benefits of a stander, due to this one-armed drive design modification.

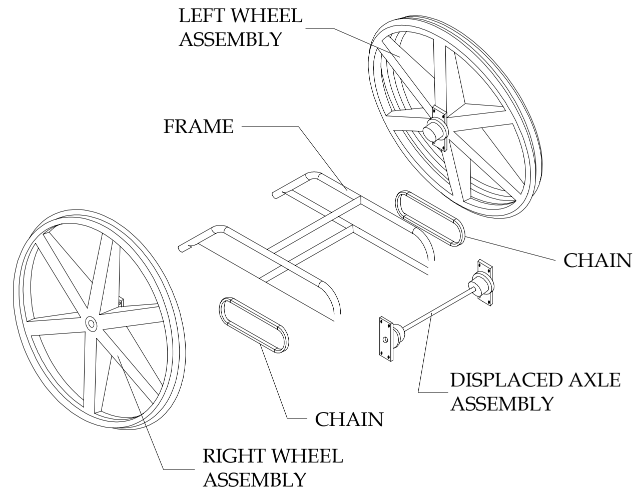

Figure 8.5. Exploded Drawing of Drive System.

The prototype was tested in the school where it will primarily be used. The testing revealed that the main design objectives have been met. The user is able to easily maneuver the stander on indoor flooring surfaces, which include carpet, tile, and hardwood flooring. The efficiency of the stander was confirmed by the user's ability to travel without fatigue and ascend an OSHA regulated incline (slope of 1:12 or less), both of which he is unable to do in his seated wheelchair.

Future improvements that may be incorporated in the prototype system include a cover for the drive chains and weight reduction.

TECHNICAL DESCRIPTION

The design solution was created through research of currently available one-arm drive wheelchair systems and basic mechanical engineering concepts. The main design requirements were determined through interviews with a physical therapist and the maker of the stander to be modified. These requirements include that the system be: 1) efficient in allowing the user to steer and propel the stander with one arm, 2) adaptable for either left or right arm use, 3) lightweight, 4) safe, and 5) easily maintained.

The final design concept is a displaced axle system with a dual push-rim on the driving wheel, illustrated in Fig. 8.5. The user controls the movement of the wheeled stander by grasping and rotating the rims. Turning only one rim will result in the stander turning in one direction, but will not propel the stander forward. The direction of turn is determined by which rim is rotated. The outer rim will cause the stander to turn in an inward direction of the rims. Turning the inner rim will turn it in the opposite direction. When they are turned together, the stander will travel along a straight path.

The inner rim is connected directly to the driving wheel like a normal wheelchair wheel. The outer rim has a hub at its center that is connected to an axle. This connection is secured by a keyway at both ends. The axle passes through the hub of the driving wheel and axle plate. Bearings inside the hub and axle plate allow the axle to rotate independently of the driving wheel. This first part of the system transmits the work provided by the user from the second push rim to the first sprocket. The rotation of the first sprocket drives an ANSI size 35 single strand roller chain along the side of the stander. The second sprocket is locked onto a ½ inch diameter solid 6061-T6 aluminum rod, the main displaced axle, by way of another sprocket key feature. This displaced axle is attached to both sides of the frame of the wheeled stander by a set of aluminum axle plates. Bearings at both ends allow free rotation of the axle. A second chain and sprocket system transmits the rotation back to the axle of the driven wheel. This wheel axle passes through the axle plate and is affixed to an aluminum spacer that is press fit into the hub of the driven wheel. This serves to transmit the rotary motion of the axle to the driven wheel, thus rotating the wheel. It is over this path, from the second push rim on dual-rim side of the stander to the hub of the opposite wheel, that the user’s input is transmitted to control the direction of movement with only one arm.

The total cost for the materials is $275.21.

WHEELCHAIR LOADING AND SECURING MECHANISM FOR MINIVAN

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Client Coordinator: Jodi Tervo, Copper Country Intermediate School District, Hancock, MI
Advising Professor: Dr. John E. Beard
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INTRODUCTION

A family requested a device that would ease loading and safely secure a wheelchair in a minivan. The objectives were: 1) no altering of seating or storage capabilities of the minivan, 2) use of a mechanical system, and 3) easy, safe and reliable use. The final device consists of two foldable ramps, mounted on roller carriages that extract from the driver-side sliding door of the minivan. The low incline grade of the ramps allows for easy loading of the chair into the minivan. When not in use, the ramps fold up and slide on a track into a storage position. While in storage, the device rests in a 0.3 square foot area next to the wheel well and does not obstruct the opening. A safety catch was also developed to prevent the wheelchair from slipping if the individual pushing the wheelchair slips or falls. This is particularly important in the winter. A crash-tested EZ-Lock system is installed on the floor of the van to secure the wheelchair to the minivan, and the occupant of the wheelchair is secured with a shoulder harness. Overall, the new system saves the family time and effort while providing them with a safe and easy system to load and secure their child in the minivan.

SUMMARY OF IMPACT

Prior to having this device, the family manually put the wheelchair in the van by tilting it back and lifting the front and then the rear wheels into the minivan. This method is strenuous, jostles the child, and causes damage to the wheelchair. Only one family member had enough strength to lift the child into the van. Once inside the van, four straps and a shoulder harness were used to secure the wheelchair to the van floor. This painstaking process took a significant amount of time and effort to complete. With the new loading and securing mechanism, every family member is able to load the wheelchair into the minivan, the ramps can be quickly unfolded or stored, and the EZ-Lock bracket provides safe and fast securing for the wheelchair. The family also maintains full storage and seating use of the van.

Figure 8.6. Fully Extended Wheelchair Ramp.

TECHNICAL DESCRIPTION

The ramps are fabricated from five-inch wide 6061 T6 Aluminum C-channel and are five feet long when extended. Fig. 8.6 shows the ramp fully extended out of the minivan. The channel is milled to a thickness of 0.19 inch, and the edges are 1.5 inches thick. Each ramp consists of two 30-inch long segments that are connected with a standard 4.5 inch door hinge. The hinges are fastened to the ramps with bolts through tapped holes. Pinch-guards are located at the hinges to reduce the likelihood of injury when extending the ramps from the van. The rings of the hinges were welded to increase their strength. Testing showed that each ramp by itself could support the weight of the child, wheelchair and parent with a safety factor of two. Grip tape covers the surface of the ramps to reduce slippage between the wheels and ramp.

Spring hinges connect the ramps to the track carriage. The torque on the hinges is adjustable and can hold the ramp upright when resting in the minivan. The spring hinges also reduce the force needed to lift the ramps from the ground into the minivan. To allow the chair to travel freely over the two tracks mounted inside the van, eight inch mini-ramps are hinged to the base of the main ramps. These mini ramps fold out to cover the tracks and stay in place when not in use by magnetic attachment.

The ramps slide on a track and carriage system consisting of stainless steel, aluminum, nylon, and steel bolts. The hinge at the base of each ramp connects to the carriage through a two-inch x five-inch stainless steel plate. Attached to this plate are two 1.12 inch x three inch cross members. Four machined nylon rollers attach by bolts to the cross members. Each roller contains two roller-blade bearings press fitted into the center of the roller, one on each end. One of the two carriages has pivots where the cross members bolt to the two inch x five inch plates. This allows the carriage to travel on the curved track. The two tracks that the carriages ride on have an octagonal cross-section. They are 1.5 inches wide and 3/8 inch high. One track has an s-shaped curve that is three feet long. This enables the ramp on the curved track to line-up behind the ramp on the straight track when the ramps are stored in the van. Fig. 8.7 shows the inside of the van when the ramps are stored. The curved track is milled using a CNC code to ensure precision and accuracy of a uniform cross-section. Each track is bolted to a 9.5 inch x 3 foot x 3/16 inch plate of aluminum with the bolts existing six inches apart from each other. The plate is then bolted to the floor of the minivan. This allows easy installation and removal of the mechanism.

The anti-rollback system mounts to the bottom of the wheelchair and consists of a safety cable with a clip. The safety cable is rolled onto a self-winding spool that is mounted on the bottom of the

Figure 8.7. Wheelchair Ramp in Storage Position.

wheelchair. To use the system, the operator attaches the clip to a hook inside of the van. The operator must hold the brake handle, which is mounted to the chair, in order to roll the chair up or down the ramp. When the handle is released, as in a slip or fall, the loss of tension on the connected brake cable causes a spring-loaded lever to engage a gear on the cable spool and stops the spool rotation. This prevents the safety cable from unwinding and locks the chair in its position until the brake handle is held again. After use, the safety cable winds onto the spool underneath the wheelchair.

The total cost of parts and materials is $1450.

ACKNOWLEDGEMENTS

The EZ-Lock Corporation donated a wheelchair lock worth $700 for the device.

CHAPTER 9
NORTH CAROLINA STATE UNIVERSITY

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TREADMILL TRAINING FOR CHILDREN WITH DEVELOPMENTAL DISABILITIES

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Client Coordinators: Charlie Gaddy Center
Supervising Professor: Dr. Michael D. Boyette
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INTRODUCTION

Children with cerebral palsy (CP) and other developmental disabilities typically receive physical therapy to facilitate motor development, enhance their independence, and maximize their potential. CP is a heterogeneous condition, encompassing a broad spectrum of developmental disabilities resulting in abnormal development of movement and postural control. As a result, a variety of treatments have been developed to either "normalize" the child's gait, a manner of walking or moving on foot, or to help the child develop a gait that will be the most efficient for that child. For the child with spastic cerebral palsy who is just beginning to walk, the objective is to counter or minimize the negative long-term effects of spasticity and weakness that prevent the greatest degree of independence. To overcome this problem, therapists generally try to emphasize balance training and gait preparatory tasks during crawling, sitting and standing.

Treadmill interventions with and without a harness and counterweight system have been used for children with Down Syndrome and CP. In both diseases, children learn to walk later than children without disabilities. Treadmill intervention without a harness and counter-weight system helped children learn to walk on average 100 days earlier than they would have otherwise. With a counterweight system, children showed improvement in gross motor function within three months.

This project addresses the current problems with existing commercial treadmill/harness systems. These systems are expensive, have limited ability to adjust load-bearing, and have handle bars which teach children a negative habit of supporting themselves with their arms while learning to walk. This design is significantly less expensive, provides a more adjustable load-bearing system, and eliminates the unwanted handlebars (Fig. 9.1).

Figure 9.1. Treadmill Training System

SUMMARY OF IMPACT

Once acclimated, the children involved will enjoy this method of therapy. It is fun for them and encourages them to walk, as opposed to previous methods of treatment, with which they lost interest quickly. The device also makes it easier for the therapist to support the walking child. Working without the harness system is awkward and tiresome for the therapist who must bend over the child and hold him up. The harness allows the therapist to concentrate on facilitating the movement of the child's limbs without having to worry about supporting the weight of the child or controlling the direction of walking.

TECHNICAL DESCRIPTION

The device consists of an aluminum frame spanning a horizontal treadmill. The frame is constructed of two-inch square aluminum tubing. The dimensions are: height 68 inches, width 36 inches, base 30 inches. Two 45 degree trusses span the vertical legs and top horizontal bar. The harness is suspended from the two trusses.

We developed two methods for suspending the harness. The first method is a counterweight system, involving a system of pulleys and a 10L Ballast Bag to offset a portion of the weight of the child. The components are referred to in lines 8-15 of the list of materials shown below.

The second method is a bungee cord system in which the cords attach the harness to the two trusses on the frame. The number of bungee cords used determines the amount of load that the child must bear. The more cords used, the less weight supported by the child. Load testing was performed on the cords to develop a mathematical relationship between the force and the change of length of the bungee cord. The components are referred to in lines 16-18 of the list of materials.

After testing, the second method using the bungee cords proved to be more practical. It is easier to connect the harness to the frame, adjust the force supporting the child, and put the equipment away for storage. The length of the cords is measured before the child is in the harness and directly after the child is in the harness to get the total deformation to calculate the force. When this support system is used in conjunction with the treadmill, we are able to measure such parameters as velocity of treadmill, child's step length and number of steps, and distance traveled. The specific parts included in the frame are shown in Figure 9.2.

The approximate cost of the project is $700.

Line	Level	Part Name/Description	Qty.	B/M*	Material Code
1	1	Treadmill	1	B	
2	2	Teekoz Harness	1	B	
3	1	Frame	1	M	Aluminum
4	2	2" Aluminum Square Tubing	33 ft.	B	Aluminum
5	2	2" OD Square Vinyl Caps (pkg 25)	1	B	Polyethylene
6	2	Teekoz Harness	1	B	
7	2	Eye Bolt	2	B	Galvanixed Steel
8	2	Pulley System	1	M	
9	3	1/2" Galvanized Cast Iron Sleeve	2	B	Cast Iron
10	3	1/4" Solid Braided Polyester Rope	50 ft.	B	Polyester
11	3	1/4" Swivel Latch Hook Pulley (2-1/2")	1	B	Zinc-Plated Steel
12	3	Open Pattern Galvanized Steel Thimble	2	B	Galvanized Steel
13	3	Fibrous Rope Clamp	2	B	Molded Nylon
14	3	Safety Snap	1	B	Zinc-Plated Steel
15	3	10 L Water-Filled Ballast Bag	1	B	1000-Denier Cordura Nylon
16	2	Bungee Cord System	1	M	
17	3	Adjustable Plastic Hooks	20	B	Plastic
18	3	5/16" Shock Cord	50 ft.	B	Bungee Cord

*B/M = Bought or Manufactured

Figure 9.2. List of Materials.

ELECTRICAL SWING FOR CHILDREN WITH CEREBRAL PALSY

Designers: JoAnn Bricker, Lauren Leaven, Phil Renfrow, Tawney Schwarz, and Matt Womble
Client Coordinator: Ms. Julie Troxler, The Charlie Gaddy Center
Supervising Professor: Dr. Michael D. Boyette
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INTRODUCTION

A center provides a year-round educational and therapeutic program for children from infancy to five years old with cerebral palsy. Since there are only a small number of teachers at the center, devices are needed on the playground that allow children with physical limitations to participate in play activity with minimal assistance. An electrical swing was designed to allow children with disabilities to experience swing motion with little assistance.

SUMMARY OF IMPACT

This device allows teachers at the center to limit the amount of time associated with pushing children in the swings by activating a power switch that turns on the swing. Once the swing is given an initial push, the swing will move forward and then backward in a continuous motion. This device integrates swing motion and adapts basic swing design to accommodate children with cerebral palsy and various other disabilities.

TECHNICAL DESCRIPTION

The major laws concerning the swing design were based on North Carolina state statutes that became effective in April 2001. These statutes directly reflect standards set by ASTM. The main design requirements for the swing included a sturdy frame in which the swing supports were attached to the frame two feet apart. Each swing support had to be two and a half feet from the end of the frame. Other requirements included: 1) swing seats should be made of plastic or soft flexible material, 2) the edges of swing seats should have smoothly finished or rounded edges, and 3) protective pillows should be added to the sides of the swing seat to secure the child's head (Fig. 9.3).

Figure 9.3. Design Team with Electrical Swing.

The electric swing has two major components, the swing seat and the motion structure. The base of the motion structure consists of rectangular one-inch square tubing (Fig. 9.4). A limit switch is mounted on the square tubing, and the tubing is attached to the swing frame, already present at the center, by two 5/16-inch U bolts. Also attached to the rectangular tubing are two J-bars that support two tubular solenoids. Two roller bearings are also attached to the bottom of the square tubing to support the structure. A rotating bar passes through the two roller bearings to add motion to the swing. Circular sprockets are attached on each end of the rotating bar. Two shaft collars are attached to the rotating bar in between the two roller bearings. The first collar has a protruding peg that is connected to two solenoids by a three bar linkage made of hinges. The second collar has a protruding peg that activates the limit switch. The second collar also has a thumbscrew, which allows the shaft collar to be adjusted easily.

The swing seat consists of a GRACO car seat with various modifications. The seat is a hard plastic structure with a locking clip, harness strap, harness buckle, crotch strap, and crotch buckle. A red vinyl weather resistant covering was added to the exterior of the seat to add cushioning and make the seat waterproof. The original five-point restraint system in the original seat is reduced to a three-point restraint system that consists of a center locking seatbelt and harness. A vinyl covered bobby pillow is also added to the chair to reduce head movement and is attached to the chair at the shoulder restraints. Two braces are added to the bottom and back portion of the to chair support the seat. Two ¾- inch pieces of square tubing are attached on both sides of the back brace of the chair and are connected to the sprockets on each end of the rotating bar. A 1/8-inch piece of flat stock connects the bottom brace to the square tubing at a predetermined angle.

Once the swing is given an initial push, the peg on the first collar hits the limit switch. When the limit switch reaches a certain position it changes state (normally open to closed) and allows the current to pass through and activate the two solenoids. The activation of the solenoids pulls the activating peg from the first shaft collar and causes the swing to pull back, thus providing continuous motion.

The total cost of materials and supplies was about $350.

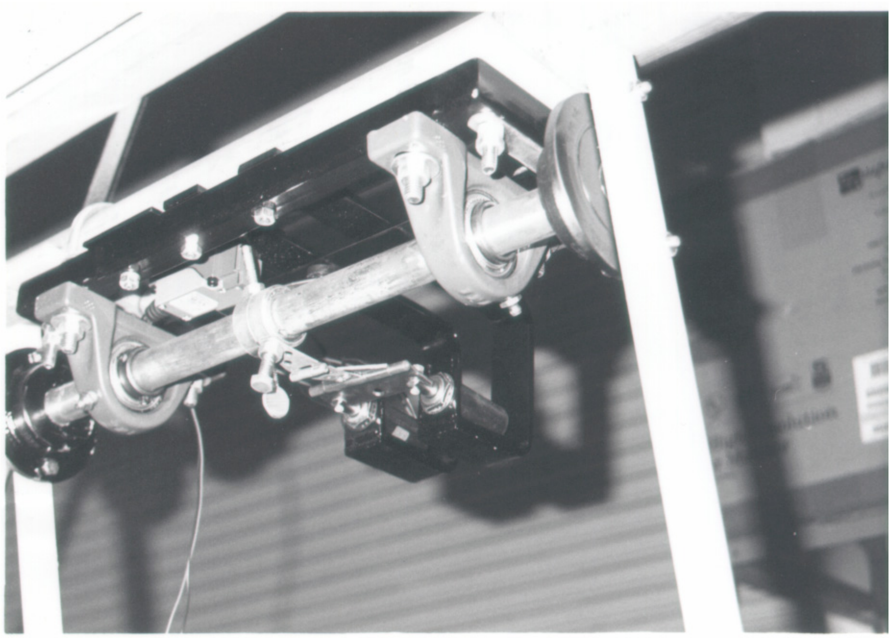

Figure 9.4. Motion Structure for Electrical Swing.

FULLY AUTOMATED POWER WHEEL WITH SEATING HARNESS

Designers: Jennifer Carpenter, C.W. Gaskill, Nathan Jean, Stuart Spencer, Miranda Williams
Client Coordinator: Julie Troxler, Charlie Gaddy Center
Supervising Professor: Dr. Michael D. Boyette
Electrical Engineering Assistance: Keith Sorensen
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INTRODUCTION

The purpose of this project was to modify a Fisher Price Power Wheel to accommodate pre-school aged children with cerebral palsy. Modifications made the Power Wheel more adaptive for a child with difficulty reaching, limited muscle use, and mental retardation. Specific modifications made in this design include: (1) new seating with seatbelt for additional support, (2) removal of an extraneous light bar for easy entrance, (3) addition of a gear motor to control steering, (4) replacement of a steering wheel with an adjustable tray table, and (5) adaptation of a joystick.

SUMMARY OF IMPACT

The major goals of this design included: (1) safety considerations for a child with cerebral palsy, (2) inexpensive modifications, and (3) appearance to appeal to the child. This modified Power Wheel will make it possible for children with cerebral palsy to participate in one of the play activities enjoyed by children and will increase their sense of independence.

Figure 9.5. Modified Power Wheel.

TECHNICAL DESCRIPTION

The modifications involved converting manual steering consisting of a steering wheel and forward/reverse motion with a foot pedal to joystick control. The torque exerted on the steering shaft to turn the Power Wheel under standard conditions was determined to be 19 inch-pounds and the gear motor was sized accordingly. The gear motor was linked directly to the standard steering mechanism and wired to the joystick. Switches were used to limit the rotation of the wheels.

The frame of a standard joystick was used to create a new joystick with a distinctly different design. Instead of using potentiometers, as is standard in joysticks, snap action switches were used to control the voltage across the steering and drive system motors. The switches were mounted on a polyethylene plate. The joystick was housed in a modified, watertight plastic box.

A tray table was constructed for easy access to the joystick. This tray was made of PVC and a thick plastic top. It rotated to allow easy entrance and exit from the Power Wheel. The sound and light bar was removed and replaced by the tray.

The standard Power Wheel seat was completely removed and replaced with a child car seat. This seat was chosen to fit exactly within the space provided and was modified by removing excess belts and straps. The seat was attached to the car with belts that were secured underneath the car. This seat provided substantial padding for comfort and protection of the user.

The final cost of this design was approximately $430, which included $260 for the Power Wheel and $170 for the modifications.

SUPER DUPER COZY COUPE

Designers: Joseph Lizotte, Brittany Barr, Jonathan Britt and Zachery Fuller
Client Coordinator: Julie Troxler, Charlie Gaddy Center
Supervising Professor: Dr. Michael D. Boyette
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INTRODUCTION

A child's toy car, the Cozy Coupe, was modified for use by children with cerebral palsy. A previously developed device that enables children with cerebral palsy to walk on their own, the Snug Seat Pony Gait Trainer, was also used. The design involved combining the functionality of this device with the aesthetic appeal of the Cozy Coupe. The car was designed for children ages one and a half to five.

SUMMARY OF IMPACT

The Cozy Coupe is one of the most popular toys with children at a center, but because of its present design, children with cerebral palsy are unable to use it. Design modification in the Super Duper Cozy Coupe address body support and leg extension range needs of children with cerebral palsy, making it possible for them to more fully participate in play activities.

TECHNICAL DESCRIPTION

The construction of the Super Duper Cozy Coupe involved the combination of the Snug Seat Pony Gait Trainer with Little Tikes' Cozy Coupe II. The functionality of the Pony Gait Trainer was to be preserved, so the primary adaptation was to the structure of the Cozy Coupe. The cab of the Cozy Coupe was the area that was primarily modified. The original seat in the Cozy Coupe was cut out and essentially replaced by the Pony Gait Trainer (Fig. 9.6).

Figure 9.6. Super Duper Cozy Coupe.

The Cozy Coupe is made of plastic. Felt was used to cover the coarse edges of the cut plastic. After the seat was removed, the Cozy Coupe was placed on top of the Pony Gait Trainer replacing the Cozy Coupe seat. To compensate for the higher seat positioning of the walker, the body of the Cozy Coupe was raised. To accomplish this, 12 gage galvanized sheet metal supports were placed at the front and rear end of the Cozy Coupe to connect the car to the Pony Gait Trainer. Using hinges, the roof of the car was made retractable allowing easier child entry into the car.

Front Support

The front support was designed to bear only the weight of the car. The walker supports the child's weight. The shape of the front support was designed to prevent wobble, and a brace was added to the front support for extra stability. The shape was also designed to allow legroom for the child.

Rear Support
The rear support was designed to bear only the weight of the car and to not inhibit the child's legroom.

Retractable Roof
The roof was modified to be retractable and to provide easier access for children to the cab of the car (Fig. 9.7). Hinges were replaced on the front roof columns to allow the rear columns to snap in and out of position. Flat plate hinges were used to allow a full 180° rotation. The flat plate hinges must be placed in the same plane to function properly. A small-machined attachment had to be added to the car to create a flat plane. Two four-inch by 1½ inch pieces of galvanized sheet metal were bent at a 90° angle and attached to the front columns to create a plane for attaching the hinges. The hinges were then rounded and covered with yellow electrical tape for safety purposes.

Cosmetic Tires
Cosmetic tires were designed to enhance the aesthetic appeal of the car. These were constructed using a machine that formed plastic wheels from a Styrofoam mold created by the design team. The wheels were made in halves from the mold and then fused together to create a hollow wheel, which are not shown on the car.

The final cost of this design was approximately $135.

Figure 9.7. Retractable Roof on the Super Duper Cozy Coupe.

TOUCH-N-GO: A REMOTE CONTROL DOOR OPENING DEVICE

Designers: Colleen Dobson, Laura Nordby, Meg Stokes, and Jody Wood
Client Coordinators: Cindy and Kevin Schaefer, Families of Spinal Muscular Atrophy, North Carolina Chapter
Supervising Professor: Dr. Michael D. Boyette
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INTRODUCTION

A remote controlled door-opening device was designed for a child with muscular atrophy due to a degenerative disease that limits the individual's dexterity and strength.

SUMMARY OF IMPACT

Individuals with muscular atrophy are dependent on those around them to help with everyday activities. Touch-N- Go will allow these individuals to have the liberty to come in and out of their homes at their own discretion. Current products on the market, although very efficient, are extremely expensive. This design provides the necessary functions while being affordable.

TECHNICAL DESCRIPTION

Several specifications were made for the design based on consultations with the client's parents. These include:

(1) The client should be able to activate the device from either side of the door, (2) The door speed should be set so that the door opens and closes at a safe speed, (3) The device should allow control of the duration that the door is open, and (4) The door should also be able to be operated manually.

Figure 9.8. Sensor for Touch-N-Go Remote Door Opening Device.

The design consists of several parts: a louver motor, cable/spindle assembly, electric strike plate, transformer, pneumatic device, and a remote control system. These parts could all be placed on any existing door. Touch-N-Go was designed for use on an exterior, solid wood door. The device consists of an electrical and a mechanical system.

The remote control system consists of a wall-mounted sensor with a handheld remote (Fig. 9.8). The sensor connects directly to the power source, and the transformer and motor are connected in parallel to the sensor. The louver motor, which requires 120V AC power, is a unidirectional motor that resists burn out. When the motor overloads, it shuts off automatically. A 120V AC to 24V DC step-down transformer is wired to the remote control system. The transformer is needed because the electric strike requires 24V DC power to operate. The purpose of the strike plate is to open the door without having to twist the doorknob.

The shaft connected to the motor rotates when powered, and the spindle is mounted on the shaft so that it also rotates. A steel cable of 0.69-inch diameter and 3-feet length is fastened at one end to the spindle and at the other end to the doorplate. The doorplate is a ¼-inch thick steel plate with a 90° bend at the top of the plate. The cable connects to a hole in the corner of the bend (Fig. 9.9). When the spindle rotates, the cable winds around it, pulling the door open.

Once the door is open to 90°, the cable is completely wound up. The door remains open as long as the power is supplied to the motor. When the individual presses the off button on the remote, the power supply is cut off. The pneumatic device then overrides the mechanics of the motor and closes the door. The pneumatic device used in this design is a standard heavy-duty storm door closer.

Figure 9.9. Door Plate with Motor and Spindle.

The total cost of the system is $255.

LIGHT SWITCH ADAPTER FOR PATIENTS WITH MUSCULAR ATROPHY

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INTRODUCTION

A light switch adapter was designed and constructed to assist a patient with muscular atrophy in activating and deactivating a standard large-faced toggle light switch. Because the client's disease is degenerative, the product had to be designed so the patient can use it as long as he is mobile by way of an electrical wheelchair. In other words, as long as he can use the controls on his wheelchair to maneuver himself, he will be able to use the adapter.

SUMMARY OF IMPACT

Muscular atrophy affects strength and movement abilities of the voluntary muscles. Although the thoughts, emotions, and overall mentality of persons who has the disease are not affected, an overwhelming frustration may result due to the lack of independence. The patient understands how to perform everyday functions but does not have the strength or fine-motor ability to do so. The main purpose of this device is to help keep the patient as independent as possible for as long as possible. It also gives the patient an opportunity for physical accomplishments.

TECHNICAL DESCRIPTION

The light switch adapter is designed to activate a wide-faced toggle light switch (Fig. 9.10). Torque, created by the operator, activates the adapter when pressure is applied to one of the two four-inch by six-inch plastic pads of the device. The left pad activates the light switch while the right pad deactivates the switch. When a force is generated in a perpendicular direction on the plastic pad, the vertical levers made of the ¾-inch aluminum angle transmit torque. This torque rotates 3/8-inch aluminum rods that make contact with the switch by means of one-inch flat aluminum tabs that are welded to the rod.

Figure 9.10. Light Switch Adapter.

The angles made by the activating tabs relative to the activating arms must be properly aligned to assure activation of the wide-faced toggle switch. The angle between the arms and the flanges is adjustable by means of 3/8-inch stops to assure that the device will work on other wide-faced toggle switches.

Loosening the screws on the stops and moving the arms to the desired angle help adjust the arms. A four-inch by three-inch mounting box, built from one-inch angle aluminum, holds the activating device onto the wall. This box is attached to the wall by five drywall anchors. Each arm has a compression spring attached to rubber bumpers on the wall. This is to prevent the arms from coming in contact with and causing damage to the wall.

The cost of the Light Switch Adapter is $99.

H.A.R.O.L.D.: HELPFUL ANALOG REMOTE OBJECT LIFTING DEVICE

Designers: Genny Evans, Wes Few, Angela Riggins, and Brian Robbins
Client Coordinators: Families of Spinal Muscular Atrophy, North Carolina Chapter
Supervising Professor: Dr. Michael D. Boyette
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INTRODUCTION

Toys, from action figures to Playstations, are integral to a healthy and happy childhood. What if a child does not have the ability to reach down and pick up a dropped toy? The helpful analog remote object lifting device (H.A.R.O.L.D), a radio-controlled car modified with a motorized scoop, was developed to help children with Spinal Muscular Atrophy (SMA). (Fig. 9.11).

SUMMARY OF IMPACT

SMA is a disease that affects the proximal muscles near the spine. These particular muscles control voluntary movements such as crawling, walking, torso bending, and head and neck control. These physical limitations may prohibit children from reaching down to pick up their toys from the floor. A child may be unable to return to an upright position after bending forward to retrieve items. Any time a child with SMA needs assistance in

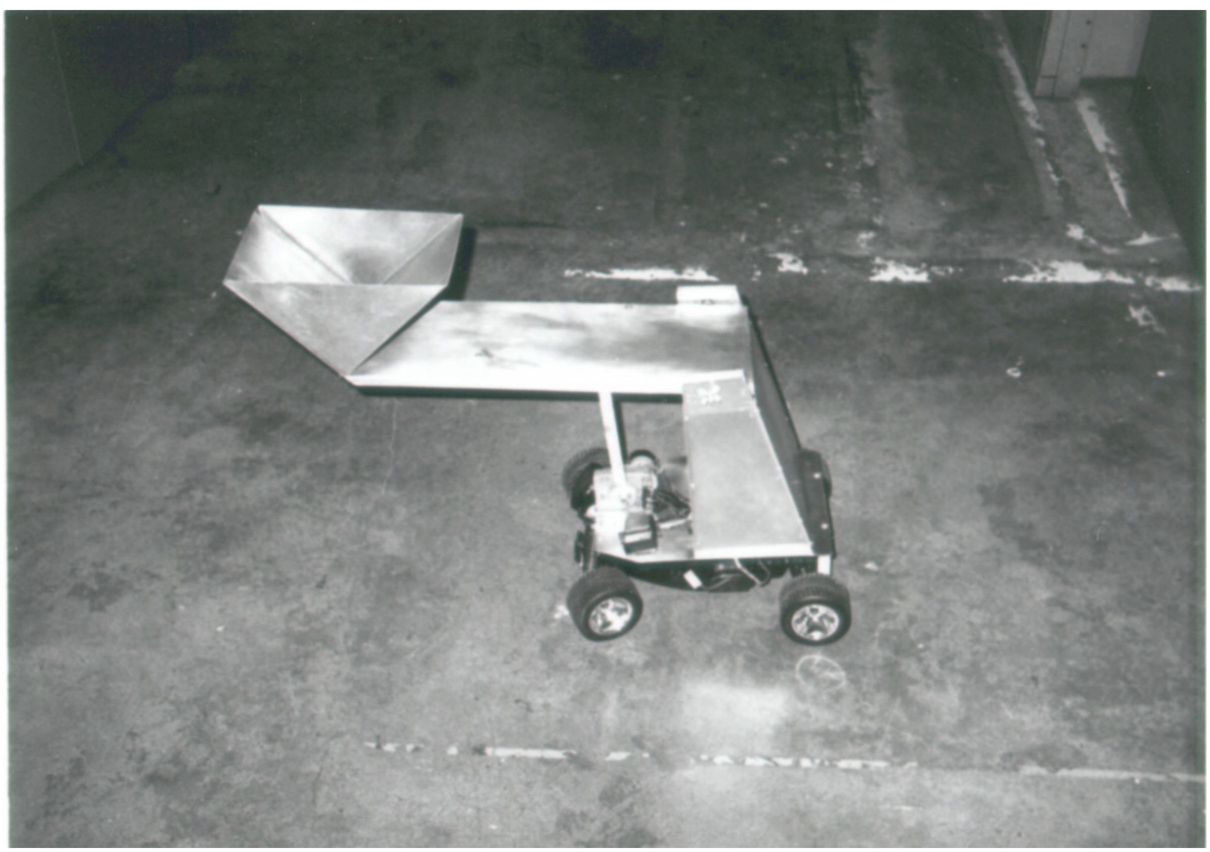

Figure 9.11. H.A.R.O.L.D: Helpful Analog Remote Object Lifting Device.

retrieving his toys, he can rely on H.A.R.O.L.D.

TECHNICAL DESCRIPTION

Our solution to retrieving dropped toys involves modifying a remote controlled car that is capable of capturing a toy then raising it (Fig. 9.12). H.A.R.O.L.D is constructed using an electric radio controlled car kit with a lift assembly attached to the car frame. The front-loading bucket attaches to vertical supports. These supports are pop riveted to a secure platform. The bucket ramp pivots about an axis at the top of the vertical supports. The bucket is raised by means of a lever attached to a rotating cam that is connected to a DC motor. Rechargeable batteries power both the car and the bucket. Any toy can be captured and raised to a height appropriate for a child to reach it. To prevent the motor from continued operation, limit switches are incorporated into a circuit. This circuit uses diodes to prevent current flow in both directions. This prevents the motor from short-circuiting. The circuit cuts power to the DC motor. This safety precaution extends the life of the motor.

The circuit includes two single throw single pull limit switches, two diodes, and an alternating power supply. When the cam raises the lever to a certain point, one switch is thrown, and power is cut off. Reversing the polarity starts the motor back in the opposite direction. Once the lever reaches a specific point, the other switch is thrown, and power is shut off. Changing the directions of the remote toggle switch starts the process all over again.

The total cost of H.A.R.O.L.D. was approximately $700.

Figure 9.12. Design Group with H.A.R.O.L.D.

SWINGING SEAT FOR CHILD WITH CEREBRAL PALSY

Designers: Megan Allison, Stacy Banks, Delia Gonzalez, and Brandon Wang
Client Coordinators: Jacquelyne Gordon, North Carolina Cooperative Extension Service
Supervising Professor: Dr. Michael D. Boyette
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INTRODUCTION

Outdoor playground equipment has been universally used to provide children with fun and exciting recreational activities. Swings are commonly seen at playground sites and tend to be a favorite among children. However, swings require upper and lower body movement, which hinders participation by children with cerebral palsy. Therefore, a swing was designed to accommodate the needs of a child with cerebral palsy.

SUMMARY OF IMPACT

The specially designed swinging seat is an excellent, innovative way for children with cerebral palsy to experience fun, outdoor activities. Since the client's family had other children without cerebral palsy, the swinging seat was designed to accommodate them as well. Additional seats included one regular

Figure 9.13. Swing Chair.

child's seat and one regular infant seat. With these additions, other members of the family could enjoy the swing as well.

TECHNICAL DESCRIPTION

The swing chair and the swing seat were specifically designed for a child with cerebral palsy (Fig. 9.13). The child's safety, recreational needs, and level of comfort were considered in the project design.

Pressure treated wood coated with additional water sealant was used for the swing set frame to provide protection against all weather conditions. To ensure stability, an "A" shape design was used on the ends of the frame. In addition, the frame was reinforced with EZ frame braces® and EZ frame brackets®. Heavy-duty swing hangers were attached to the frame using carriage bolts and were secured with two nuts to prevent loosening. The swing hangers were spaced to allow for the 22 inch width of the swing. On each side of the swing chair, two plastic coated chains were joined using an "S" hook and attached to the beam with an additional chain.

Aluminum was chosen for the swing seat frame because of its durability, resistance to corrosion, and strength. The main frame was fabricated from 1¼ -inch angle with one-inch square connectors and reinforced with side supports made of one-inch flats. One-inch hinges were attached to the base of the seat to allow for the adjustable leg support. The adjustable leg support consisted of one, one-inch flat with one hole joined with a nut and a bolt. Unlike commercially available swings, this design allowed the user to enjoy a range of positions. In addition, aluminum mesh was laid in the interior of the aluminum angle and secured with rivets. Certified technicians welded all aluminum materials to create the backbone of the seat.

To achieve an optimum level of comfort, a three-inch thick chaise lounge cushion was modified to fit the needs of the client. Six inches of material were taken from the bottom of the cushion to properly fit the swing seat. Also, four two-inch slits were made in the top third of the cushion to accommodate a harness. Two backpack shoulder straps and one waist belt were joined to create the harness design. The harness, which was commercially used for backpacking purposes, was modified to fit the dimensions of a small child. The harness was secured to the cushion by fastening one side of the two-inch webbing to the harness clips, passing the webbing through the cushion slits and riveting it to the aluminum mesh. This technique provided a secure fit and a maximum level of safety for the client while swinging.

The final cost of the project was $700.

MANUALLY OPERATED DEER HUNTING TREE STAND FOR INDIVIDUALS WITH PARAPLEGIA

Designers: Devesh Amatya, Antonio McGuire, Jenna Russell and Rebecca Silverstein
Client Coordinators: Jacquelyne Gordon, North Carolina Cooperative Extension Service
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INTRODUCTION

Hunters use their arms and legs to climb up trees and hunt from traditional tree stands. However, deer hunters who have paraplegia, the paralysis or loss of movement and sensation to the lower part of the body, are unable to use this type of tree stand because of the inability to climb with their legs.

SUMMARY OF IMPACT

The design criteria allow a hunter with paraplegia to use his upper body strength to manually elevate himself with a pulley system to a position 10 feet above the ground. This elevated position is desired because it allows him to be hidden while giving him a broader vision of the terrain and wildlife. Thus, he is able to aim at the target with more accuracy.

TECHNICAL DESCRIPTION

The tree stand was designed to lift a 250-pound hunter 10 feet in the air. It consisted of three main components: a ladder, a manual winch, and a chair (Fig. 9.14). Several safety features and accessories were also included in the design.

The 28-foot aluminum extension ladder consisted of two 14-foot sections. The section of the ladder that was used for this design was the wider of the two sections, which had a skid-proof base. The selected ladder can hold 350-pounds, which is more than adequate to hold both the weight of the client and the aluminum chair, which total approximately 300

Figure 9.14. Deer Hunting Tree Stand.

pounds. Several modifications and additions were made to the ladder. A small flange was bolted to the bottom of the chair to keep it from running off the end (Fig. 9.15). Another large flange, which serves as a stopper, an anchor for a ratchet strap, and a place to attach the winch's steel cable, was attached to the top of the ladder.

The manual ratchet winch had a 1400-pound weight limit. The winch was bolted to an aluminum base positioned on the right side of the chair to accommodate the right-handed dexterity of the client. The winch system was used to lift and lower the client along the ladder's height by winding and unwinding a steel cable. A lever switch on the winch determined the direction of motion. The switch was in the up position for ascension and in the down position for decline. The steel cable was looped around an eyebolt that was attached to the large flange at the top of the ladder. The cable then passed through a pulley system and wound around the drum of the winch. The pulley system consisted of two pulleys that were attached to the chair frame. The purpose of the pulley system was to change the direction of the force pulling on the cable and to move the position of the cable from the right side of the chair to center of the chair.

The frame for the chair was made of 1¼ inch square aluminum tubing. It had a width of 22-inches and depth of 15-inches. These measurements were calculated, researched, and proven to be ergonomically correct for the client. A seat cushion to accommodate long periods of sitting was purchased and attached using two aluminum flanges for support. Diagonal beams were included in the design to distribute the forces applied by the client and the tension from the winch's cable. Flanges were bolted to two slider bars on the rear of the chair to act as a track system along the legs of the ladder. The sliders were lined with high-density polyethylene strips to reduce friction caused by metal-on-metal contact.

Several features were added to the tree stand to ensure the safety of the client. A ratchet strap device was used to secure the stand to the selected tree. The strap was attached to the large flange at the top of the ladder. A seatbelt was also added to the chair for safety purposes. Also, square plugs were inserted into the open ends of the tubing to eliminate sharp corners.

Finally, the stand was painted to camouflage it. This procedure was necessary to allow the tree stand to blend into the wood scenery, a necessity to allow for successful deer hunting. Other accessories including padded elbow rests, a cup holder, and a storage bin were also added to increase the comfort-level of the user. The final cost of the project was approximately $460.

Figure 9.15. Side View of Deer Hunting Tree Stand.

CHAPTER 10
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CAUSE AND EFFECT DEVICE

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INTRODUCTION

A Memory-Cause and Effect device was built because of the flexibility and enjoyment for someone using such a device. Regular cause and effect devices only light up or make a sound when you complete one task. This device will light up when the user has completed one task, but it will also provide a greater reward if the task can be completed four times in a row. To complete this task four times there has to be an understanding of the concept of cause and effect and also simple memory skills. With this memory game, there are also levels of difficulty so it can be used with a variety of clients. With both the cause and effect and memory components the device should be fun and interesting for the user.

SUMMARY OF IMPACT

The device is designed to help teach cause and effect to the user. The operator should be able to use this device on a desk or tabletop. The device will flash a random display of lights that the user will have to repeat correctly to obtain a lightshow. If the light sequence is repeated incorrectly a light will turn on to indicate a wrong answer. The difficulty of the light sequence will be able to be controlled from a switch that can be set to three different level settings.

TECHNICAL DESCRIPTION

The Cause and Effect Device consists of three main components: input buttons, output lights, and a controller. The input buttons were selected to be large lit momentary action push buttons, so the operator can easily hit these buttons. In addition, the sequence the operator is to repeat can be presented to the operator by lighting up these buttons in the order they are to be pressed. By lighting up the buttons themselves, problems with associating a light with a different button are avoided.

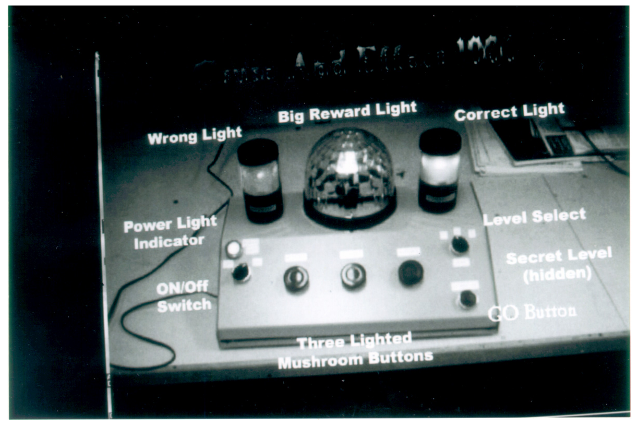

Figure 10.1. Cause and Effect Device.

The output lights consist of the lighted buttons themselves as well as three indicator lights. A red light indicates that the operator has not successfully repeated the pattern. A green light indicates that the pattern has been repeated correctly so far. A large white flashing beacon serves as the 'big reward' if the operator successfully repeats the pattern four times in a row.

The controller for the Cause and Effect Device was selected to be a programmable logic controller (PLC). Several other projects have been designed using a microcontroller. Using a slightly different controller allowed comparing a PLC to these microcontrollers. A PLC is an off-the-shelf device, which will allow the operator to replace it in case of failure.

The PLC that was chosen is the Allen Bradley Micrologix 1000. This PLC requires 24 volts DC to power the relays and to operate on. This PLC contains six relay outputs and ten 24 volts inputs that are available for use. It has a memory limit of 1024 instruction words with an error of plus/minus 12%. The cost of the PLC was about $225 from Border States Electric.

By using a PLC, the circuitry for the Cause and Effect Device is trivial: the relay outputs are placed in series with power and the lights. By closing a relay, the corresponding light turns on. The button inputs are also easy to connect: the +24V is connected to the PLC's inputs in series with the buttons. A challenge was the programming of the PLC itself using ladder logic.

The programming of the controller using ladder logic was challenging. Four ladders (similar to four programs) are written to control the functions:

Ladder 1 (Level Select and Randomizer): This ladder activates the subroutines, randomizes the sequence of lights, and selects the levels. The level select switch activates the level select. When the level is selected, it activates a series of move instructions. These move instructions send different times and counts to the timers and counters. The randomizer consists of one timer that counts up to 17 counts in 17 sec and then resets and counts up to 17 again. When an operator presses the go button it grabs one of those 17 counts randomly, depending on the count the timer is on.

Ladder 2 (Flashing Light Sequence): The Light Sequence consists of 17 different sequences. This light sequence uses one timer and five bits in every flash and one delay timer. The timer in the sequence, times how long the light is on depending on the level selected. The five bits control a pulse to the counter, which counts the number of flashes and then shuts off the sequence.

Ladder 3 (Responses): The response consists of latches and unlatches, the latches latch when a correct answer is given and then trigger the next response depending on the order that the lights flashed in

Ladder 4 (Rewards): There are three types of rewards: correct light, wrong light and super light. The wrong light comes on after a wrong response. This light will come on for five seconds and then turn off, indicating a wrong response. The correct light comes on after a correct response that is triggered from the correct response counter discussed in ladder four. This light will also come on for five seconds and turn off, indicating the response was given for the sequence of lights correct. The super light also lights up both the wrong light and the correct light. This happens when the user gets four correct responses, and the lights will stay on for 10 seconds.

All together, these ladders contain 129 rungs and 1012 instructions words. This program maxed out our processor's memory.

Results

While using a PLC did work for this project a microcontroller would have been better. The initial design would have required 200 timers:, more simply achievable with a microcontroller using 200 bytes of RAM. The PLC, however, only had 40 timers, forcing us to simplify some of the light sequences. Second, the PLC had problems with latching and unlatching the button inputs. This problem was addressed at the cost of time and program space. A microcontroller could make this a trivial problem by connecting the buttons to interrupt lines. Finally, the memory available on a $225 PLC was taxed with a fairly simple task. A $5 PIC processor would have been able to do the same, although it could not be programmed in ladder logic. Considering the complexity of the program, a structured C program on a PIC processor would probably have been as easy to develop and maintain.

The total cost for this project was $508.00.

VOICE CONTROLLED TV REMOTE

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INTRODUCTION

A Voice Controlled TV Remote was designed, built, tested, and delivered. This remote control uses voice recognition technology to allow the operator to turn a TV on and off, select channels, and adjust the volume of a TV using voice commands.

SUMMARY OF IMPACT

Through the use of this device, a person who has voice control but lacks motor control of his hands will be able to enjoy watching television better. This in turn will help him keep up-to-date on world events (through news programs), follow favorite sports teams, etc. Moreover, it will give this person greater autonomy, no longer depended on help from another person to operate the buttons on a remote.

TECHNICAL DESCRIPTION

The Voice Controlled TV Remote was designed in two stages. The first stage developed a normal keypad controlled TV remote, and the second stage added an alternate voice input.

The TV remote was developed by using a PIC16F876 microcontroller to read several push buttons, and then drive an IR transmitter through a 555 timer. The infrared remote controls operate by transmitting a signal using pulses of infrared light. To keep various remotes from interfering with each other, a special set of codes have been designed that identify the make and model of television that is being controlled. For this project, signals were generated to operate a GE Model 13GP300 television. These codes were determined using reverse engineering: the signals from a working remote were recorded using an IR detector and an oscilloscope. The PIC was then programmed to generate like signals – verified by using the PIC to control the TV's operation remotely.

Once a working TV remote was developed, a voice input was added. This included a microphone, a wireless transmitter and receiver pair between the microphone and TV remote, and a voice recognition chip.

The voice recognition chipset used in the design, Voice Direct 364, proved to be an appropriate selection in voice recognition technology. The module came complete with all switches and components necessary and was easy to assemble. The manual included in the kit described the steps to train and use the system. Once constructed, the device was found to be easy to use and quite accurate. It was also found that interfacing the Voice Direct 364 with other circuitry was rather effortless. The following paragraphs explain how the Voice Direct 364 operates.

Voice Direct 364 performs speaker-dependent discrete word recognition by comparing a pattern generated in real time with previously trained word templates. The pattern generated by Voice Direct 364 is based on a digital reconstruction of the voice command. Each word to be recognized must first be

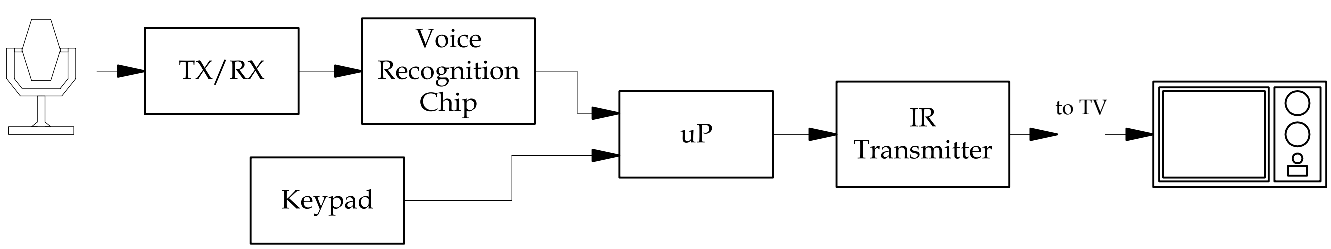

Figure 10.2. Voice Controlled TV Remote Components.

trained. During training, Voice Direct 364 constructs a template representing the individual speaker's unique sound pattern for each specific word or phrase to be recognized. Templates are stored in serial EEPROM memory. During recognition, a new pattern is produced and compared to the stored templates to determine which word was spoken.

The total cost of this device was $430.

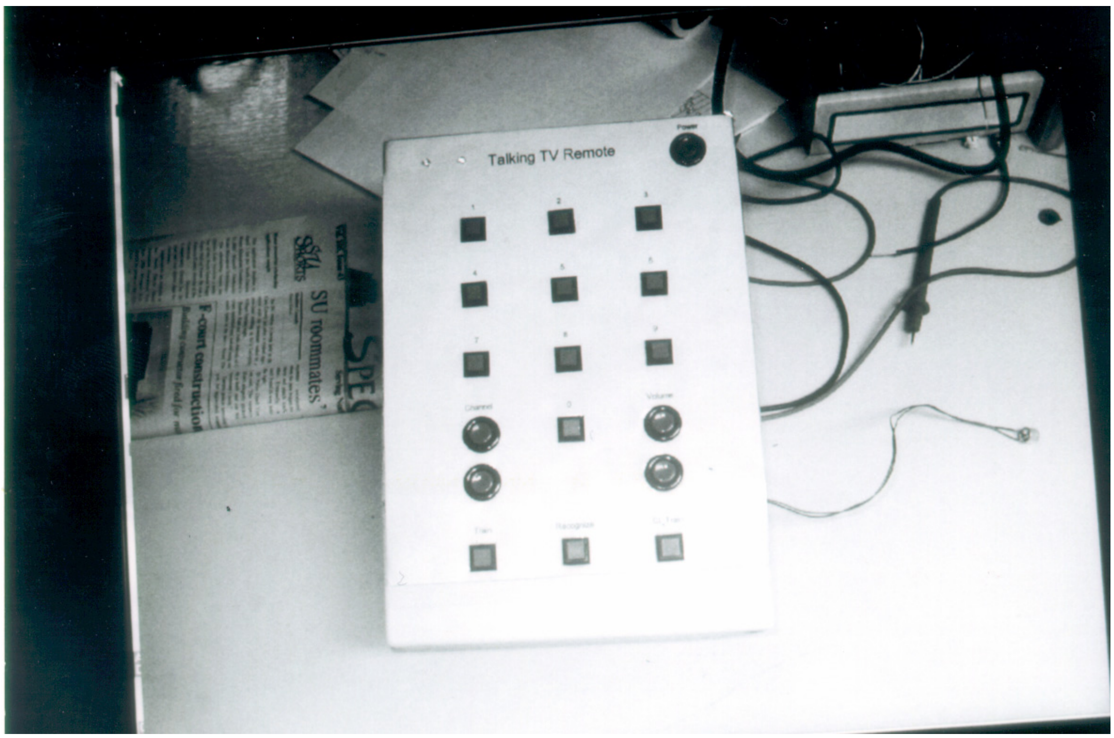

Figure 10.3. Voice Controlled TV Remote.

SPEAKER VOLUME DISPLAY

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INTRODUCTION

Without the ability to hear well, hearing impaired speakers are unaware of noise levels. Hearing background noise allows people to adjust their conversation level so they are not shouting in the library or whispering at a loud concert.

For a person who has normal hearing, the intensity of his or her own voice can be self-monitored in the context of background noise. Typically, when a person talks, he or she gets feedback from the listener as to whether speech is too soft or too loud.

The goal of this project is to create a device that will assist individuals with hearing impairment in adjusting their voices to the level of room noise. This device must be discrete so as not to draw attention to the user.

SUMMARY OF IMPACT

This device will give a speech–language pathologist a tool to help patients learn how loud they should talk in different environments. By simply looking at a display, they can judge how loud the background noise is as well as how loud they are talking.

TECHNICAL DESCRIPTION

Two units were developed for this device: a base unit that monitors the background noise and displays both the speaker's voice intensity and the background noise, as well as a handheld unit that monitors the speaker's voice. The base unit contains the background noise microphone, a Panasonic

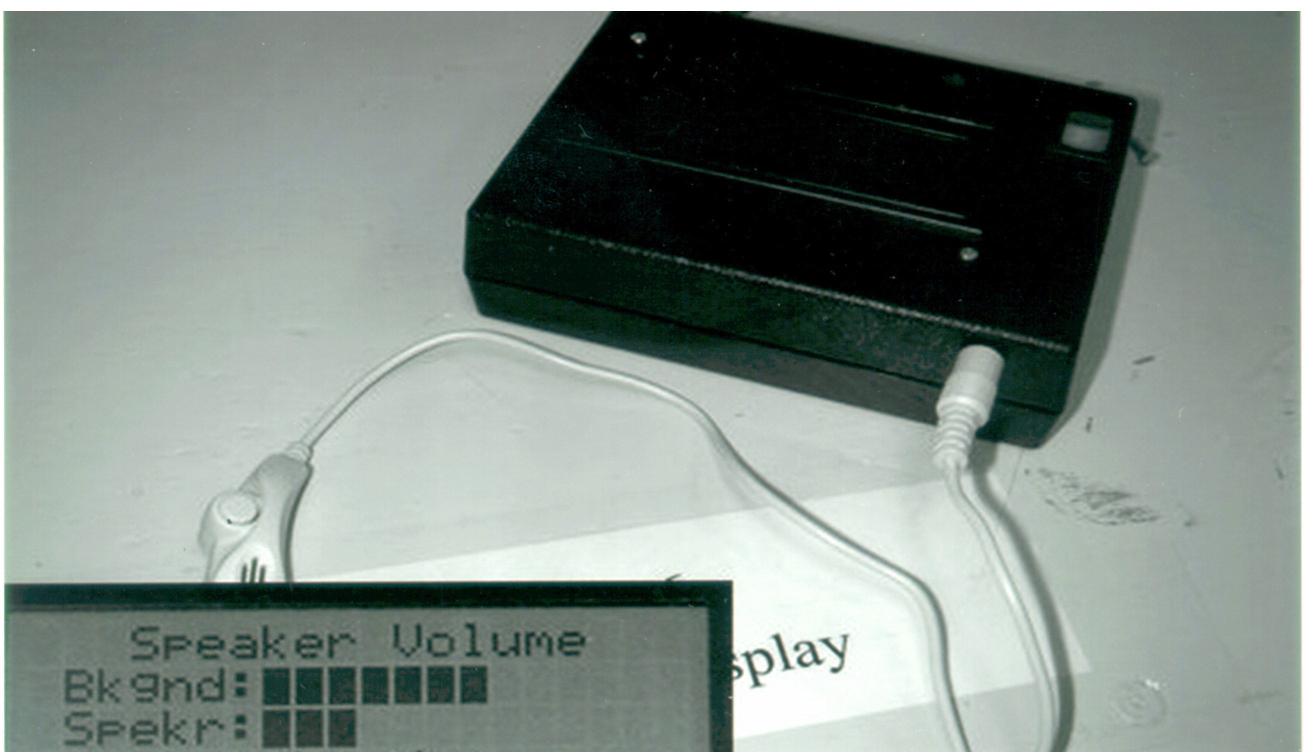

Figure 10.4. Speaker Volume Display.

WM-60AY. The speaker's unit contains a lavaliere omni-directional microphone. Signals from both microphones are passed through a 200Hz - 12kHz band-pass filter. These signals are then rectified and low-pass filtered with a one Hz cutoff frequency. The magnitude of this rectified signal is then proportional to the sound level detected by each microphone. This level is monitored with a 10-bit A/D using a PIC16F876 microcontroller. This microcontroller subsequently drives an LCD display, with a bar chart indicating the volume of the corresponding signal.

The goal for the speaker is then to make the voice bar match the length of the background bar.

A nine-volt battery, which powers the unit, is specified to provide 595 mA.hrs. The Speaker Volume Display draws 25 mA of current. Therefore a simple calculation shows that the system's battery life is approximately 24 hours.

The Speaker Volume Display was tested from 30 dB to 90 dB in the controlled environment of a concert. Thirty decibels is the noise level found in a very quiet room, although most quiet rooms contain noise levels of 40 decibels due to fans and other noises. Ninety decibels is a very load environment comparable to what may be found at a loud concert or bar. One potential concern was that the device may be overloaded in the upper decibel ranges and the device would be rendered useless. However, testing revealed that the device will not overload in tests up to 90 dB.

Real world tests were also carried out. One was at a local establishment meant for recreation and revelry. This was a good test of the loud background range, in this case at or above 80dB. This real world test results were similar to those in the controlled testing. The device gave excellent feedback to the user if there was a need to talk louder.

Another real world test was done late at night at a bar with loud background noise as indicated on the LCD display. Overall, the display worked well in quiet and noisy environments.

The total cost of the speaker volume display was approximately $210.

ARCHERY AIMING SYSTEM

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INTRODUCTION

A device allows an individual with quadriplegia to perform the acts of aiming and firing a crossbow using simple controls. The device will allow the user to aim a crossbow in the x- and y-axis directions; when the crossbow is pointed at the desired location, the user will then be able to fire the arrow. The device has a targeting system so that the user will be able to see where the crossbow is pointed without being directly in the line of sight.

An aiming and firing device was created to be compatible with a normal crossbow. A micro-controller was used to read a program that will allow the user to aim and fire the bow. The PIC controls the motors in the stand, operating them at a slow speed. A LCD or LED visual display of arrows (left, right, up, and down) shows which way the bow is moving. A Jelly Bean pressure switch or joystick will allow the user to choose which direction they would like to move the bow. Once the bow is aimed properly, the user will be able to fire using the same controller.

SUMMARY OF IMPACT

The recipient has had quadriplegia since a car accident six years ago. Since then, she has defied doctors' predictions by learning how to talk, how to eat with the help of others, and even how to use a computer on her own. In order to become a more independent, the client would like to be able to again participate in some of the hobbies she enjoyed before her accident; one of these activities is archery. Currently there are many archery systems to aid people with paraplegia or quadriplegia. Unfortunately there are currently no devices to help people with C-2,3 quadriplegia. The goal of this project, using ideas from systems already available, is to design a system that will allow the client and other individuals with quadriplegia to aim and fire a crossbow utilizing a minimum number of inputs.

Figure 10.5. Archery Aiming System.

TECHNICAL DESCRIPTION

To operate a crossbow as shown below, the operator must be able to aim the crossbow, turn off the safety, and fire the crossbow. In addition, the crossbow must be mounted to a stand with the servo motors controlled by the operator.

User Controls

An off-the-shelf operator interface called Jelly Bean was selected as the best option for the user's input. This is mounted onto the wheelchair utilizing a home-made telescoping arm.

Visual Display

The visual display consists of an array of color-coded LEDs. As seen in the panel display diagram, Figure 10.6, the colors of the LEDs correspond to the different functions of the device. The PIC logic controller is mounted on the same circuit board as the panel display. The PIC was chosen due to its ease of use and familiar programming.

Stand

The panel display is connected to motors located on a tripod stand. A motorized pan head (Bescor

Model MP-101) is attached to a tripod and used to move the crossbow in the horizontal and vertical directions. The pan-head can be removed from the tripod for easier portability. Also, the pan-head has its own separate power source consisting of four AA batteries. A tripod was chosen as the stand because of its ease in setup and portability. The tripod chosen was the Bescor Medium Duty Fluid Head Model TX-25. This model is rugged and durable enough to withstand normal environmental pressures. The tripod includes rubber feet and leg spikes for a sure grip on most surfaces. The mount on the top of the tripod will need to be modified in a way so it can hold a crossbow.

Visual Aiming

A laser was chosen for the visual aiming aspect of the system. Since the crossbow is to be mounted to the side of the user, and since the user has limited head movement, an aiming device is required. The laser will allow the user to see where the arrow is being aimed at on the target by watching the projected laser beam. The type of laser chosen is a BSA weaver-mount laser Model LS650 and has its own battery power supply.

Solenoid Trigger

A pneumatic solenoid switch controls the firing of the crossbow. It is attached either to the stock of the bow or to the mount of the tripod depending on the model of crossbow given to work with. Once the pneumatic solenoid is energized, it will allow air pressure to depress the trigger, therefore operating the release and firing the arrow. The 6V DC linear solenoid was not used since it could not generate the six pounds of pressure required to depress the trigger of the crossbow.

Power Supply

Most of the major components used in the aiming and firing device (i.e. the pan-head and laser) come with their own power supply. The only other components that require a dedicated power supply are the circuit board and the PIC controller. The PIC microcontroller requires a power input of five VDC, which is provided using AA batteries. This power supply is located in the user panel with a removable section on the casing where the batteries can be interchanged. The solenoid needed to depress the trigger on the crossbow requires a source of 24 VDC. The source used to provide this power is the two 12 VDC batteries used to motorize the user's wheelchair.

Operations

The assembly of the crossbow begins with the stand. The stand must be extended to the height the user wishes to use it at and then be locked into place. Once the stand is set up, the pan-head is attached to the top of the stand by flipping the black lever outwards and then releasing the lever so the pan-head is securely in place. After this, the air cylinder unit is placed on top of the pan-head and screwed securely in place by turning the round disk-like lever. The crossbow is now ready to be put on top of the air cylinder unit. The crossbow slides into place using the two pegs on the surface air cylinder unit. The user interface (LED screen) is attached to a telescoping arm that is then attached to the user's wheelchair. The Jelly Bean is then attached to a telescoping arm, which is adjusted to the user's cheek. The Jelly Bean and air cylinder unit are attached to the user interface through their proper cords. The motor's cord is attached to the pan-head and then to the user interface. The air cylinder is powered by the 24 VDC source on the user's wheelchair through another cord. The stand and crossbow should be set off to the left of the user. The system is now ready to be used.

To begin the program, the on/off switch is turned on, which allows power to flow to the circuit. The LED lights are initially off. The mechanical safety on the crossbow may be set to fire position once the user is ready to use the system. Once the user has pressed the Jelly Bean, the initial LED sequence begins; the AIM light turns on and then off, followed by the SAFETY light turning on and then off. This sequence is continued until the user either chooses AIM or SAFETY. Once the user has chosen AIM, the directional arrows, UP, RIGHT, DOWN, LEFT, and EXIT toggle on and off in the previously mentioned sequence. The user may then choose a direction to aim the crossbow by depressing the Jelly Bean when the correct LED is lit. The crossbow will then move in that direction until the Jelly Bean has been pushed again. After the aiming in that direction is complete, the directional LED sequence will automatically start with the EXIT LED again. If the user wishes to leave the directional sequence, the Jelly Bean is to be pushed when the EXIT LED is lit. This will take the user back to the AIM/SAEFTY sequence. The user may then go to AIM again or may choose the SAFETY LED which will take the user to the FIRE /EXIT mode that allows for extra safety when preparing to fire. This way, the user must push the Jelly Bean to either FIRE or EXIT, in this sequence.

The EXIT will take the user back to the AIM /SAFETY sequence while pressing the Jelly Bean when the 'FIRE' LED is lit will fire the crossbow. Once the crossbow has been fired, the sequence is stopped and the Jelly Bean must be pushed in order to start the AIM/SAFETY sequence again.

The total cost of this device was $429.

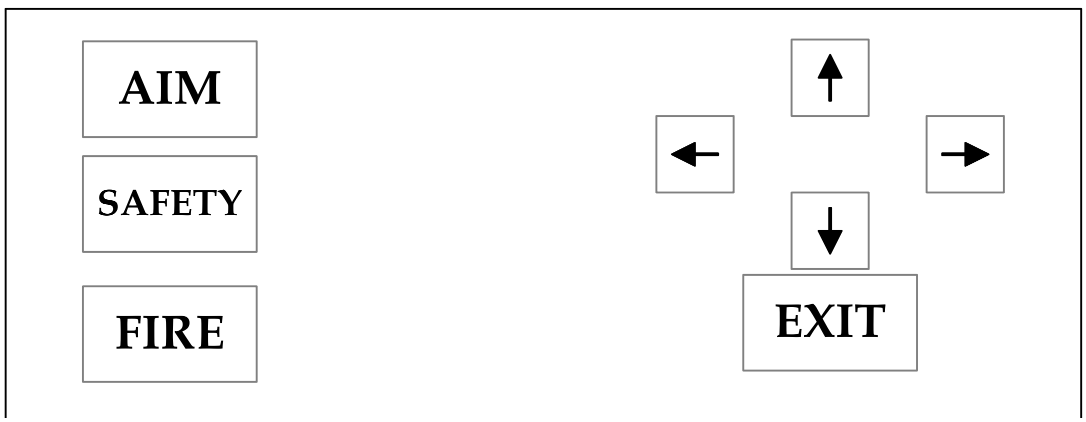

Figure 10.6. Panel Display.

CHAPTER 11
RENSSELAER POLYTECHNIC INSTITUTE

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GOLF CART RETROFIT FOR GOLFERS WITH DISABILITIES

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INTRODUCTION

Over the last year, student teams have been pursuing the goal of a practical retrofit for conventional golf carts that will permit individuals with disabilities to enjoy the game of golf. The current version (Fig. 12.1) is designed for golfers with paraplegia, but could also be useful for people with a variety of conditions where it would be convenient to play without having to leave the golf cart. This design is innovative in that it offers features similar to those on golf carts devoted to a user with a disability such as the Club Carts Solorider, but because it is a retrofit to a regular golf cart, it promises to have a much lower incremental cost. Currently available specialty golf carts range in price from $4,000 to $10,000. The goal was to design a retrofit kit that would have a manufacturing cost in the range of $1000 at a production level of about 50 and could sell in the range of $1,500, including hand controls. To the authors' knowledge, no one offers comparable golf cart retrofit kits.

SUMMARY OF IMPACT

Participation in sports can play a critical role in improving the mental and physical health of people with disabilities. Golf is one activity that people with a disability who have sufficient upper body strength and limited or no use of their legs can play and enjoy. However, there is a significant barrier to wider participation because the cost of specially designed golf carts has made it impractical for golf courses to provide them. This means that golfers with disabilities need to invest in their own fairly expensive units. If the golf cart retrofit that is being developed is successful, it would remove this barrier. Golf courses might then find it to their advantage, or even be required, under the American's with Disabilities Act, to provide this accommodation and provide independent access to golf for millions of individuals with disabilities.

Figure 11.1. Golf Cart Retrofit Undergoing Field Trial.

TECHNICAL DESCRIPTION

The current design includes several simple elements, that when incorporated together create a unit that allows sliding from a driving position to a playing position, a comfortable all-weather seat that pivots and locks, and a hand control for driving without use of the legs. The main structure of the seat system consists of a track structure that replaces the normal golf cart seat. The sliding seat frame is supported in the track by four rollers. An electric motor moves the seat between the driving and playing positions. In Fig. 12.2, the assembly that provides the basic functions required for a disabled golfer to play from a seated position is shown. The person translates the seat to the side of the cart by actuating the electric motor. The seat is then rotated to the outside of the cart for hitting the golf ball. A right-handed golfer swings toward the rear of the cart. The golfer is supported by a harness of the type used by rock climbers that provides support without interfering with upper body motion. An optional midriff-level seat belt support is also provided.

The design also includes hand controls that actuate the brake and accelerator without use of the legs. A commercial automobile hand control modified for the golf cart was tested as well as a specially constructed hand control as part of the retrofit kit. Both controls work, but tests indicate that the hand control that was designed for the golf-cart is more effective and less costly than the modified automobile hand control. The specially designed hand control is shown in Fig. 12.3.

The cost of parts/material used for the field test prototype with the specially designed hand control is about $500.

Figure 11.2: Seat Assembly in Playing Position.

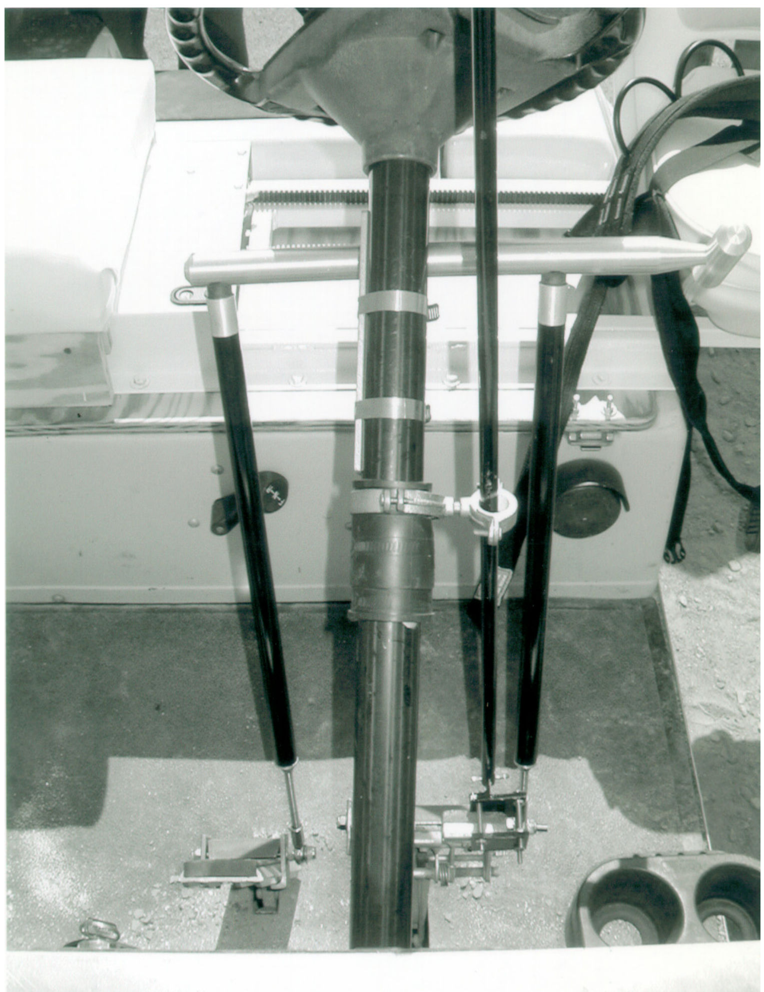

Figure 11.3: Hand Controls.

ADAPTIVE FEEDING DEVICE

Designers: Eric Kemner, Erik Wengart, Molly Zazenski, Meagan Mares, Ryan Hevner, Lauren Smachetti, and Jerry Amato.
Supervising Professor: Dr. Mark W. Steiner
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INTRODUCTION

The purpose of this project was to design and build a device that would allow a young boy with Cornelia De Lange Syndrome to eat more autonomously. Cornelia de Lange Syndrome is a congenital disorder that includes digestive problems, deformities in the lower arms, and mental retardation. Because of these problems, the client has to be fed by a caretaker. The adaptive feeding device is designed to allow the client, lacking a conventional hand, to use a spoon to bring food from the tabletop to his mouth. The device consists of a neoprene sleeve, spoon, two bearings, a collar, a bearing holder, a brace, and a counterweight.

SUMMARY OF IMPACT

The client lacks wrists that would normally provide him with the rotational movement needed to keep a spoon level, and fingers to properly grasp a spoon. Therefore, without a device to provide for these functions, the client is unable to grasp and manipulate a spoon. The adaptive feeder provides for these functions and, if successfully integrated into the client's daily routine, could have a profound positive impact on his eating habits.

It is also possible that this device, through simple modifications of the size and shape of the brace and sleeve, would be adaptable for other people with similar disabilities. It is possible to attach other devices to the end of the bearing holder such as paintbrushes, drawing implements, and a toothbrush. This would add to the versatility of the device and expand its relevance to a broader spectrum of application.

Figure 11.4 –Adaptive Feeding Device.

TECHNICAL DESCRIPTION

The most essential element of the adaptive feeding device is the bearing holder. The bearing holder acts as the housing for the spoon and bearings, which are the moving parts of the device, and is the attachment point for the brace that secures the entire device to the user. It is machined out of Delrin, a plastic that is FDA approved for contact with food, and has an extremely high strength to weight ratio. This provides the client with a lightweight device that will not require great effort to manipulate, as well as a durable product that can stand up to the wear and tear of a young child.

Inside the bearing holder are two plastic/glass bearings. They are press-fit mounted at the front and rear of the bearing holder so that they can be replaced without much difficulty. The spoon, made from stainless steel, slides into the bearing holder and sits firmly in the two bearings. A small C-clip prevents the spoon from sliding too far back into the holder, while a collar at the rear of the holder tightens down on the spoon to prevent it from sliding out of the device. The counter weight is mounted to the bottom of the collar and rests behind the bearing holder so it is out of the way while the device is in use.

The working end of the device is attached to the client's arm with a brace and a specially fitted neoprene sleeve. The brace is made from a thermoplastic casting material donated by Chesapeake Medical Products, Inc. It is molded to the shape of the client's arm and can be adjusted for growth by simply heating and reshaping it. The brace is attached to the bearing holder using nylon screws. It must be noted that due to the material properties of the thermoplastic, the brace must be cleaned with cold water. The neoprene sleeve is designed to wrap around Will's arm and uses hook and loop (i.e., Velcro) fasteners to adjust and attach to the underside of the brace. The neoprene sleeve can be detached and cleaned in a washing machine.

Figure 11.5 – Final Prototype and Exploded CAD Assembly.

The total cost of the adaptive feeding device is $450.

CHAPTER 12
STATE UNIVERSITY OF NEW YORK AT BUFFALO

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ADAPTIVE VIDEO GAME CONTROLLER

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Supervising Professor: Dr. Joseph C. Mollendorf
Mechanical and Aerospace Engineering Department
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INTRODUCTION

This project addresses the problem that children with disabilities face when using video game controllers with many small buttons. Some clients do not have the motor skills required to use many toys traditionally used by other children the same age. Playing video games will help these children develop better motor skills and hand-eye coordination.

SUMMARY OF IMPACT

With this device, children now have the capability of playing a video game. They can also play with and compete against others.

TECHNICAL DESCRIPTION

This project is based on the game "Sonic the Hedgehog" for the Sega Genesis. This is a simple game that consists of a character running and jumping. Once properly set up, the game can be controlled by only two buttons on the video game controller.

Almost any child could use this controller. Since each added button is run in parallel from the original controller, either the original controller buttons or the auxiliary larger buttons can be used. This allows the game to be adapted to different children and also allows another person to play with that child.

To keep this device versatile, the added larger buttons are connected to a headphone type plug on the front of the original controller. Fig. 12.1 shows this connection. The universal connection allows each child to use his or her own button, with a choice as to the part of the game to operate (i.e., making the character run or jump).

The device was designed by using the original controller and adding two headphone jacks on its face. This allows the original controller to be used without modification or it can be adapted with additional larger buttons. When using the added larger buttons, the controller is still completely functional as before but there are additional wires from that headphone jack to the added buttons.

With the intricacies of the controller's circuit board, a way to connect a parallel circuit before the main processor that is attached to the circuit board was needed. The best way was to connect the circuit close to where the original buttons were on the controller.

A small hole was drilled in the circuit board through the positive side of the circuit path; this was done to separate the paths. A ground was made at a common ground to keep it from interfering with the other circuit paths. Fig. 12.2 shows how the connections were made.

An area on the face of the controller offered the space required to mount the headphone jacks. Holes were drilled for the jacks and routed the wires so that could the controller faceplate and backing plate could be reattached when finished.

The total cost of this project was $25.

Figure 12.1. Controller with Auxiliary Button.

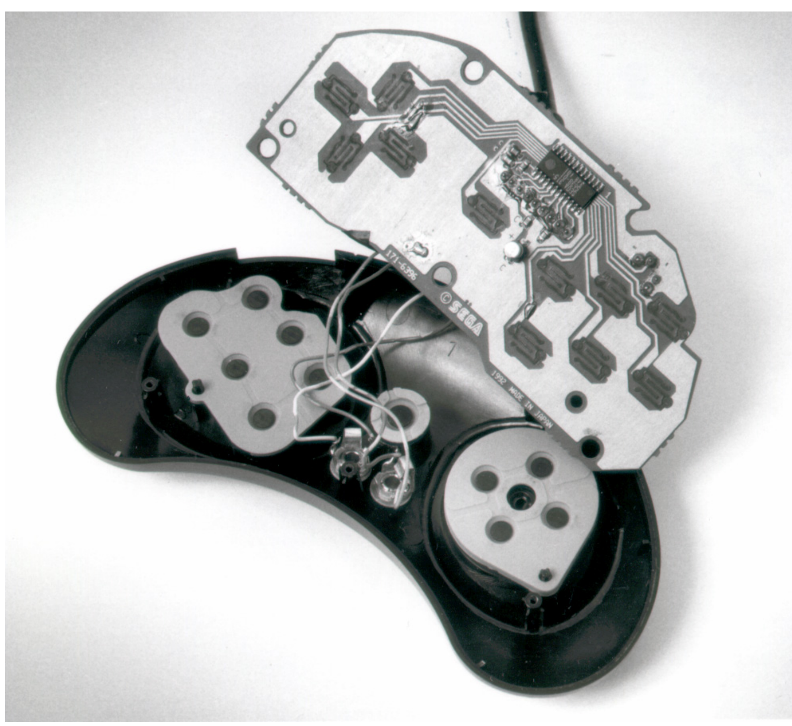

Figure 12.2. Circuit Connections Inside the Controller.

BI-FOLDING REFRIGERATOR DOOR TO FACILITATE ACCESS

Student Designers: Ben Kaye, Paul Near, and Kenneth Class
Supervising Professor: Dr. Joseph C. Mollendorf
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INTRODUCTION

This project addresses problems that affect people in wheelchairs, on crutches, using walkers or having any general mobility problem. People with such mobility problems have difficulty trying to accomplish a task while moving. One result of this problem is the difficulty in opening a refrigerator door while standing in front of the refrigerator. A standard refrigerator has a large opening radius for the door as shown in Fig. 12.3. As a result, the door cannot be opened while a person is still standing in front of the refrigerator.

Figure 12.3. Standard Refrigerator Door.

SUMMARY OF IMPACT

By taking a regular refrigerator and implementing a bi-folding door, the turning radius of the refrigerator door was drastically reduced. As a result, a person with a mobility problem will be able to stand in front of the refrigerator and open the door without having to move at the same time. In addition, other points were considered such as making sure that the shelving could slide out towards the person, and the controls for the refrigerator were not located in the back (as they most often are). This modification allows the refrigerator controls to be adjusted without much effort.

TECHNICAL DESCRIPTION

The design that was considered took advantage of the existing door on the refrigerator. This door was converted into the bi-folding door by cutting the original door in half and then placing a hinge on the center of it. Since the door folds in the center, it is important that to not have any gaps that would allow cold air to leak out. Another basic requirement of the design was to make a track to guide the door as it was opened and closed; the track was constructed from aluminum with two aluminum brackets welded to it. Figures 12.4 and 12.5 show the opened and closed bi-folding refrigerator door.

Figure 12.4. Opened Bi-folding Door.

Figure 12.5. Closed Bi-folding Door.

Another essential part of the design was the seals of the refrigerator door. Since the door is bi-folding, the seals could no longer be attached to the inside of the door because the seals would not allow for the door to fully open. New seals were designed and attached to the face of the refrigerator itself. The door closed against the magnetic strips that were placed on the seals. This prevented cold air from leaking out of the refrigerator. Seals were also placed in the seam of the bi-folding door so that when the door closed, air would not leak out through the center of the refrigerator.

The total cost of this project was $327.

BOTTLE TWISTER ASSISTER: A DEVICE TO ASSIST PERSONS WITH LIMITED USE OF HANDS TO OPEN TWIST BOTTLES.

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INTRODUCTION

A large number of people have limited to no use of their hands. This category of people includes the elderly and those with conditions such as muscular dystrophy, cerebral palsy, and arthritis. This design problem is to create an assistive device that would alleviate some limitations that the individuals face. The major focus of this design project is to create a device to assist people in opening twist top soda bottles or other similar type bottles. The design is to be simple and lightweight so that a person can use it with ease. An assumption for this project is that the person operating the device has enough use of their hands to hold a bottle while handling the device.

SUMMARY OF IMPACT

The impact of this device is that it will ease the everyday frustrations that people encounter when attempting to open twist type bottles. By doing so, it will satisfy the need for self-reliance and increase the confidence of the user. The simplicity of this design will allow for a practical and user-friendly device.

TECHNICAL DESCRIPTION

Three designs were considered, however each one uses the same general concept similar to that of a candlesnuffer. Each device utilizes a cupping device that fits over the cap of the bottle. Along the inner surface of the cupping device are sharp radial teeth that allow a strong grip on the bottle cap once a torque is implied. The concept resembles that of a common nutcracker-like bottle-opening device that has a split handle which wraps around the bottle cap.

The first design is a single handle device that increases the torque generated by the twisting motion used to open the bottle. The handle is made of a solid aluminum shaft to decrease the weight of the device. The cupping device allows for the handle shaft to slide, providing various lever arm distances. Upon application of a perpendicular force to the lever arm, an increased torque due to the long lever arm is generated, and the bottle opens with ease. The lever arm also contains an ergonomic handle to allow a better hold of the device. The T-bar configuration of the slider arm aids users who cannot close their fingers around the bottle cap when opening a bottle; this configuration allows for a better grip.

Figure 12.6. Three Bottle-Opening Designs.

The second and third designs also contain the cupping feature used to grip the bottle cap. However, these designs contain different handle concepts than that of the first design.

The second design uses a thick foam padding that is added to the outer surface of the cupping mechanism. The purpose of the foam is to create a larger grip diameter around the bottle cap. This extension creates a larger, more comfortable grip around the small bottle cap that is often a source of frustration. This design is more compact and convenient than the first design; however it does not offer as much torque when opening a bottle.

Finally, the third design is generated using the same concept as the first through the use of an extended handle shaft. However, the handle for this design features a ratchet mechanism attached to the cupping device. The ratchet feature decreases the range of torque motion required to open the bottle, thus making it more convenient for users with limited hand motion. Similar to the second design, the shaft of the ratchet also contains foam padding as well as a strap; the strap is placed over the users hand to facilitate a stronger grip. The ratchet design also features the cupping device as a detachable part similar to a socket attachment of a socket wrench. Thus, this device can be used as a regular socket wrench that has a more padded comfortable grip and a secured adjustable strap.

Fig. 12.6 shows all three device designs. Starting at the top moving counterclockwise is the sliding handle shaft design, the compact padded handle-less design, and the ratchet handle design.

The torque generated by this device is a function of the radial position of the input force multiplied by the input force of the user. Without the use of this device, the torque generated to twist the bottle cap would simply be the radius of the bottle cap times the input force, as shown in Fig. 12.7a. Using a device with a lever arm to twist the bottle cap increases the torque generated by a factor of the ratio of the extended radial distance to the radius of the bottle cap shown in Fig. 12.7b.

For the first design, utilizing a sliding handle shaft allows for a range of torques to be generated using the same input force. The sliding handle shaft mechanism consists of a bearing and spring interaction which lock into small radial grooves along the handle shaft. The location of these grooves determines the torque generation factor. An average bottle top radius is determined experimentally and is approximately 0.06025 inches. Using this specification and the torque ratio equation, various torque factors are determined.

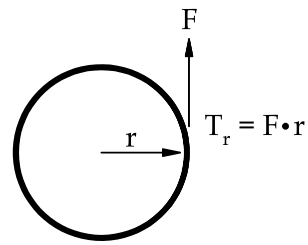

Figure 12.7a. Torque Required to Open Bottle.

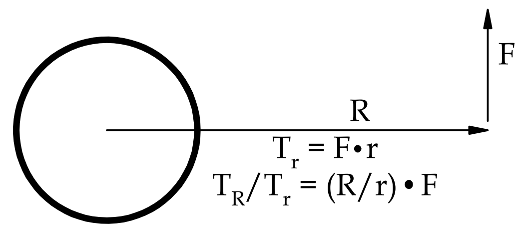

Figure 12.7b. Calculation of Torque Ratio Factor.

To accommodate different types of bottle caps, the cupping device has an angled edge. A straight (90°) angle will only fit one bottle cap size. However, if the angle is reduced slightly, the cupping device can accommodate a variety of bottle cap sizes. It should be noted that the angle must be straight enough to maintain enough grip to turn the cap. An edge angle of 81° is found to be optimal to accommodate various bottle cap sizes.

The total cost required to implement these design models was approximately $30.

DOOR LEVER: A DEVICE TO FACILITATE EASIER OPENING OF DOORS THAT USE A KNOB

Designers: Dennis P. Brady and Bryan C. Silverblatt
Supervising Professor: Dr. Joseph C. Mollendorf
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INTRODUCTION

Twisting a doorknob poses a significant challenge to many people. An adapter that transforms a doorknob into a lever is was designed. This mechanism utilizes a large moment arm and a self-locking design to transform the twisting motion of the hand into a larger, linear, action of the arm that effectively converts a doorknob into a door lever.

SUMMARY OF IMPACT

An assistive device was designed to convert the twisting action used to open a doorknob into the movement of a lever. The user will be able to turn a doorknob, utilizing the increased leverage created by our device, with a subsequently easier and broader motion. The system of links squeezes harder on the doorknob as the moment arm is pushed downward, ensuring its grip as rotation begins. The design also does not interfere with the doorframe, as it has a low profile around the doorknob. Overall, this device will provide an easier experience for those who have difficulties turning doorknobs.

TECHNICAL DESCRIPTION

By pushing the doorknob into the joint, between the flat and angled inner edges of the mechanism, the device closes in upon itself. As the mechanism is pushed in further, or as the handle is moved downward around the doorknob, the device closes in with greater force and uses friction to create a firm grip. The inner edges of the device are lined with rubber to further ensure this.

Many aspects were considered in the design process to ensure practicality and reliability. The final design for this device has the following features.

Self-locking – The device locks itself on the doorknob and does not rely upon the strength and ability of the individual. By design, the device grabs onto the doorknob and uses friction to ensure a solid grip throughout the entire movement.

Figure 12.8. Opened Device.

Lightweight – The device is formulated from polycarbonate. This material makes it strong, durable, and lightweight. This facilitates the ease in which it can be used by those with limited strength as well as making it portable.

Easy to Use – The handle of this device is placed as far away from the doorknob as possible to allow maximum leverage without being cumbersome to the user.

Compatibility – This device works for various doorknob sizes. There are no restrictions imposed on its movement by the door jam, doorframe, depth or shape of the doorknob.

Functionality – The device works for doorknobs located on the left and right hand sides of the door. There are also implications for use in other twisting motion applications (i.e. opening and closing jars and other similar items).

Aesthetics – In order to promote the marketability of the mechanism, aesthetics were considered. The design and material used are selected such that our device is not intimidating or complicated.

When closed, the device has no open holes, gaps, or pinch points, which may cause a safety concern. The dimensionality of the design has been extended so that it closes in upon itself and maintains the same thickness throughout the mechanism. The project has been formed with three layers of 0.25-inch sheets of polycarbonate, and cemented together for thickness as needed. Pins in the joints also serve to insure that the layers maintain alignment, as well as provide mobility.

The total cost for the device was $44.

Figure 12.9. Device in Use.

THE E-Z SEAT LIFTER: A MECHANICAL DEVICE TO ASSIST IN LIFTING AND LOWERING A LAVATORY SEAT

Designers: Wendy McKenzie and Mark Newman
Supervising Professor: Dr. Joseph Mollendorf
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INTRODUCTION

The E-Z Seat Lifter is a device designed to assist the elderly and disabled with using the lavatory. The objective of this project is to allow people to lift and lower the lavatory seat without bending or overexerting their backs. The device is adjustable and can be applied to a variety of household toilets.

Once the E-Z Seat Lifter is installed, it will convert a small force into the complete routine motion of lifting and lowering the seat and cover. The use of a foot to apply the force makes for easy operation.

SUMMARY OF IMPACT

This device could improve functionality for the elderly or those with back problems. The addition to the market of a safe, easily functioning, and practical device would be a benefit to many.

Considerations in the design and construction of the E-Z Seat Lifter were size, aesthetics, durability, adjustability, and most importantly, cost. The E-Z Seat Lifter is constructed with an inexpensive budget to make it affordable for everyone.

TECHNICAL DESCRIPTION

The E-Z Seat Lifter is an assistive device that uses a foot pedal to mechanically lift the seat and lid of the lavatory. The frame of the device is made of stainless steel and aluminum. The lever is a metal plate (attached to the ground) with a pivot connection where a T-shaped aluminum bar is attached. The foot pedal is at one end of the T shaped aluminum bar, and a pivoting aluminum rod is at the other. Both the aluminum bar and the rod have various holes drilled at the connection points. These holes allow the mechanism to be adjusted so that it can be used on a wide variety of lavatories. The aluminum bar is fastened to a clevis joint and threaded rod. This is drilled into the stainless steel rod, which supports and rotates the seat and cover.

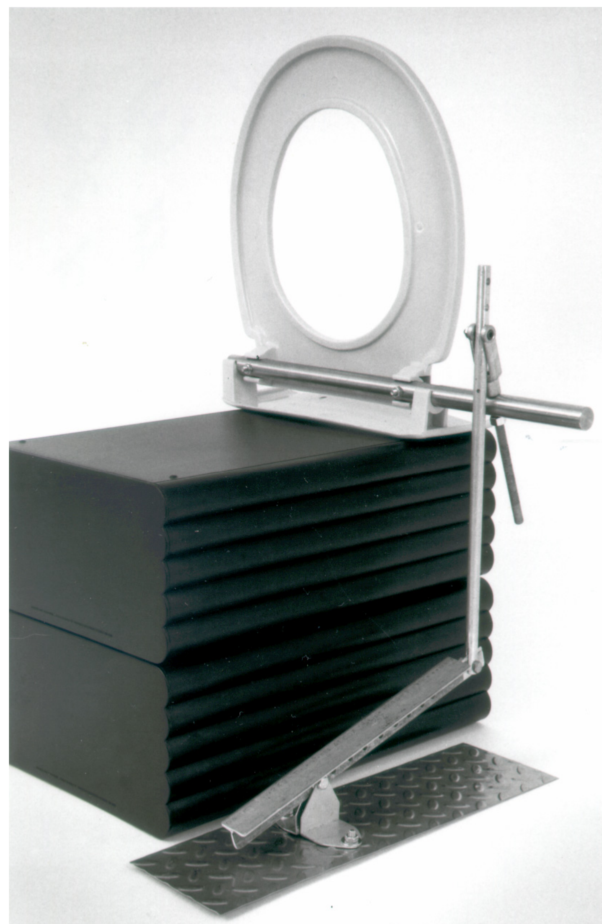

Figure 12.10. E-Z Seat Lifter in Upright Position.

The seat and cover are plastic and handicap certified. The cover can detach from the stainless steel bar and the seat can then be easily unscrewed from the lavatory. This feature allows adjustments to be made to the seat and lid. It also makes cleaning the device and surrounding area simple.

The device is placed to the side of the toilet. It sits in an obscure area where it does not obstruct the path of traffic or take up excessive space. While the majority of seats on the market are standard, two-piece hinged lids, the E-Z Seat Lifter offers an inexpensive, helpful alternative to the norm.

The overall cost of production was $47.

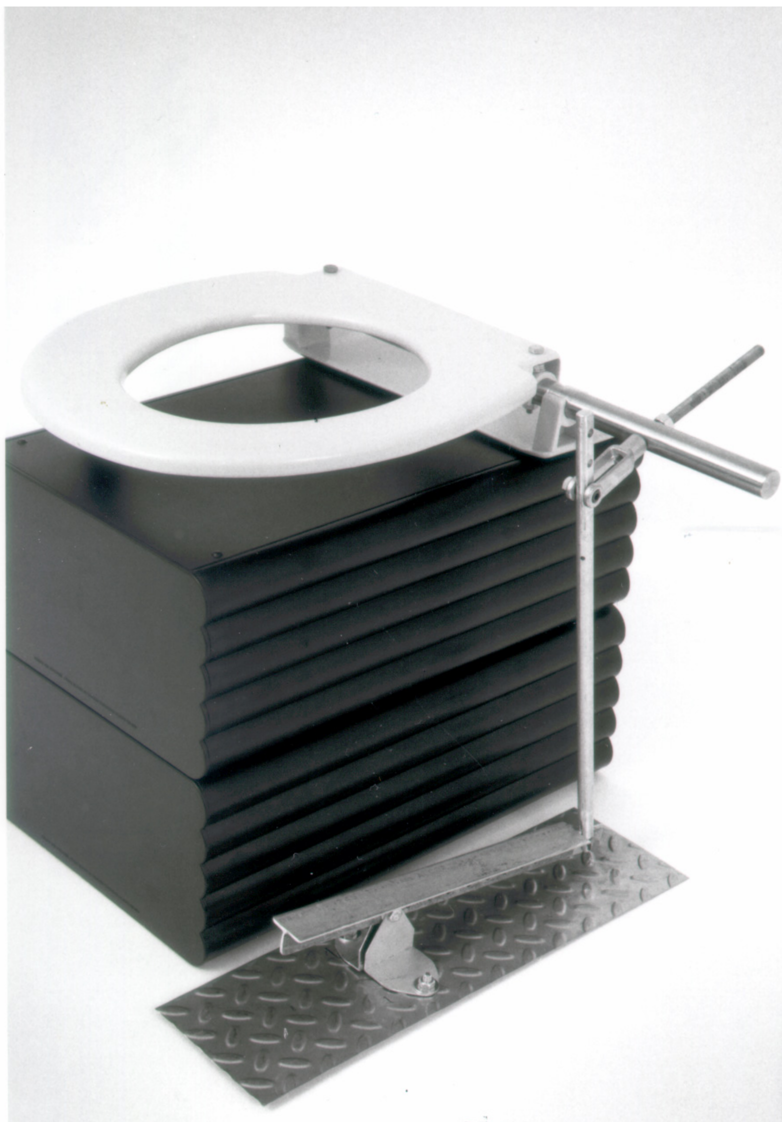

Figure 12.11. E-Z Seat Lifter in Closed Position.

THE GROCERY LIFTER: A DEVICE TO AID THE REMOVAL OF HEAVY OBJECTS FROM THE TRUNK OF A CAR

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Supervising Professor: Dr. Joseph C. Mollendorf
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INTRODUCTION

The goal in designing the Grocery Lifter is to develop a lifting system to help remove heavy items from the trunk of a car. There are several technical issues that must be addressed in designing such a product. First and foremost is safety. The device must not contain any sharp edges, have a limited number of pinch points, and the load must be secured on the device. In order to make the device durable and long lasting it must be able to exceed its recommended lifting capacity and be constructed to have adequate strength. Finally a power source is needed that will not only lift the load, but lift it in a reasonable amount of time.

SUMMARY OF IMPACT

The specific technical goal is to design the Grocery Lifter to raise a load of 200 pounds a vertical distance of 18 inches in under 20 seconds. This device will aid those who have difficulties lifting due to bad backs or other disabilities.

The design challenge is to find a motor that will provide the optimal torque to lifting rate ratio that

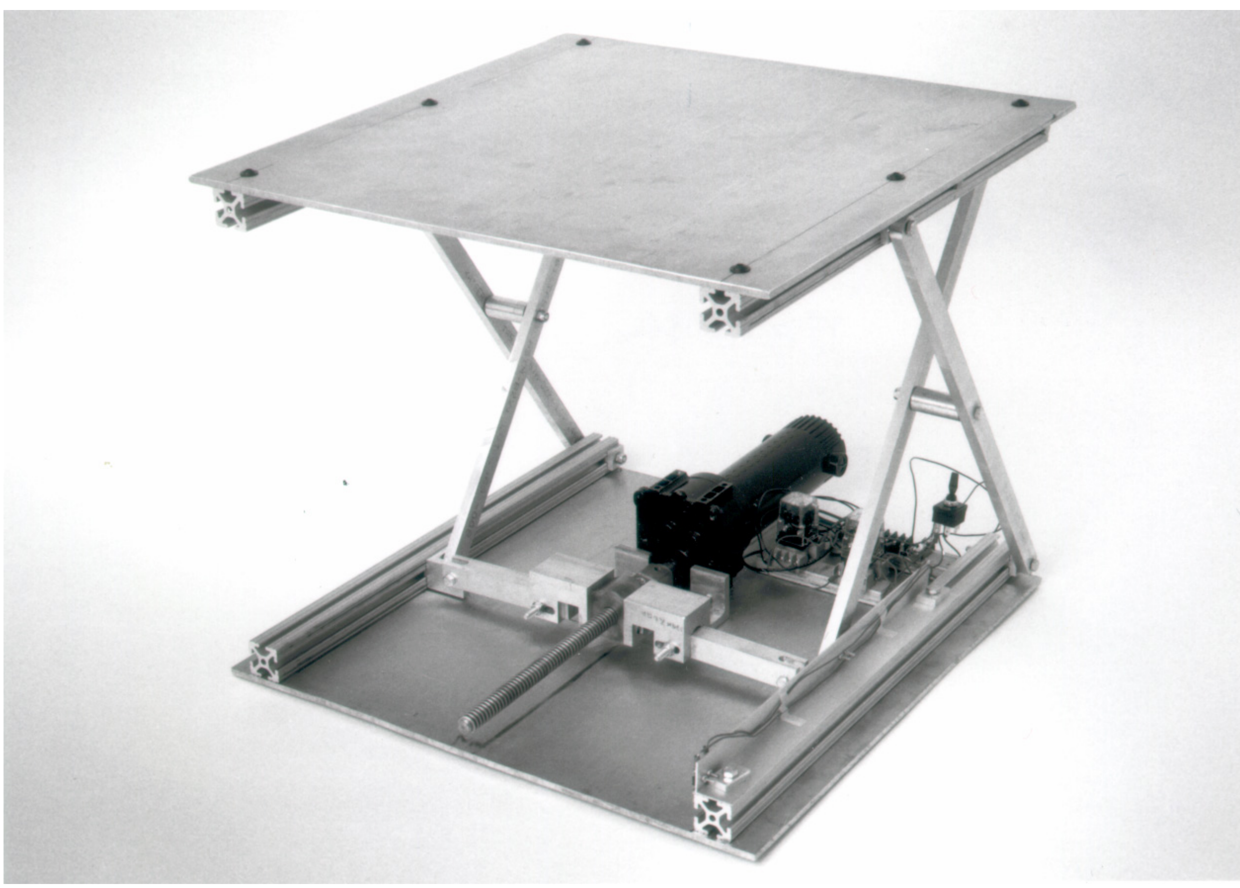

Figure 12.12. The Grocery Lifter in Open Position.

will meet the requirements of the project. Aluminum is used to build the device since it is high strength and low-weight. Since the lift is to be installed in the trunk of a car, the easiest source of power to use is from the car battery itself.

TECHNICAL DESCRIPTION

A single-shaft 12 Volt DC motor is placed in the center of the trunk and is used to turn an ACME threaded rod. When the motor is turned on, the rod turns through a nut that is connected to two bars that stem out from each side of the nut and run perpendicular to the rod. Each bar is connected to a sliding end of a pair of scissor type mechanisms at the base of the device. The scissors are connected at each end to 80/20 aluminum channels. Each pair of scissors has two fixed ends in the rear of the device and two ends that slide from front to back. As the scissors are slid from front to back by the rod, the table raises and lowers. A top plate is connected to the two pairs of scissors, creating a platform for objects to be raised and lowered on. Limit switches are used at the highest and lowest point to limit the travel of the top plate.

The goal of lifting a load a desired height within a certain time given power restraints has been met. The Grocery Lifter is an effective method for aiding in the removal of heavy objects from the trunk of a car. It has been built with durability, longevity, and safety in mind. Also, it can be easily installed in the trunk of a car and enables the trunk to remain functional when the lifter is not in use.

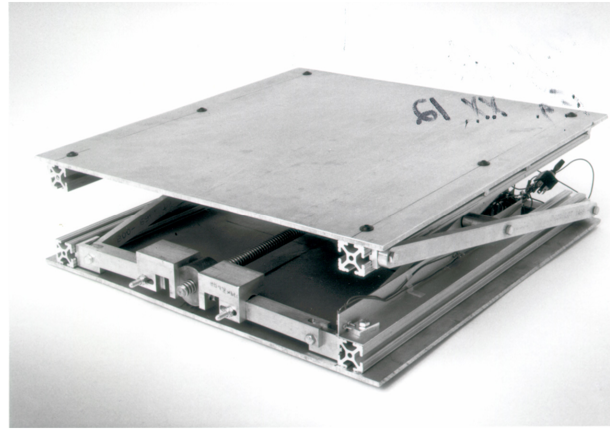

Figure 12.13. The Grocery Lifter in Closed Position.

The total cost of this project was $700.

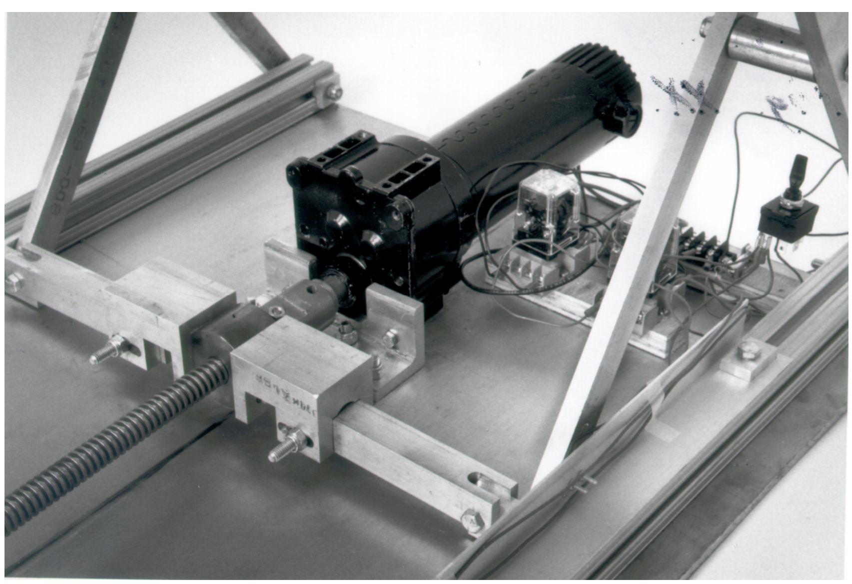

Figure 12.14. The Lifting Mechanism.

THE MELT MASTER: A DEVICE TO FACILITATE SALTING OF RESIDENTIAL DRIVEWAYS

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Supervising Professor: Dr. Joseph C. Mollendorf
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INTRODUCTION

During icy winter days people often spray salt on the driveway to melt the ice so it is not slippery when walking. It is unsafe for those persons with disabilities to walk or use their wheelchairs on icy pavement. The Melt Master is a device that will allow a person to spray the driveway with ice without having to move.

SUMMARY OF IMPACT

The Melt Master is to be placed at a fixed location that will allow the user to spray salt over the driveway from that fixed point. This will allow a person to spray salt on the driveway fairly easily and without needing to move. The salt sprayer is mounted at the end of a leaf blower motor, which will reduce the cost of the salt sprayer. The person can use the leaf blower to blow leaves during the fall and in the winter for the Melt Master. The Melt Master was tested to spray salt as far as 15 yards.

TECHNICAL DESCRIPTION

After removing the nozzle from the motor of the leaf blower, this motor can be installed into the Melt Master frame. The leaf blower motor is used since it operates on the same concept as the Melt Master. The Melt Master nozzle is composed of a venture, a valve, a salt tank, and a flexible spray hose. These components are displayed on the picture below,

Figure 12.15. The Melt Master with Frame.

with the exception of the flexible hose.

The Venturi is used to accelerate the air coming out of the leaf blower and creates a vacuum that sucks the salt from the salt tank. The valve is placed directly below the salt tank and regulates the amount of salt sprayed. The salt tank is used to hold enough salt to spray a standard driveway two to five times depending on the type of salt used. Finally, the flexible hose allows the operator of the Melt Master to direct the trajectory of the salt sprayed.

The total cost of this project was about $350.

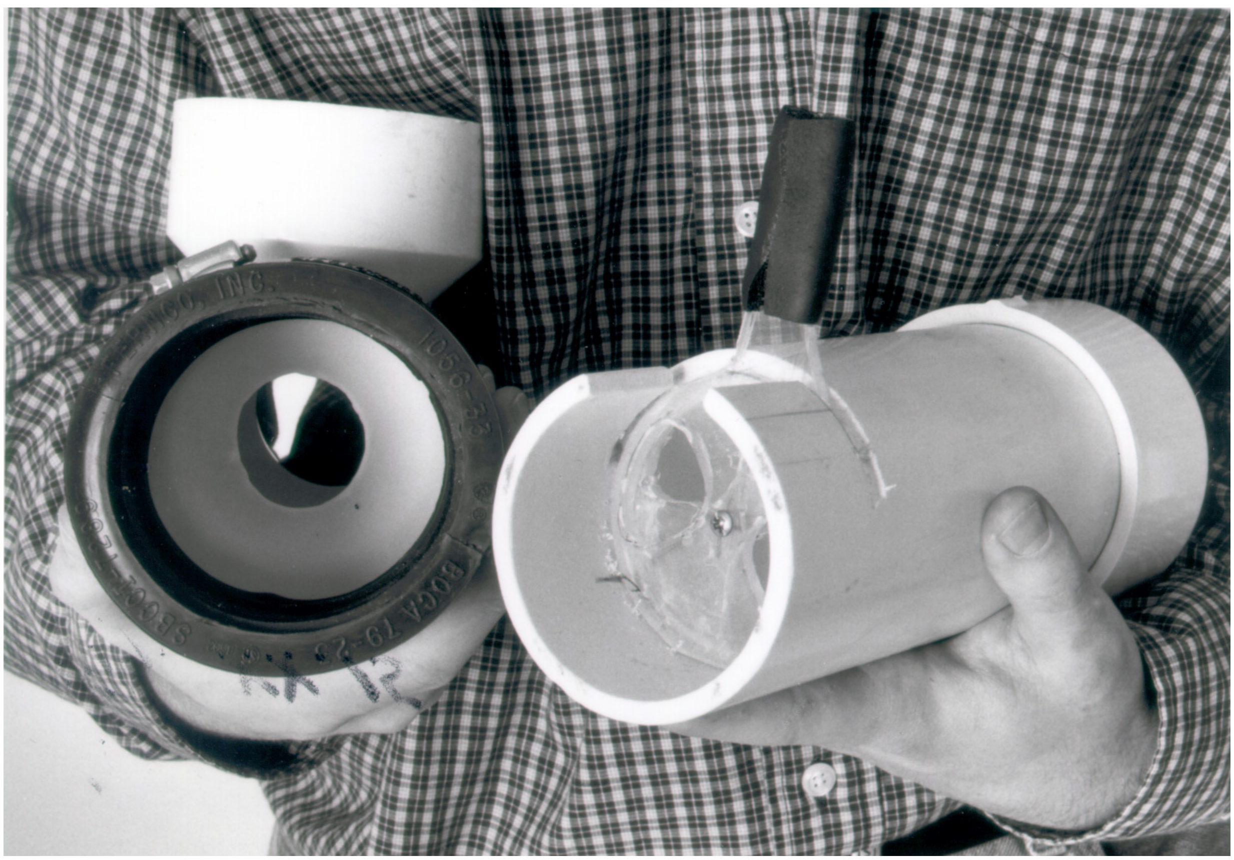

Figure 12.16. The Valve and Venturi.

THE SERVO CONTROLLED ROBOTIC ARM: A DEVICE TO AID IN MOVING OBJECTS

Student Designer: Daniel D'Alfonso
Supervising Professor: Joseph C. Mollendorf
Technical Advisors: Roger Krupski and William Willerth
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INTRODUCTION

The goal of this project was to design and build a robotic arm that would assist people in wheelchairs to move objects from one location to another. It was also a goal to design an inexpensive and simple system that could be used by anyone. The robotic arm that was designed for this project has many low cost yet functional qualities.

The device is intuitive and easy to operate, requiring little to no training. It is also adaptable to a wide variety of controller types (i.e. joysticks, puff-switches, microprocessors, speech recognition systems, etc.). The functionality and flexibility of this device makes it suitable for a wide range of users and user abilities. See Fig. 12.17.

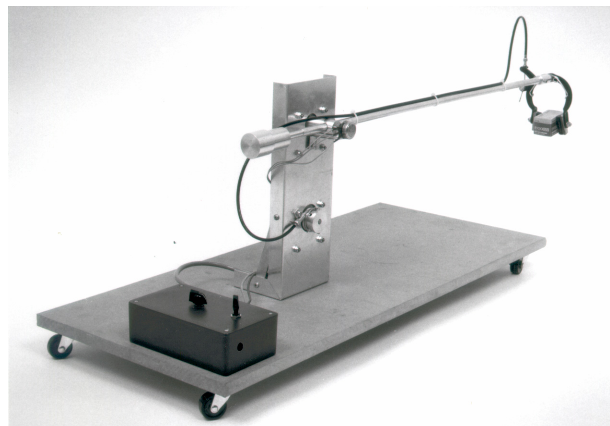

Figure 12.17. Servo Controlled Robotic Arm

SUMMARY OF IMPACT

The robotic arm that is developed in this project will give people in wheelchairs greater independence and more mobility, enabling them to utilize time more effectively.

TECHINCAL DESCRIPTON

The entire system can lift a maximum of one kilogram a vertical distance of 0.9 meters with a velocity ranging from 0.228-0.304 meters/second. The robotic arm itself is a 0.762 meter hollow aluminum rod with a 0.95 centimeter inner diameter. One 4.5 rpm, 12 volt, DC-motor with a 186W rating generates enough torque for both the static and dynamic loading conditions the device will undergo. Another similar motor is used as the gripper actuator to produce an estimated 0.0016N of gripping force. This allows for adequate gripping and holding power throughout the arm's entire range of motion.

The gripping mechanism is a slightly modified mountain bicycle brake caliper. The brake pads can be rotated to provide the optimal gripping configuration. The gripper is connected to the DC gear motor via an aluminum pulley, bicycle brake cable, and cable housing. The configuration of the brake housing ensures that the cable will not slip off of the pulley in addition to guiding it properly. In its current configuration as shown in Fig. 12.18, the gripping mechanism is able to pick up objects such as perfectly flat sheets of paper, dimes, cordless

Figure 12.18. The Gripping Mechanism.

phones, and clothing.

From the outset it was decided that only a 'proof of concept' device would be built instead of a full-scale version. This helped save money while still allowing the designers address all the technical issues of a full-scale model. Fig. 12.19 shows a possible location where the servo-controlled robotic arm can be affixed. The design is flexible enough to allow multiple attachment arrangements. Other features, such as a collapsible arm, would make storage of the robotic arm more convenient.

Servo-Motor Controller Description

The servo motor controller is built around a Motorola MC33030 DC Servo Controller integrated circuit (chip). Because the power requirements of the robotic arm exceeded the drive capability of the chip, an H-Bridge power amplifier is added between the controller chip and the motor. The H-Bridge circuit is designed to provide current feedback information to the controller chip to allow the over-current and braking functions to continue working while greatly boosting the drive capability of the servo circuit.

Servo Motor Operation

A DC gear motor is coupled to the robotic arm via an aluminum hub; also attached to this hub is a feedback potentiometer, this is shown in Fig. 12.20. The potentiometer provides position feedback information to the servo controller chip. The robotic arm is positioned by applying a control voltage to the servo controller chip. Depending on the applied voltage, the motor will rotate the arm, up or down, as required such that the output of the feedback potentiometer matches the control input. The controller chip also provides a dead band so that the robotic arm does not "hunt" or oscillate around the desired point due to mechanical inertia. Since the servo controller chip input is a simple DC level, it is easily adaptable to a wide range of controls such as a joystick, a puff switch, or even a microcontroller. The very low voltage DC control signal (0 to 5 volts) also makes the system inherently safe for the user.

Safety Features

The servo controller incorporates several safety features to protect both the user and the robotic arm itself. The most important safety feature of this controller is programmable over-current protection. The robotic are is designed to lift a maximum mass of one kilogram. This mass, along with the moment

Figure 12.19. Representation of Mounting Placement.

arm of the aluminum tubing, defines a torque requirement for the servomotor. This, along with the motor specifications, allows the selection of a maximum permissible motor current. This maximum current value is programmed into the servo controller circuit via a current limiting resistor. This protection scheme not only protects the servo system from an overload, it also protects the user from injury by limiting the output torque of the motor. The servomotor itself is chosen so that its maximum output torque does not exceed what is needed. As a result, even if the safety circuit failed, the motor would be incapable of damaging itself or the user.

The entire project cost was $110.00.

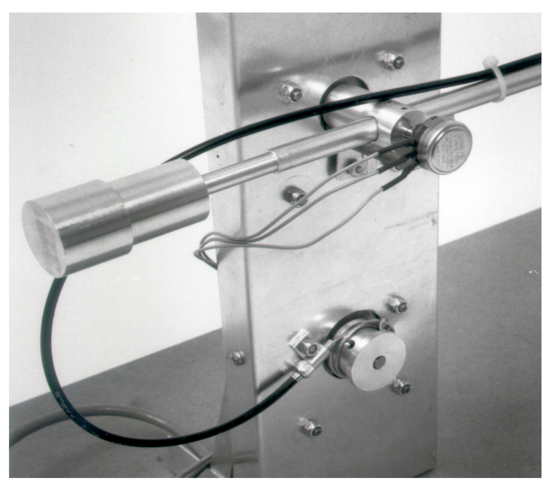

Figure 12.20. Servo Motor Setup.

SILENT ALARM SYSTEM FOR INDIVIDUALS WITH HEARING IMPAIRMENT

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INTRODUCTION

Waking up to an alarm clock is one of the everyday liberties that most people take for granted. Individuals with a hearing disability may not be able to be wake up with standard alarm clocks. For this reason, a device was created that uses the sense of touch, rather than hearing, to wake such an individual.

The device created employs a microphone to detect the alarm and a circuit that uses the input from the microphone to switch on a vibrating motor. The vibration from the motor is the sensation that wakes the individual wearing the device.

SUMMARY OF IMPACT

This device is an improvement over the many existing units. Some existing units use a strobe light to wake the user; however, this method may be ineffective depending on the person's sleeping position. The use of a vibrating motor, connected directly to the person, eliminates this uncertainty.

The nature of this design makes the unit portable, as it functions with any standard alarm clock and can be made into a compact unit given further development. The device also has the added safety feature of waking the user in the case of a fire alarm.

Figure 12.21. Unit Packaged on Wristband.

TECHNICAL DESCRIPTION

The major aspect of this design is the switching circuitry. The approach chosen was to use an op-amp circuit. An LM 324 quad op-amp chip is used for its high gain and its capability of running at low

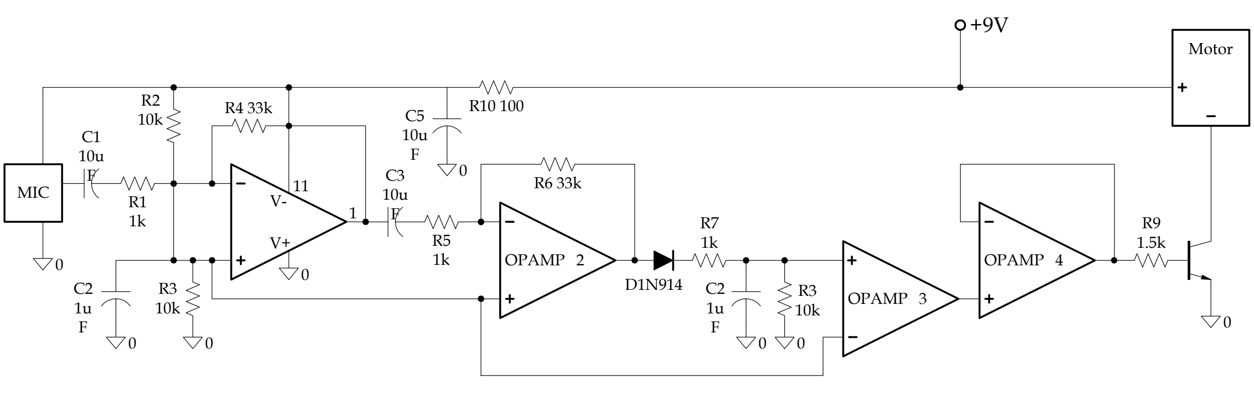

Figure 12.22. Circuit Schematic.

voltages.

The microphone chosen is a condenser microphone element. The microphone supply voltage range is between 1.5 and 10 volts. A nine volt power supply is used to accommodate both the op-amp chip and the microphone.

First, the signal from the microphone must be amplified so that it can be used to switch on the motor. This is done using the first two op-amps on the chip, rather than just one, to ensure that the amplification levels are at safe values. The output of the Microphone is coupled via a 10 uF capacitor, to block the AC signal, and to a 1K ohm resistor. The signal from the 1K resistor is passed to the negative side of the first op-amp, and a 33K feedback in order to set the gain at 33. A half and half circuit containing two 10K resistors sets the reference voltage at 4.5 volts to the positive side of op-amp one. In addition, a 0.1 uF capacitor is placed from the half and half circuit to ground in order to stabilize the circuit.

The output of the first op-amp is passed through a 10 uF capacitor and then through a 10K resistor. This resistor is passed into the negative terminal of the second op-amp, and with a 33K feedback resistor, resulting in another gain of 33. This results in an overall total gain for the circuit of approximately 1089. The second op-amp is referenced to the positive side of op-amp one.

Now that the signal has been amplified, a third op-amp is used as a comparator to detect the voltage increase when the microphone detects the alarm. An IN914 diode and a 1K resistor at the output of op-amp two reduce the voltage by approximately 0.77 volts; this sets a difference between the comparator's reference signal and the input signal. The input signal is connected to the positive side of op-amp three. The comparator then gives an output when the signal is raised above the reference, which travels from the negative terminal of the op-amp to the positive side of op-amp two.

Just before the comparator, it is necessary to put in a filter to reduce background noise so the device is only triggered when a large signal is detected. The filter is placed after the 1K resistor and is composed of a 470K resistor and a 10 uF capacitor, wired in parallel, from the 1K resistor to ground.

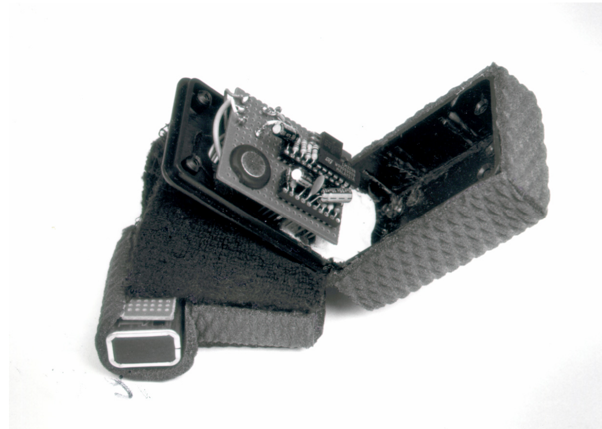

Figure 12.23. Internal Circuitry.

The last op-amp does not have a function in the circuit but had to be wired in because of the nature of the chip. The output of op-amp three is wired directly to the positive input of op-amp four. A voltage follower is connected between the negative input and the output. Lastly the output of the last amp goes to a 1.5 k resistor and then to the base of the TIP 120 switching transistor. The collector of the transistor is wired to the negative side of the motor and the emitter is connected to ground. When the transistor is switched on by the output of the comparator, the motor is switched on and the unit vibrates.

A small PC fan is used for the motor because of its low current drain and small size. The fan blades are removed and it is given an unbalanced load resulting in vibration as the motor is spun.

The op-amp and microphone are to be decoupled from the motor. This is done using a 100-ohm resistor between the nine volt power supply and the rest of the circuit. A 10 uF capacitor is then placed after this resistor, connecting from the resistors output to ground.

The components are then mounted on an athletic sweatband that is slipped over the hand and onto the wrist. The circuit is mounted on the top side of the band and covered with a plastic cover and padding. The motor is placed on the underside because it is the most sensitive part of the wrist and the battery is mounted adjacent to the motor as shown in Fig. 12.23.

The cost of this project was $172.

THE SOCKMATE: AN ASSISTIVE DEVICE THAT HELPS PEOPLE PUT ON THEIR SOCKS

Student Designer: Patrick J. Mann
Supervising Professor: Dr. Joseph C. Mollendorf
Mechanical and Aerospace Engineering Department
State University of New York at Buffalo, Buffalo, NY 14260

INTRODUCTION

A reliable, convenient, easy to use dressing aid has wide appeal to the millions of people who have chronic back pain. Any degree of immobility caused by back pain can affect an individual by making even the simplest of tasks difficult to perform. Something as mundane as putting on a pair of socks becomes a time consuming and painful chore. Since people have to get dressed in order to go about their daily lives, there is a need for a device that can either reduce the pain or allow an individual who has back pain to avoid it all together. A device to move the sock in close proximity and line up with the foot eliminates the need for the person to bend over. The device is non-destructive to clothing and free of any pinch points or snags. It is also suitable to accommodate a wide range of foot sizes.

SUMMARY OF IMPACT

The SockMate makes it possible for people who have chronic back pain to get dressed with ease by eliminating the need to bend over. The device allows socks to slip on with minimal effort and discomfort. This device can be of great benefit to back surgery patients because it gives them the ability to get dressed without the pain they would

Figure 12.24. The SockMate.

otherwise experience.

TECHNICAL DESCRIPTION

The boot of the SockMate is made from a flexible piece of molded thermoplastic. The flexibility of the material allows several different sock sizes to be used. A single adjustable handle is attached to the back of the boot. The handle is a two-piece aluminum pole that is tapered toward the bottom. The inside diameter of the lower part of the pole is 0.75 inches and the outside diameter of the top part of the handle is 0.75 inches with a clearance of 0.01 inches. This ensures that the handle can be adjusted to accommodate people of all heights while either standing or sitting. Eight holes, spaced an inch apart, are drilled into the lower part of the handle. A spring-loaded pin that fits into any of the adjusting holes is attached to the upper part of the handle. The pin fits into any of the adjusting holes and locks the upper part of the handle in place. At the top of the handle is an ergonomic handgrip that maintains comfort during use.

The SockMate comes with a gripping system that keeps the sock from slipping off the device when pulling the sock past the heel and over the ankle. A lever, resembling a bicycle brake lever, is located at the top of the handle. A jacketed, thin braided wire cable runs from the lever down the pole where it connects to a pivoting gripper. Squeezing the lever operates the gripper by lifting it away from the sock. The gripper force is supplied by a spring that applies about ten foot-pounds of pressure on the upper rear of the sock in order to hold it against the boot upper. The contact surface of the gripper is a knobby rubber pad that will not harm the cloth of the sock. The gripper allows the boot to be easily pulled out of the sock as the lever is squeezed.

The overall cost to produce this prototype was $25.00.

Figure 12.25. Sock Attached to The SockMate.

TAS-5000: THE TRUSTABLE ADJUSTABLE SINK

Student Designers: Andrew Rybarczyk, Jonah Wojtanik
Supervising Professor: Dr. Joseph C. Mollendorf
Mechanical and Aerospace Engineering Department
State University of New York at Buffalo, Buffalo, NY 14260

INTRODUCTION

The Trustable Adjustable Sink, the TAS-5000, was designed and developed in order to assist individuals with disabilities with using a sink in their homes. A wooden sink base has been created that is fully height adjustable by means of an electric motor.

The sink is designed so that not only can an individual in a wheelchair roll up and under the sink, he can adjust the height of the sink/countertop to whatever height suits him. This adjustable design can accommodate any personal preference. This design can not only accommodate people with disabilities, but it could work for any individual. The adjustable aspect allows people to set and adjust the sink and countertop to a specific need.

SUMMARY OF IMPACT

The sink was designed to not only help people with disabilities in a functional way, but in many parts is a different kind of assistive device. The aesthetics of this design are a major part of the project. Adjustable sinks on the market today lack the aesthetics that most people prefer. They are plain and simple, consisting of a sink basin, usually ceramic, mounted to a steel track mounted on the wall. This design looks to be a luxurious sink and counter, typically for use in a bathroom. The sink sits in a beautifully designed wooden cabinet base, which is fully adjustable. With the simple push of a switch the sink will raise and lower to the desired height.

In addition, not only does the sink raise and lower, the entire countertop of the wooden base also moves along with the sink. This design was found to be more useful than the competition's use of a simple sink basin mounted to a track on the wall. With other designs, there is no countertop, it appears unpleasant, and the bathroom mirror, which is usually mounted to the wall behind the sink, is found to be useless to someone sitting in a wheelchair. This design has the ability mount a countertop mirror to the wooden sink base itself, which in turn would adjust right along with the sink and wooden base.

Figure 12.26. The TAS-5000.

TECHNICAL DESCRIPTION

One other specific aspect that was redesigned for TAS-5000 was the faucet handles. All sinks on the market have the standard faucet handles located in the rear of the sink. This design places the faucet handles on the front side of the wooden base to make them more accessible and easy to use.

Figure 12.27. The Lifting Mechanism.

The TAS-5000 operates on 120V ADC current, meaning it can be simply plugged into the wall. The entire wooden base and sink is self contained, so it does not require mounting to a wall or floor. The wooden sink countertop adjusts in height approximately 22 inches up to 36 inches above the ground. The adjustable sink is equipped for maximum safety, with two limit switches to cut the power when the sink reaches its maximum and minimum heights. It is also equipped with two limit switches attached to a safety bar. When the sink is being lowered and there is an obstruction under the sink, the safety bar will trigger and the power will be cut. This prevents anything or anyone from being crushed.

The lifting mechanism runs off a single chain drive system, using a 1/4hp electric motor, and four synchronized linear jacks. The system is also equipped with a fuse to protect the user and the electrical system. The lifting mechanism is controlled from a simple, easy to use switch. The switch is momentary, therefore if the user lets go, the movement of the sink will cease. The sink countertop is capable of lifting approximately 300 pounds, which is done for safety of the users and device. The TAS-5000's faucet handles are placed in the front of the sink base for easier access and use.

The overall cost of the TAS-5000 was approximately 40-50% less expensive, not including labor costs, to build than the competition's ceramic sink basin on a steel track. The overall cost of the sink was approximately $710.

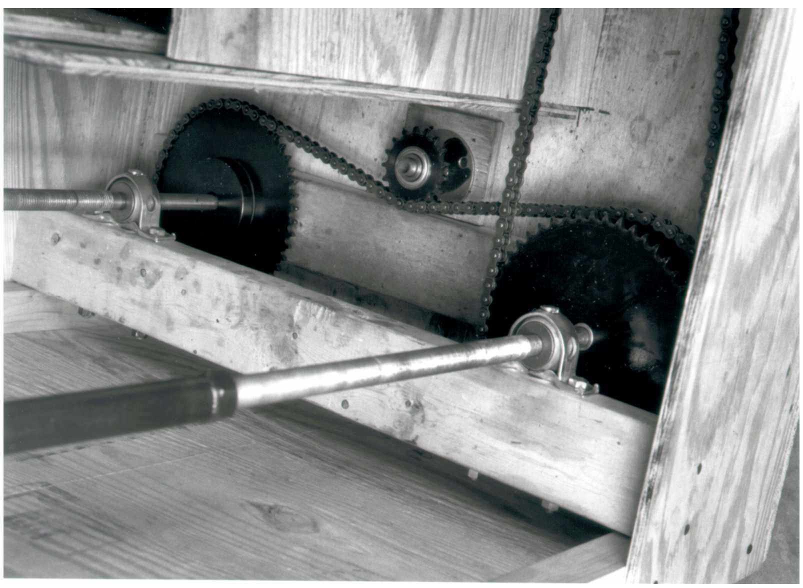

Figure 12.29. Chain Linkages.

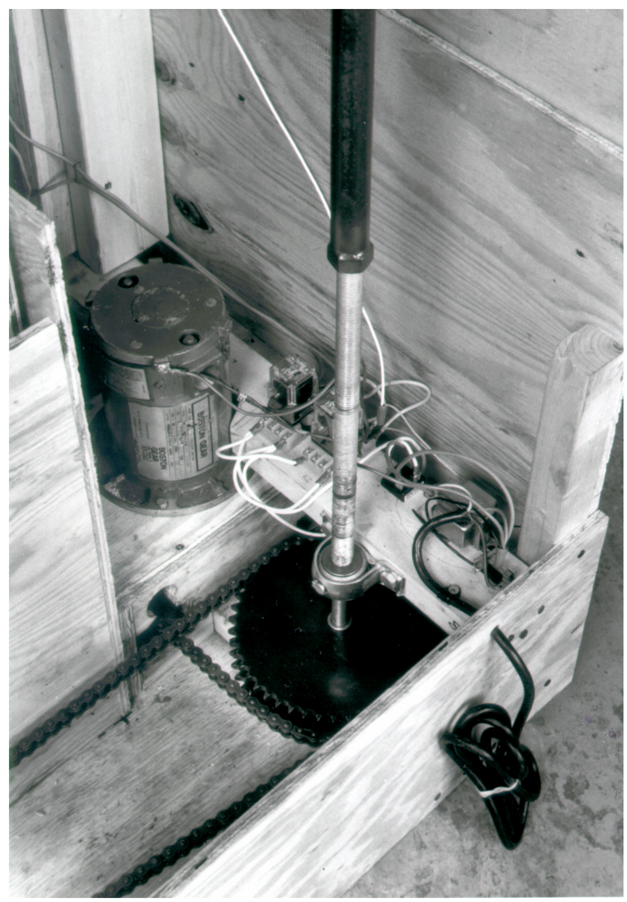

Figure 12.28. Motor-Chain Drive System.

TABLE PRO: A PORTABLE WORKING SURFACE FOR PEOPLE WHO USE WHEELCHAIRS.

Student Designer: Timothy F Barbour
Supervising Professor: Dr. Joseph Mollendorf
Mechanical and Aerospace Engineering Department
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INTRODUCTION

The objective of this project was to design and build a portable flat surface that could be utilized by anyone in a wheelchair. People in wheelchairs are constantly looking for a suitable working space to be used for work, school, or even just a place to eat. The Table Pro was designed to be custom fitted on a wheelchair to allow for easy access to a useable surface that would not prohibit the regular use of the wheelchair. Using an aluminum body and a carbon fiber tabletop, the Table Pro will have ample strength to hold regular everyday objects (i.e. a book or portable computer) with little effect on the wheelchair itself.

SUMMARY OF IMPACT

The Table Pro was built with the specifications based on the needs of an average person. The table was sized to be 16 x 16 inches, which is as wide and as long as an open text book. It is lightweight, collapsible, and can be used with a collapsible wheelchair. The Table Pro will make ample workspace available.

Figure 12.30. Mounted Table Pro.

TECHNICAL DESCRIPTION

The Table Pro is constructed with a piece of round aluminum stock and rectangular piece of aluminum stock welded together. The pieces are drilled with an inside diameter 0.001 inch- 0.003 inch larger than the outside diameter of the leg of the wheel chair. Then it is split in two directions, with a clamping hole drilled and tapped. When the screw is tightened, the inside diameter will decrease and squeeze the leg of the wheel chair. The flat surface has a ball bearing place inside to allow for a full three sixty-degree rotation around the table leg. The aluminum arm is then mounted to the base using a 5/8 inch bolt with a washer and lock nut to prevent them from separating. There are two indentations strategically placed in the base that allow for the arm to lock in place by utilizing a spring pin. The arm is custom fit so the length of the arm is equal to the width of the back of the particular wheel chair. The arm has a rectangular flat plate at the end that allows for a more equal load transfer from the table to the arm of the chair, helping to keep the table rigid. A hinge is mounted to the plate to allow for the table to fold for minimal space consumption when the wheel chair is folded. The table is a carbon fiber molded table that allows for a higher strength /weight ratio with an aluminum base.

Total cost of project was $250.00.

Figure 12.31a. Collapsed Table Pro.

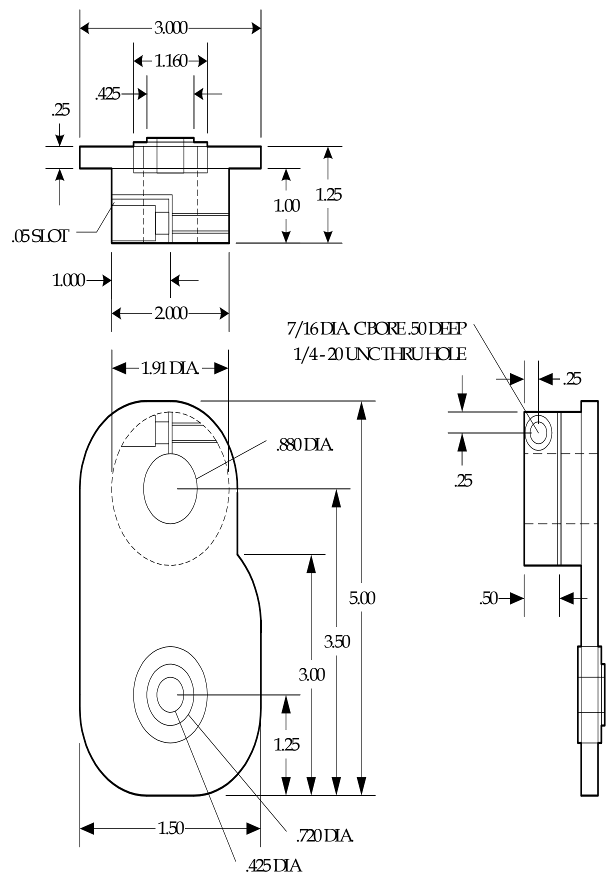

Figure 12.31b. Schematic of Mount.

WHEELCHAIR WHIRLIGIG: A DEVICE TO HELP PEOPLE IN WHEELCHAIRS TURN AROUND IN AN ELEVATOR

Student Designers: Di Song, Brian J. Wells, and Daniel R. Keating
Supervising Professor: Dr. Joseph C. Mollendorf
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INTRODUCTION

This project addresses a problem that affects wheelchair-restricted individuals using an elevator. Once inside the elevator, the individual must go back and forth in small increments in order to turn around 180 degrees so they can face the elevator door upon exiting. This can be even more difficult in small elevators or when there are other individuals present in the elevator. The Wheelchair Whirligig is specifically designed to aid the individual in turning around 180 degrees with a minimal space requirement.

Many devices to solve this problem have been devised over the years, not one that is designed for use in an elevator. Several designs were evaluated; one particular design was chosen.

For the device to be effective, the following guidelines are set. It must be able to operate with a load of up to 600 pounds, have a low profile, sturdy construction, operate on AC voltage from the elevator power supply, start and stop at precisely 180 degrees, tamper resistant (device locks if someone tries to turn it manually), and can only be operated by the person in the wheelchair. The device is also to be built into the elevator floor, so having a low profile is very important. For safety reasons during operation, wells are cut into the top surface for the wheelchair wheels to dip into, so the wheelchair will not slide as the device rotates.

SUMMARY OF IMPACT

This device is not only beneficial for individuals in wheelchairs, but also beneficial to factories and plants. The whirligig can be used in rotating pallets of raw materials in cargo elevators. This can save the operator a lot of time and cut costs for the factory. It also eases the strain on the operator when compared to having to move the pallets manually.

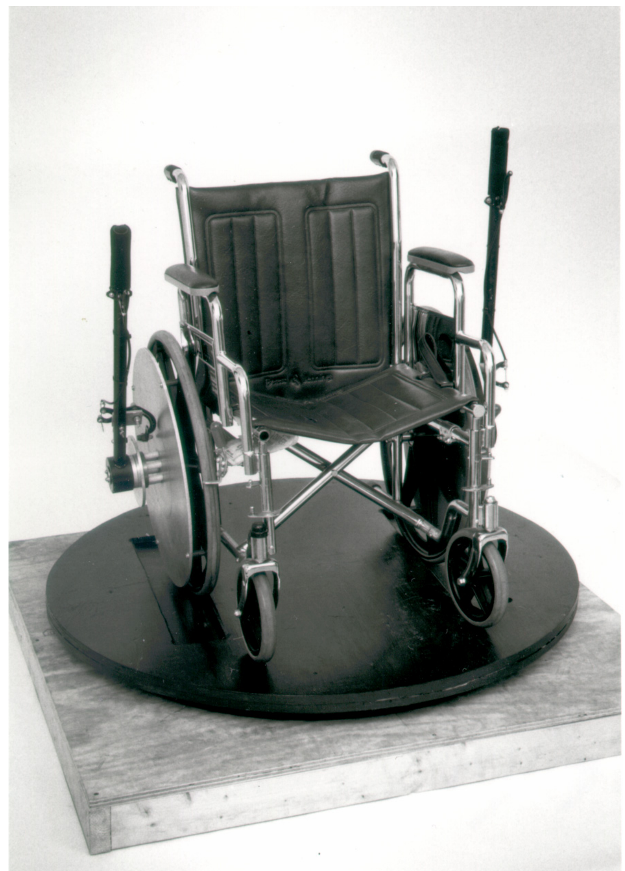

Figure 12.32. Wheelchair Whirligig.

The top layer of the device is removable, allowing quick changes to be made for various shapes and sizes of pallets and wheelchair sizes.

TECHNICAL DESCRIPTION

A 100-RPM DC motor with 720 ft-lb of torque is selected to power the device. A power supply converts the 115 Volts AC power from the elevator into 24 Volts DC needed to run the motor. The circuitry for transforming AC to DC to power the motor and the timing device used to ensure a 180-degree turn detailed in Fig. 12.33.

The output speed is reduced from 100 RPM to 5 RPM in order to perform a half rotation in six seconds. The speed reduction is achieved by utilizing a worm gear and worm. The worm gear is chosen because of its ability to prevent motion in the opposite direction. This satisfies one of the safety concerns addressed earlier. To make sure that the rotation stops at 180 degrees, a timer is utilized in the circuitry to provide power to the device for approximately six seconds. A 20-tooth worm gear and a six-tooth worm are used. The worm is attached to the keyed output shaft of the motor while the worm gear is attached to a four-bolt flange mount with self-aligning bearings via a keyed shaft. The keyed shaft is then connected to the rotating platform through a self-made keyed mount. The mount is then attached to the rotation platform. The rotating platform sits on a four-foot diameter ring lined with bearings that enable it to rotate; the platform has a profile of only one inch (see Fig. 12.34). The electrical component is placed on the top of the elevator while the mechanical components are placed under the floor of the elevator.

The motor, bearing, gears and electronic components are purchased from various companies. The body of the device is constructed out of wood. Wood was chosen because of its weight, cost, and ease of modification. Paint was applied to the wood for aesthetic purposes.

Acknowledgements are made to Kenneth Peebles and Bill Macy for their assistance in machining and welding.

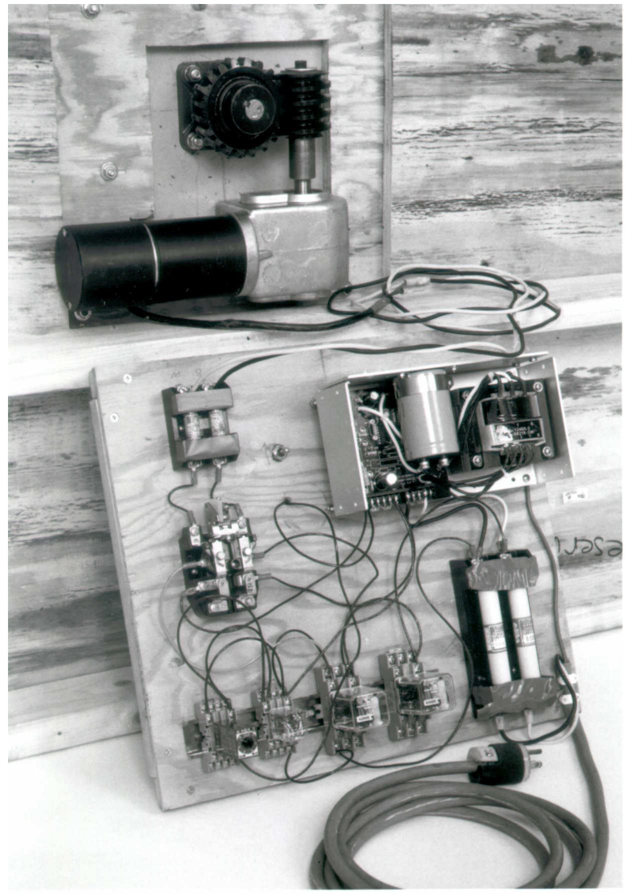

Figure 12.34. Mechanical and Electrical Assembly.

The total cost of this project was $822.

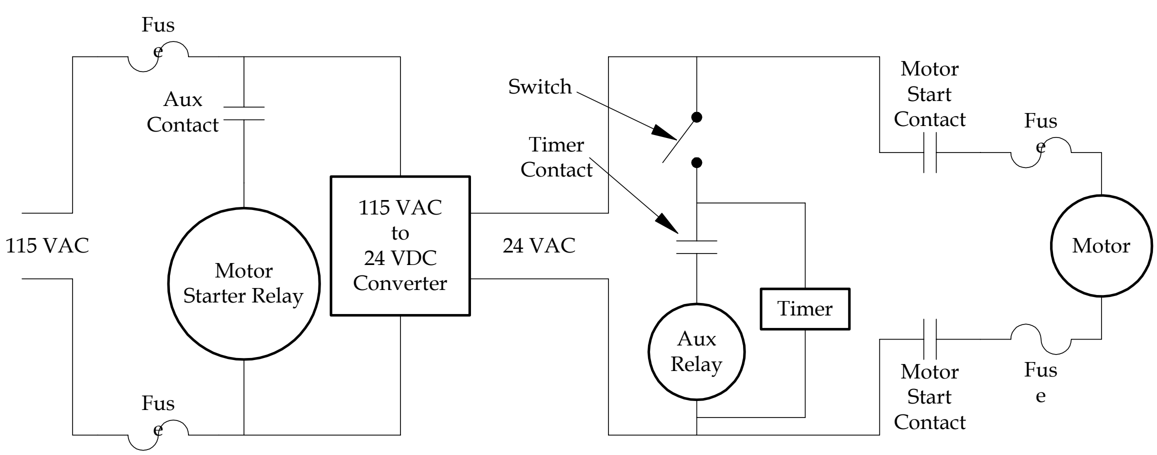

Figure 12.33. Motor Control Schematic.

A COLLAPSIBLE CRUTCH TO FACILITATE INCREASED CRUTCH PORTABILITY

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INTRODUCTION

This device was designed to assist an individual who requires the use of a walking aid such as a crutch. Crutches are big, clumsy, and hard to store, yet they satisfy a necessary function for someone who has no other alternative other than the temporary use of crutches. If the size of the crutch could be physically divided into four individual sections, this would drastically increase the portability and the ease of storage while the crutches are not in use. When the individual is riding in a car or a bus, they can simply collapse the crutch down for storage and then quickly reassemble it when necessary.

SUMMARY OF IMPACT

This design will reduce the hassle involved when using a crutch yet maintain the complete functionality of the device. This would allow individuals more freedom than they initially had with the old design; they would be able to go to public places without needing to find a place to store the crutches when they are not in use. For example, they could go to the movie theater and not have their crutches be in anyone's view or in the way.

TECHNICAL DESCRIPTION

Two cuts were made through the original aluminum of the crutch at 12 inches and at 21 inches from the ground. Four pieces of half-inch diameter, three inch long, copper pipe were inserted into the lower half of each of the slots in the aluminum frame. A 3/8 diameter hole was drilled through each section,

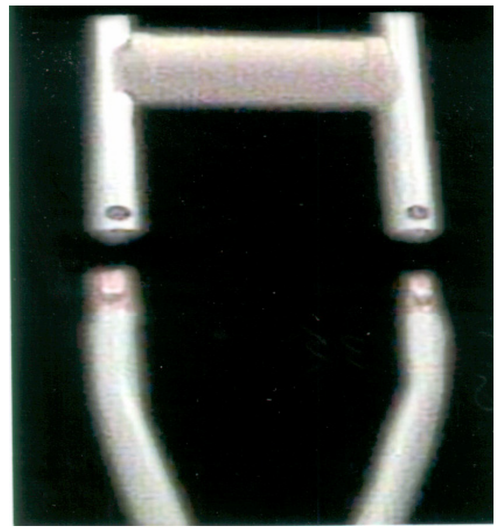

Figure 12.35. Connection Using Push Button Latches.

and a push button latch was inserted to keep the separate sections from disengaging when the crutch was in use; the push button also makes disassembly of the crutch much easier. The push button latches along with the copper tubing maintain the original rigidity of the crutch. The latches are kept in place by a tension rod inside the copper pipe. An epoxy was used to keep the copper pipe in place as to maintain the alignment of the holes. The final weight of the unit was only slightly greater than that of the original crutch.

Total cost of the project was $49.45.

SEAT BELT HANDLE TO FACILITATE DONNING AND DOFFING OF AUTOMOTIVE SEATBELTS

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INTRODUCTION

This project addresses the difficulties that some people with disabilities face when attempting to buckle and unbuckle an automotive seatbelt. For many, it is difficult to grasp the seatbelt and pull it to the buckle or vice versa when taking it off. The Seat Belt Handle is a device that will make the process easier by providing a larger, more ergonomic grip on the seatbelt. The device is small and is not very noticeable when attached. The device also does not require any modification to the seatbelt. In addition, it can be taken off and used in other vehicles without difficulty.

SUMMARY OF IMPACT

For people who have a hard time using their hands, putting on a seatbelt can be quite difficult. This device will make the task much easier. By doing so, the person can feel more comfortable when in a vehicle since it will not be such a hassle to put on or take off a seatbelt. The device is small enough so that it does not look awkward when attached.

TECHNICAL DESCRIPTION

The Seat Belt Handle is constructed out of a lightweight plastic. It is designed to give a better handle on the seatbelt by providing an ergonomic grip on the belt. It is also designed so there is no modification to the seatbelt itself, so it does not violate any safety regulations. The handle grips the seatbelt by wrapping the belt through two slots; one of the slots has teeth that will grip the material of the seatbelt. Once the user pulls on the handle, the seatbelt is gripped by the teeth and moves with the device. The handle easily slips on and off the seatbelt if it needs to be moved from one vehicle to another. The size of the device is approximately 4 inches x 4 inches x 0.125 inch in dimension. This size is small enough so that it is not bulky once attached in the vehicle.

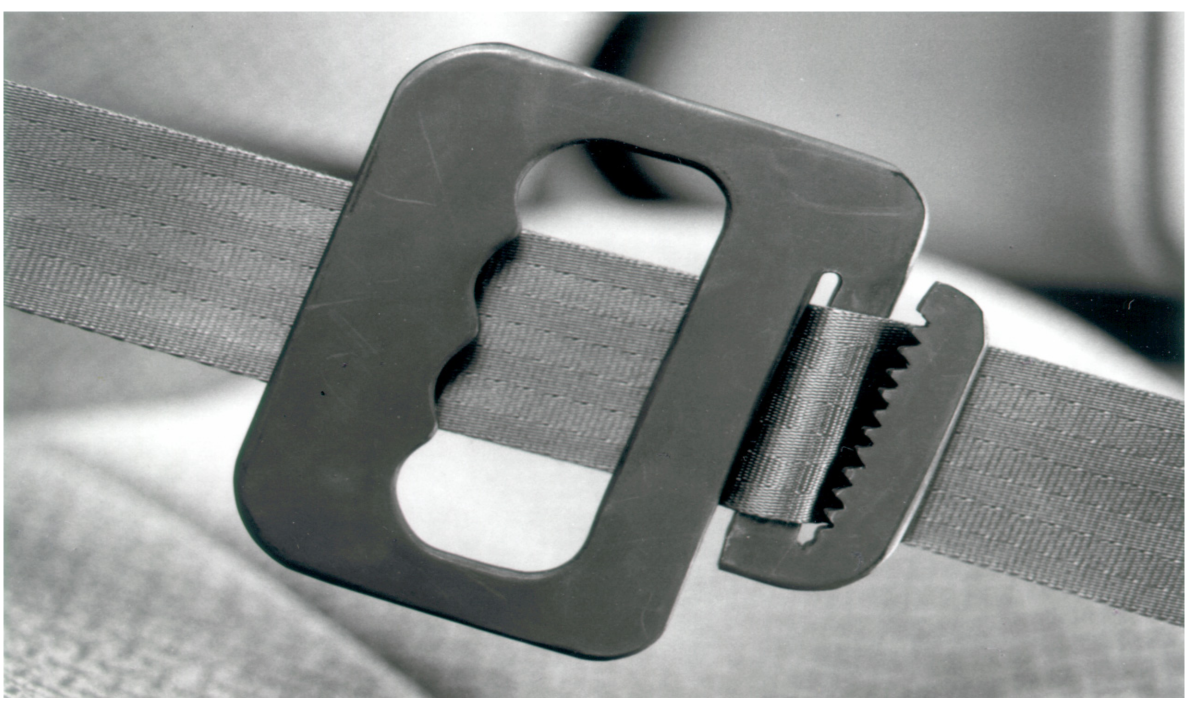

Figure 12.36. Seat Belt Handle.

CHAPTER 13
STATE UNIVERSITY OF NEW YORK AT STONY BROOK

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CONTROLLING A POWER WHEELCHAIR WITH MACHINE VISION

Students: John D. Antonakakis, Avren U. Azeloglu, and Theophilos Theophilou.
Client Coordinator: Thomas Rosati, Forest Brook Learning Center, St. James, NY
Supervising Professor: Fu-Pen Chiang
Department of Mechanical Engineering
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INTRODUCTION

The goal of this project is to integrate a machine vision technology into a power wheelchair system so that a client with quadriplegia can control the direction of movement of a wheelchair. The machine vision technology employed was developed at Stony Brook. Professor Chiang originally developed the technology, computer aided speckle interferometry or CASI, for solid mechanics applications. For this project, the students applied this technology to detect the direction of head movement, which is used in turn to control the direction of the wheelchair movement. Compared with existing machine vision technology, CASI has the advantage of being able to detect the movement reliably.

SUMMARY OF IMPACT

The machine vision system is developed using standard PC components and allows a client to control the direction of wheelchair with his head movement.

TECHNICAL DESCRIPTION

The original CASI is developed using special high-resolution CCD camera with expensive image capture board. For the wheelchair application, a CCD webcam (cost around $100) is used along with the standard graphics card in a PC. No special image board is required. The webcam is mounted behind the client's head on the chair. It is used to capture the movement of the back of the client's head. To be most effective, the client needs to wear a hat with a speckle pattern on it. A sample speckle pattern is shown in Fig. 13.1.

A MS Visual Basic software is developed to capture the five images of the speckle pattern during the

(a) (b)

Figure 13.1: (a) Wheelchair with Vision System. (b) Close-Up with Speckle Pattern.

head movement, extract the displacement information from the image, and send an appropriate command to direct the wheelchair movement. The schematic of the software is shown in Fig. 13.2.

Shown in Fig. 13.3 is a custom designed circuit board used to convert the output from the parallel port to the interface board on the power wheelchair.

The cost of the parts/material is about $2750.00. This includes the power wheelchair (purchased with deep discount at $2,500.00), $150 for electronics, and $100 for the webcam. The Mechanical Engineering Department provided the lap top computer and its accessories.

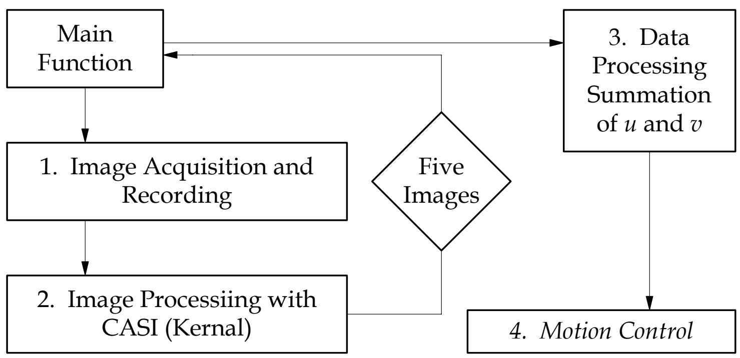

Figure 13.2: Software Architecture.

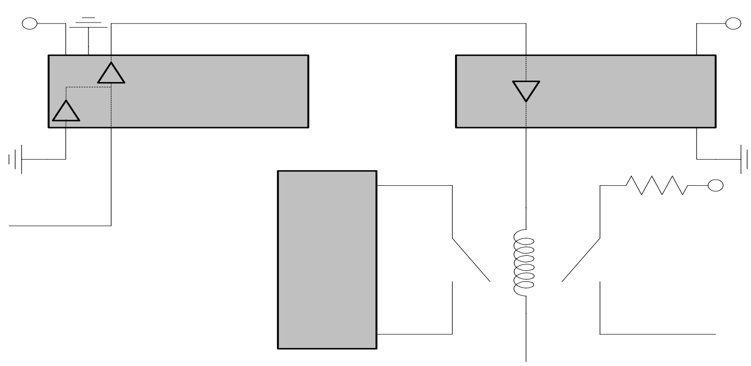

Figure 13.3. Adaptor Circuit.

CONTROLLING A POWER WHEELCHAIR WITH VOICE RECOGNITION TECHNOLOGY

Students: John D. Antonakakis, Avren U. Azeloglu, and Theophilos Theophilou.
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Supervising Professor: Fu-Pen Chiang
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INTRODUCTION

Instead of using machine vision, this project uses voice recognition technology for controlling wheelchair movements. The voice commands for controlling the movement can be recorded and programmed, and then can be customized to each individual. The hardware system is exactly the same as the vision system. The microphone needed for recording comes with the webcam. Once a voice command has been recognized, an appropriate motion command is sent to the parallel port, which in turn, controls the direction of wheelchair movement through the adaptor circuit shown in Fig. 13.3. In this project, the voice based wheelchair control software is developed using Microsoft Visual Basic with Microsoft's Direct Text to Speech and Direct speech recognition technology.

SUMMARY OF IMPACT

This machine vision based system is targeted for patients with quadriplegia.

TECHNICAL DESCRIPTION

The speech recognition engine used in this investigation is Microsoft's Direct Text to Speech and Direct speech recognition. The Program is written in Visual Basic and enables the user to basically operate various functions on the computer by voice activation. Fig. 13.4 is a schematic diagram of the speech recognition control system. The analog sound wave propagates through the microphone and is digitized by the AD board of the computer (sound card). The digitized information is stored in the computer and is processed by the visual basic program. The voice command is then recognized and the analogous directive to that command is executed.

Fig. 13.5 depicts the visual interface of the speech recognition program. The software can access virtually almost all of the computer functions. However, it was noticed that sometimes phrases had to be repeated, and the user had to be close to the microphone when talking. The accuracy was

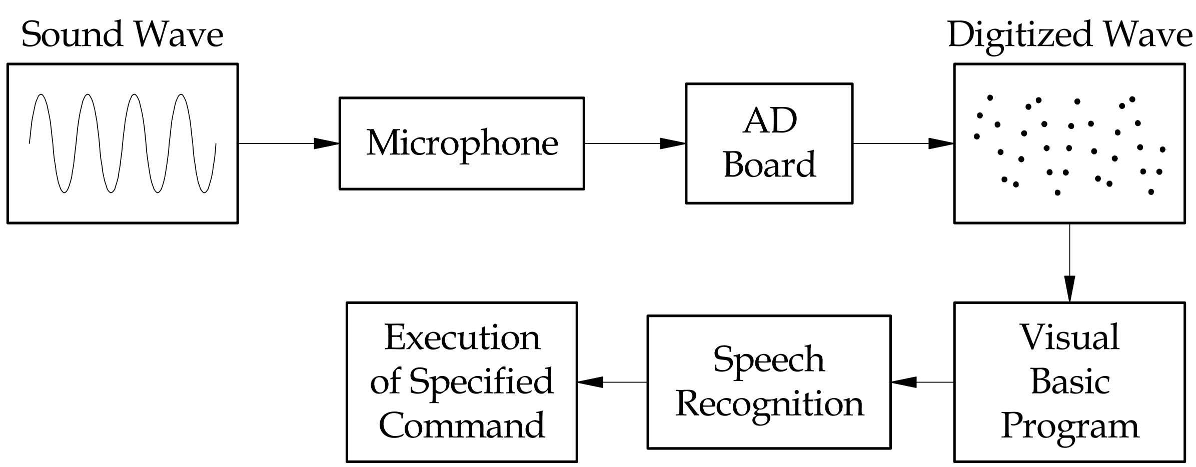

Figure 13.4: Schematic of Voice Recognition System.

drastically improved when the vocabulary was minimized. Archimedes was tested with a vocabulary up to 50 words and phrases, and the resulted accuracy was 78%. However, when the vocabulary was dropped to 10 words or phrases, the accuracy improved significantly to an acceptable performance of 90%. Furthermore, the accuracy increased to 95%when the selected words were phonetically very different. In the targeted application of Archimedes which the automation of a wheelchair, the words that will need to be recognized are “forward”,” backward”, “left”, “right”, “stop”, “accelerate” and “decelerate”. The number of commands is well in the range of acceptable accuracy and they are phonetically dissimilar.

There is no additional cost to this voice based system. The same hardware system is used as the machine vision system.

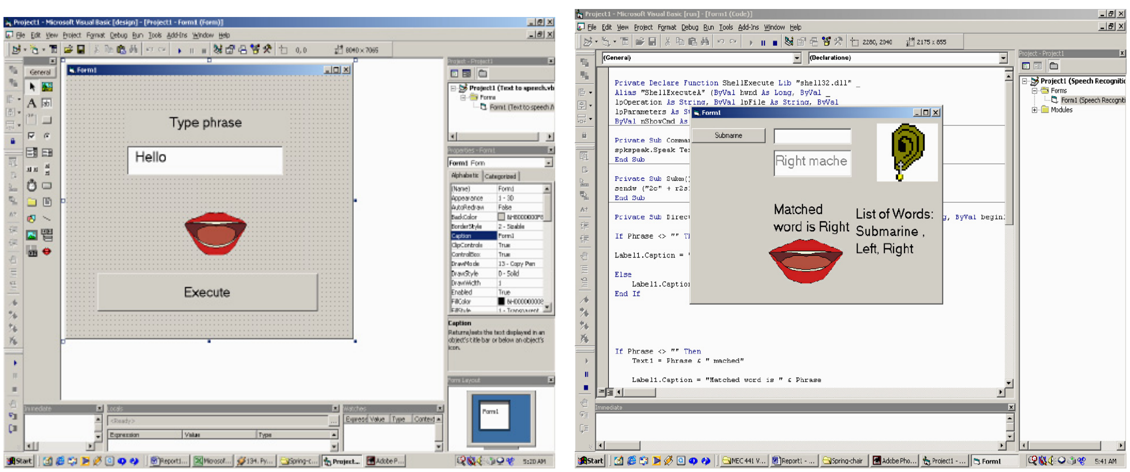

Figure 13.5: Graphical Interface for Voice Recognition System.

PEDALO TRICYCLE

Students: Allision Fusswinkel and Anne Rose Gan
Client Coordinator: Thomas Rosati, Forest Brook Learning Center, St. James, NY
Supervising Professor: Jeff Ge
Department of Mechanical Engineering
State University of New York at Stony Brook
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INTRODUCTION

The Pedalo, shown in Fig. 13.6, is a useful exercise vehicle for children with severe disabilities. It is a combination of platforms, wheels and supports, which are fit together to create a smooth forward and backward motion. Therapists use this mechanism to train children in proper balancing techniques and increase muscle strength. The existing Pedalo is a registered product of Abilitations. It uses the split-axle principle for its operation and can be used by people of any age. This Pedalo can convert a walking-like motion into forward or backward motion but it is not capable of turning. The improved Pedalo will follow this same basic principle, but will have additional features of a steering mechanism. This Pedalo was designed specifically for a child and was customized for his size and needs. Safety and speed were taken into consideration.

SUMMARY OF IMPACT

A custom-made Pedalo tricycle for the client will allow him to move around in the building while getting proper training in balance and muscle strength.

TECHNICAL DESCRIPTION

The final Pedalo design as shown in Fig. 13.7 consists of two platforms connected by a set of double-center wheels. The outer wheels of the original Pedalo were not used for this design. This double-wheeled configuration is connected to three other wheels through a beam joined from the stationary centroid of the inner wheels to the shaft of the driven wheels and the front wheel. These wheels are set up in a tricycle- type configuration, with two wheels at the back and one wheel at the front. A gear chain located at the center of the double wheels is used to drive the shaft of the two back wheels. The front wheel is used for steering. A handlebar type steering mechanism is used to steer the front wheel. Additionally, the client's Pedalo will be equipped with removable side handlebars and foot guards for

Figure 13.6: The Original Pedalo.

Figure 13.7: The Pedalo Tricycle.

safety.

Overall, the design and construction of the Pedalo tricycle was a success. The prototype works in accordance with the design specifications. The only major problem is that the motion is not entirely smooth all the time. Although corrected with the use of a double-chain ring with the rear crank, the problem is not completely solved yet. However, other modifications can be made to this design to increase its safety and performance.

One additional modification would be to add an anti-tipping device to the Pedalo-tricycle. This would entail adding extra supports and side wheels at the left and right side of the mechanism. This would add extra stability and operate similar to training wheels on a bicycle. Another safety feature that can be added is side handlebars. This would provide extra support for balance of the user. Foot guards can also be added to the platforms to keep the child's feet in place to avoid slipping. This would prevent the child from falling and would guide the placement of the child's feet while the Pedalo-tricycle is in use. Other modifications to the design could include the addition of a seat, an adjustable handlebar stem, and electronics to further enhance the safety and features of the Pedalo-tricycle.

The total cost for constructing the Pedalo tricycle is $524.00.

THE ESCHER SKETCHER: A MICROPROCESSOR CONTROLLED ETCH-A-SKETCH

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Supervising Professor: John Kincaid
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INTRODUCTION

The purpose of this design project centers on modifying the interface to a popular toy called Etch –a-Sketch as well as adding to its functionality. The ultimate goal is to provide the same enjoyment and satisfaction received from using the toy to someone who might not have the motor skills or bimanual coordination to use it. Additionally, the device could be used as a teaching aid to enhance the cognitive skills of the users. This could help them increase hand-eye coordination, as well as increasing confidence. It would accomplish this by abandoning the existing interface of two small white knobs, instead providing a simpler mechanism such as a keypad, joystick, or palm-activated trackball.

SUMMARY OF IMPACT

This project develops a microprocessor-controlled platform that allows a bi-manually impaired child to play with the classical Etch-A-Sketch.

TECHNICAL DESCRIPTION

As shown in Fig. 13.8, the mechanical design of the microprocessor-controlled platform expands the Etch-A-Sketch into the shape of a laptop computer. The device would encase the toy inside of its screen half, and control the knobs via small stepper motors mounted on each side. Fine tooth nylon gears, some of which would replace the knobs on the front of the Etch-A-Sketch, would boost torque. The keyboard half of the laptop style design would house a keypad or series of directional control buttons as well as a trackball mounted inside. The entire mechanism would fold up into a flat, easily carried shape. In addition, the screen half would pivot around its center either automatically or manually.

Figure 13.8: Microprocessor Controlled Etch-A-Sketch.

One nice feature was the LCD display which could act as an operator interface during a game, a countdown timer, a screen to read numerical input such as desired X and Y coordinates, or radii of circles.

The full electrical schematic is shown in Fig. 13.9. Power enters the device with a standard three-prong appliance plug similar to the kind commonly found on the back of computers. The 110VAC passes through a double pole switch and a fuse before it heads toward the power supply. Heavy gage, well-insulated wire is used on all high voltage lines. The power connector, power switch, and fuse holder are salvaged from an old, broken printer. When the switch is turned on, the power supply converts the 110VAC into a more usable 5VDC with enough amperage to drive both motors and plenty to spare for power consumption on the circuit board. Once the Basic Stamp receives this five-volt supply, it comes to life and begins automatically running its stored program.

The total cost for the project is $265.50. Some of the components are either donated or salvaged. For example, the joystick is salvaged from a junked plotter.

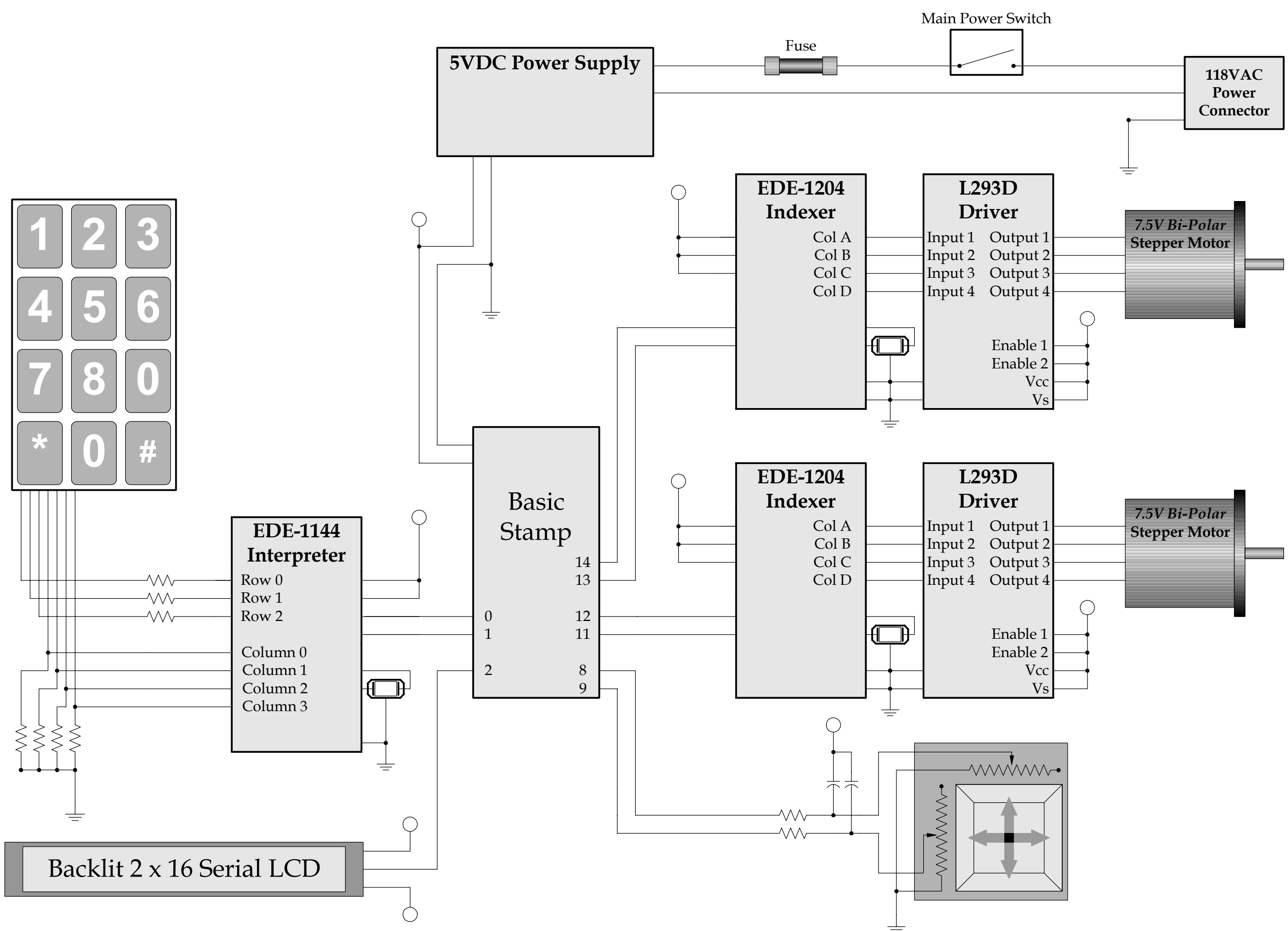

Figure 13.9: Electrical Schematic for Basic Stamp Based Controller.

A MOTORIZED WHEELCHAIR WITH AN OPTICAL GUIDANCE SENSOR SYSTEM

Students: Marcos Navia, Kwok Wing, Wong, Chu Kei, Chow
Client Coordinator: Thomas Rosati, Forest Brook Learning Center, St. James, NY
Supervising Professor: Fu-Pen Chiang and John Murray
Department of Mechanical Engineering
State University of New York at Stony Brook
Stony Brook, NY 11794-2300

INTRODUCTION

A low-cost motor assisted wheelchair was designed with an optical sensing device to track on a predetermined path. This device can be used for learning to keep direction under control or just safely riding around. The optical sensing device will serve initially as an alarm system if the wheelchair gets slightly off the track. If the rider keeps riding away from the predetermined path, the motor will shut off immediately. An emergency switch will be placed in the back of the wheelchair, for the supervisor to control, in the event an emergency happen. By switching to off, the power will be shut off to the entire system.

SUMMARY OF IMPACT

This project is a motorized wheelchair with a guidance system for use indoor use.

TECHNICAL DESCRIPTION

The prototype wheelchair developed consists of two DC 24 volts gear motors with their corresponding controllers, a controller interface board, a programmable chip (Basic Stamp 2), LCD display, a joy stick and three sets of optical sensors as input devices. A schematic of the wheelchair system is shown in Fig. 13.10. The general layout of the wheelchair with optical sensors is shown in Fig. 13.11. Fig. 13.12-13.14 show the gear motors, their controllers, and an interface board that receives the signal from the Basic Stamp 2 and sends output to motor controllers for forward and backward motions.

The Programmable Interface Chip (PIC) Basic Stamp 2 is used as the central processing unit. For this particular board, the processor can be programmed by a personal computer using Parallax BASIC (PBASIC) programs. They have fully programmable Input and Output (I/O) pins that can be used to directly interface to TTL-level devices, such as buttons, LEDs, buzzers, and potentiometers.

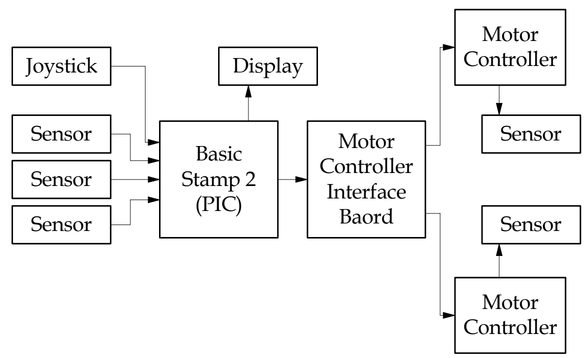

Figure 1310: Schematic of Powered Wheelchair with Optimal Guidance System.

Two DieHard Lawn and Garden Tractor batteries power the motors and the associated circuitry. A

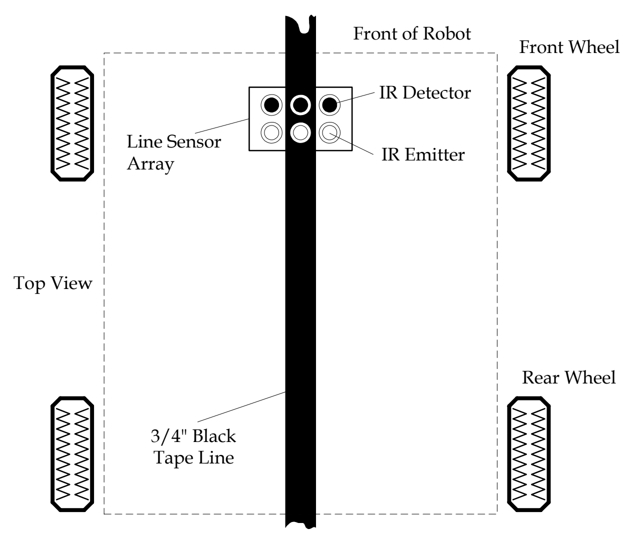

Figure 13.11: Top View of Wheelchair.

Logitech analog joystick is used to control the direction of movement for the wheelchair.

The total cost of the system is $1522.00.

Figure 13.12: Two Gear Motors NPC-74038.

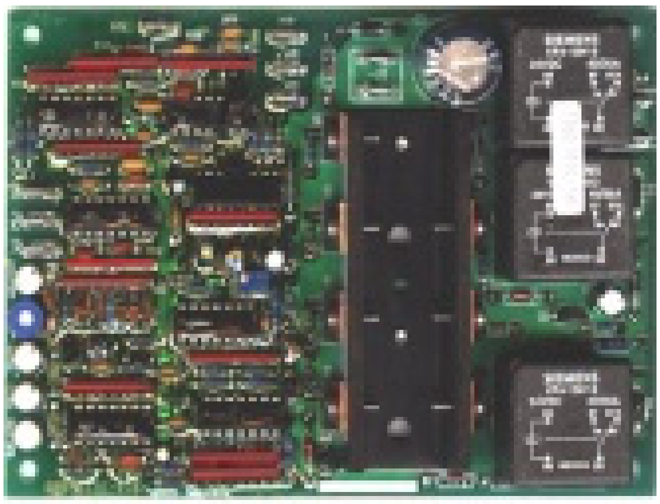

Figure 13.13: Motor Controller MCIPC-24.

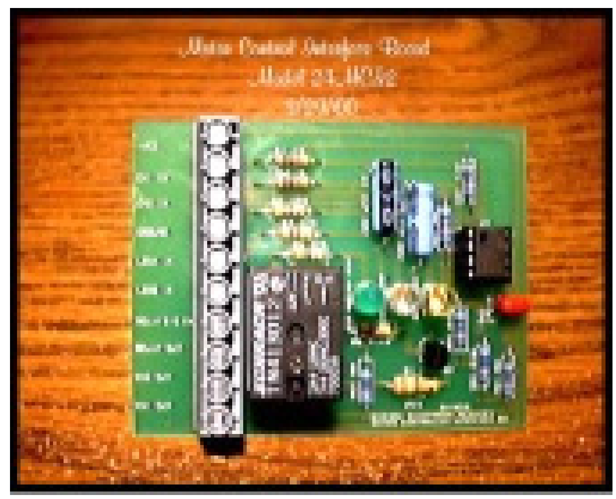

Figure 13.14: Motor Controller Interface Board DES 24VMCI2.

R. M. D. WALKER

Students: Marcos Jan Wei Chang, Kim Ng, Paul Redwood
Client Coordinator: Thomas Rosati, Forest Brook Learning Center, St. James, NY
Supervising Professor: Jeff Ge
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INTRODUCTION

The rowing motion driven (RMD) walker is designed for individuals who are incapable of walking for long period of times. The project is designed to help children developing their mobility skills. The individual that this device is intended for has extremely poor motor skills and has a cognitive disability. However, the individual can walk independently but will tend to become fatigued after a certain period. The user can then use the hands for the rowing motion as an alternative for moving the walker. The main goal of this device is to help a single individual become more independent while walking, thus giving the user a greater sense of freedom to move as he wishes. The driving system used to accomplish this task is a four-bar linkage attached to the side of the walker. A literature search for similar products available today in the market revealed that the decision to choose a modified walker is limited. The products available are simple walkers used for walking. The user does not have the option to rest if tired. The alternative is just regular wheelchairs.

SUMMARY OF IMPACT

This project develops a rowing motion driven (RMD) walker/wheelchair combination device. A driving system will assist the individual when he is tired and then the user, seated, can use the rowing motion to move instead of walking.

TECHNICAL DESCRIPTION

The main feature of the RMD walker is the incorporation of a four-bar linkage into a walker that allows the conversion of a rowing motion into the rotation of the wheels. The walker is a Rifton K502 Gait Trainer purchased through a catalog. It is then modified to include two four-bar linkages and two

Figure 13.15: R.M.D. Walker.

wheels. The main design challenge was to obtain a four-bar linkage that can generate the desired motion and at the same time can be properly and securely mounted on the existing walker. Many design factors have to be considered, such as the Grashof condition, since the four-bar has to be a crank-rocker, no toggle positions present, and the input link rocks the range required to move the walker. We used an Excel spreadsheet to find the most suitable link lengths that met the requirements of the design equations. A plot of input angle vs. output angle was made after the lengths were determined to observe if the movement of the links The simulation software called Working Model was used to simulate the linkage motion (see Fig. 13.16).

After Working Modeling simulation and verification, the link lengths were determined to be six-inches, 23-inches, 20.5-inches, and 20-inches.

The total cost of the walker is $900.00.

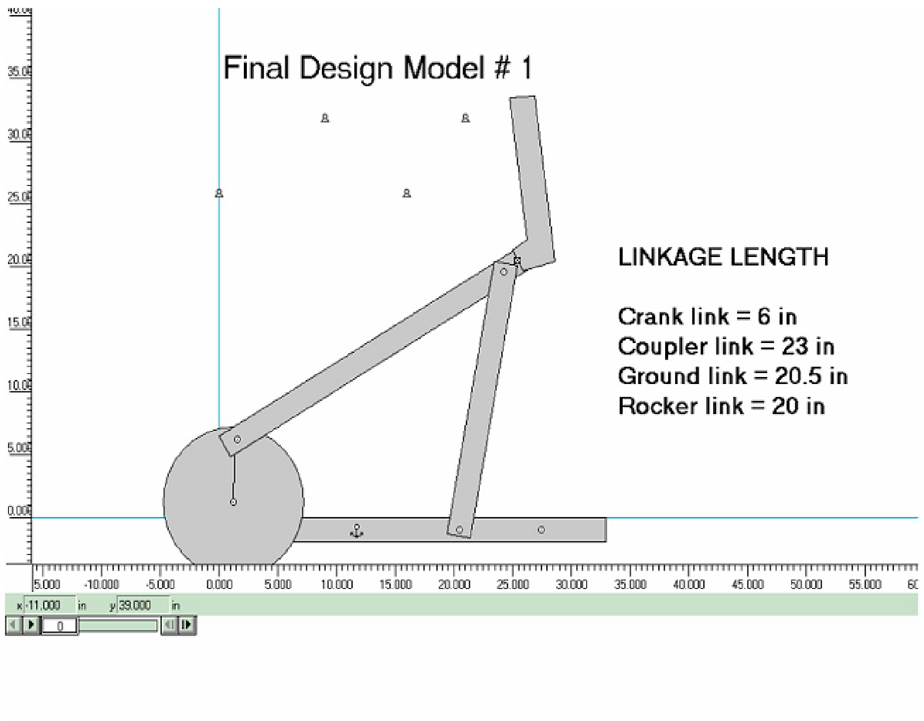

Figure 13.16: The Four-Bar Linkage in Working Model.

ADJUSTABLE ROLLER RACER

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Supervising Professor: Robert Kukta
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INTRODUCTION

The aim of the project was to modify an existing Roller Racer for a child. The child uses the Roller Racer as her only means of moving around independently. The Roller Racer also contributes to physical therapy goals in strengthening her legs and hips. Since she had outgrown her Roller Racer, this project was intended to make the existing Roller Racer adjustable according to her size.

SUMMARY OF IMPACT

This project modifies an existing roller racer so that it is adjustable and can accommodate the varying size of a child with a disability as she grows up.

TECHNICAL DESCRIPTION

The original Roller Racer is patented by W.E. Hendricks in 1972 and is marketed by the Mason Corporation of Tennessee. It is available in amusement parks as a ride for very young children. A child with a disability uses it to move around in the hallway.

The Roller Racer consists of a triangular platform, a handle bar and four wheels arranged in a triangular configuration. The two wheels in the back are fixed to the base of the triangular platform. The front two wheels are very close to each other and are connected to the handle bar. By rotating the handle bar left and right, the weight of the client is used to push the Roller Racer forward in alternating directions. It works somewhat like a sit-down or lie-down skateboard.

In order to make the Roller Racer adjustable, the original handle is removed and replaced with a custom-made, adjustable handle bar. Fig. 13.17 shows the modified Roller Racer in two configurations.

The total cost of the adjustable Roller Racer including labor is $379.00.

Figure 13.17: Adjustable Roller Racer in Original and Extended Configurations.

CHAPTER 14
UNIVERSITY OF ALABAMA AT BIRMINGHAM

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Principal Investigator

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OVER-THE-BED COMPUTER STAND

Designers: Hilary Hornbuckle, Nat Lavoy and Tony Seale
Client Coordinators: Laura Vogtle, Dept. of Occupational Therapy
Supervising Professors: Alan Eberhardt, PhD, B.J. Stephens, PhD1
Department of Biomedical Engineering
1Department of Mechanical Engineering
University of Alabama at Birmingham
Birmingham, AL 35294-4461

INTRODUCTION

An over-the-bed laptop computer holder was needed for patients at rehabilitation in a hospital. The clients who will use this apparatus have various impediments that require them to lay with minimal elevation or completely supine. Several requirements for the design were set prior to the design-phase of the project by members of the advisory team. The requirements to be met were that the apparatus: 1) be a stand-alone, portable unit, 2) accommodate the adjustability of bed heights, 3) be aesthetically pleasing, 4) be stationary while not in use, but quickly removable in case of medical emergency and 5) be compatible with most models of laptop computers. In addition, the monitor must tilt to at least 90 degrees. Safety is very important since the apparatus will support a monitor above the patient's head and upper body. Additional requirements were that the surfaces must be easy to clean, with the fewest possible seams in the integral construction and exposed edges rounded.

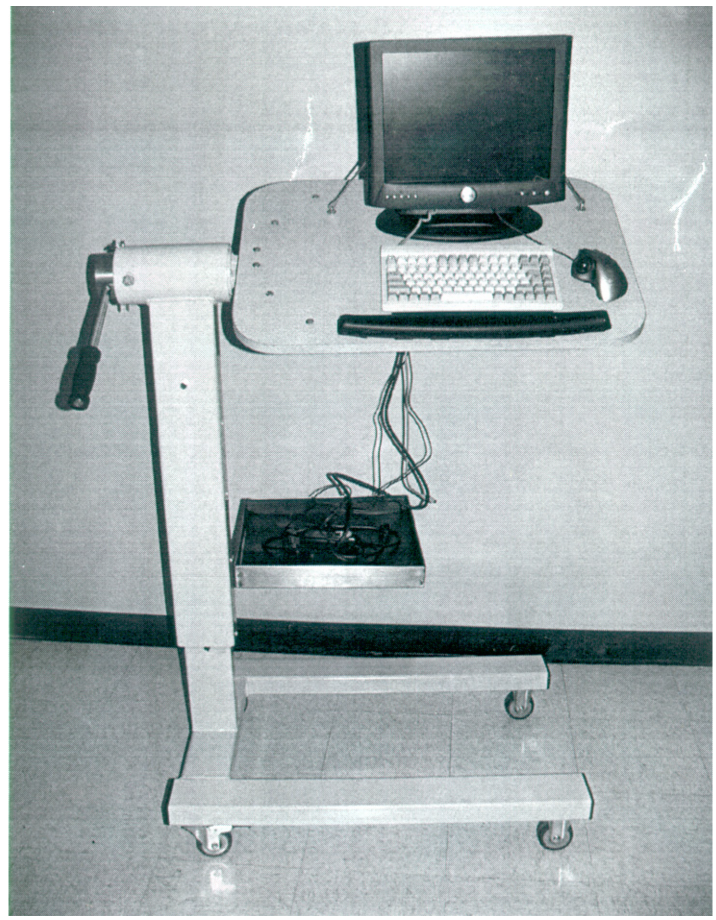

Figure 14.1. Over-the-Bed Computer Stand.

SUMMARY OF IMPACT

Most of the patients for whom this device was designed have been injured in car accidents or other situations that result in severe injuries to the spine, pelvis or lower extremities, immobilizing them for weeks or months. Many of the users are professionals who must complete work while in the hospital, and some wish to use their laptop computers. The computer holder successfully provides the opportunity to work on a computer while bedridden, and also enables additional leisure opportunities other than television. The patient's laptop sits on the lower tray and links with the monitor, which is permanently attached to the tray, along with the keyboard and roller mouse. The assisting nurse positions the device over the client's bed and establishes the angle position of the monitor using the handle at left and locking pin.

TECHNICAL DESCRIPTION

The overall structure of the device is modeled after a hospital food serving apparatus. The working surface cantilevers over the bed, supported on a base with casters, as shown in Fig. 14.1. While in use, the table is kept stationary using total-lock casters at the rear, which prevent both swivel and rotary motion. Height adjustment is achieved through telescoping tubing. The outer tube is three by five inch, 11 gage steel and the inner tube is two by four inch 11 gage steel. An ultra-high molecular weight polyethylene bushing is cut to fit between the two tubes. A power screw lifts the tabletop and attached monitor, keyboard and mouse.

Tilt of the apparatus occurs in the tabletop portion of the device and is achieved through use of two concentric pipes. The outer pipe is welded to a vertical column and remains stationary. The tabletop is bolted to one inch by one inch tubing with ¼ inch galvanized steel carriage bolts. The one by one inch tubing is welded onto a plate and then welded into the inner tube. On the back end of this inner pipe a lever is attached for use as a handle for turning. Aluminum-bronze bushings are press-fit into each end of the outer pipe. A ¼ inch 18-8 stainless steel pin that is inserted at the back end of both pipes provides the stop for the tilting mechanism. Pinholes are drilled at 0°, 30°, 60°, and 90° along the inner pipe and one hole is drilled at 90° in the outer pipe for positioning the tabletop at these angles. A safety stop allows the device to rotate through only 90° of motion, and is engaged if the tabletop is dropped while in use.

To meet the compatibility requirement and to decrease safety hazards, a flat screen monitor is attached to the tabletop. To ensure safety, cables are attached from the monitor to the tabletop. These straps prevent the monitor from falling onto the patient if the monitor support bracket fails. The patient's laptop sits in a stainless-steel shelf provided along the vertical column of the table. A power strip is attached to the vertical column for the laptop and monitor.

All metal components are painted light gray. The tabletop is cut from countertop laminate material and is a light gray to match the stand. The tabletop is edged in matching laminate material and is rounded at the corners. End-caps are used on all tubing.

Total cost was $1306.18.

CHILD BATH LIFT

Designers: Kristen Bridges, Cahalan Mackin, and Marty Sims
Client Coordinators: Marlese Delgado, UCP Hand-in-Hand
Supervising Professors: Alan Eberhardt, PhD, Raymond Thompson, PhD1
Department of Biomedical Engineering
1Department of Materials Science and Engineering
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INTRODUCTION

A bath lift was requested for children with cerebral palsy (CP) to be used in the home. The design team was given the task of designing a device that would lift a child having little or no muscular control into and out of a bathtub, without causing harm to the child. Design constraints included: 1) child weights ranging from thirty to fifty pounds, 2) child heights ranging from two and a half to four feet tall. Requirements were that materials, components, and systems: 1) be compatible with a bathing environment, 2) not present a safety hazard for the child or the caregiver, 3) be able to fit and operate inside a home bathtub (16 to 17 inches inside width and 38 to 44.5 inches inside length). Because the children who will be using this device have little to no muscular control, there were to be head and body supports that fit the individual child. Lastly, the device was to be portable.

SUMMARY OF IMPACT

The primary impact of this device was to enable children to take baths who, due to their disabilities, may have been prevented from doing so in the past. This is important in terms of maintaining proper hygiene. Taking a warm bath provides pleasurable sensory input for the child and may even be considered play activity. A secondary benefit of the device relates to the caregivers. Many caregivers of children with disabilities suffer from back pain as a result of regularly lifting a heavy child in and out of the bathtub. The present device, which lifts the child to a height level with the top of the bathtub, reduces the amount of back strain experienced by the caregiver.

TECHNICAL DESCRIPTION

The Child Bath Lift is a mixture of commercially available equipment and custom fabricated parts. The commercial products include a water-powered bath lift mechanism (Sunrise Medical) and a shower chair (Rifton Medical Supplies). The water-powered lifting device fits into a custom-made base, constructed from 6061-T6 rectangular aluminum tubing and lifts the frame and chair (Fig. 14.2). The base consists of a rectangular aluminum tube with two arms welded on either end. Four suction cups support the arms-one on each end. A nylon bushing is located near the end of the rectangular tube into which the hydraulic tube is placed. Stainless steel bolts attach the chair to the frame, constructed from 6063-T52 square aluminum tubing, and attach to the tube by means of aluminum brackets and stainless steel bolts. The brackets are welded to the tubing and the seat is subsequently attached.

The lift mechanism has a hose that attaches to the water faucet in the bathtub. Turning on the water causes the chair to rise in the tub to the height of the bathtub edge. At this point, the child is easily placed on the chair and various restraints are used to secure the child to the chair. A water release valve allows the chair to slowly descend into the tub. The caregiver is responsible for ensuring that the water is the proper temperature and depth; however, the seat was designed so that the child's head could never be below water level, even if the tub were completely full.

Total cost was approximately $1200.00.

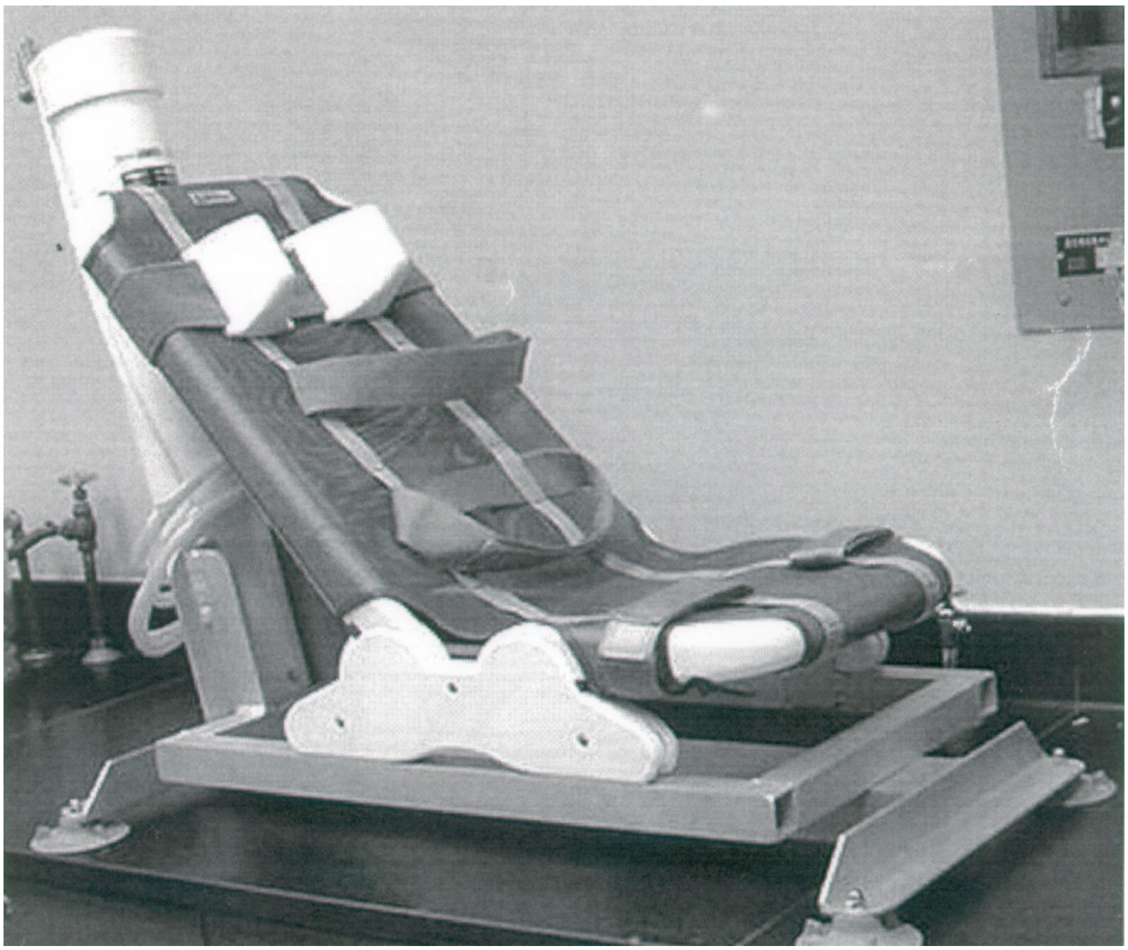

Figure 14.2. Child Bath Lift Including Base, Tube, Frame and Chair.

COFFEE BREWING SYSTEM FOR CLIENT WITH CEREBRAL PALSY

Designers: Bradley Bingert, Nadia Wright, and Kip Carlisle
Client Coordinators: Laura Vogtle, UAB Occupational Therapy
Supervising Professors: Alan Eberhardt, PhD, Raymond Thompson, PhD1
Department of Biomedical Engineering
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INTRODUCTION

The present design was developed specifically to benefit a young woman who has cerebral palsy. She enjoys coffee and wished to have a device to help her pour her own cups of coffee throughout the day. The client has a non-spastic form of the condition and could potentially carry out many of the tasks associated with brewing coffee, provided suitable automated mechanisms were designed for her use.

The primary objective of this design was to produce a device capable of providing the client with a means of dispensing coffee at a temperature between 105 and 125 degrees Fahrenheit. The coffee was to be delivered into a drinking container that is spill resistant and compatible with a straw. In so doing, the coffee maker was to satisfy the following conditions: 1) difficult to overturn (should withstand a force of 50 lbf to any surface that requires contact for operation), 2) actuation mechanisms easily cycled by the client, 3) fits into current residence with a minimum of disturbance to the current arrangement, 4) has a positive placement device such that the drinking container is stable while coffee is being dispensed, 5) requires at least one lbf be applied to the container to remove, and 6) conforms to all applicable codes and standards.

SUMMARY OF IMPACT

The present device allows the client autonomy to perform a task for which she previously had to depend on the assistance of others. This allows her to receive the pleasures of coffee at any time and cut down on the use of personal care assistants.

TECHNICAL DESCRIPTION

The control system is divided into three major subsystems: 1) brew, 2) heat and 3) dispense. The brew subsystem is perhaps the most complex, since the brew cycle consists of filling a tank with water, heating that water to the temp necessary to produce coffee, and then returning to the off state to save power and increase safety. The heat subsystem is placed on a timer so the client would not be required to actively return the device to an off state. Beyond the timing circuit, this subsystem consists of an electrical resistance heater and a thermostat to regulate the output of the heater. The dispense system consists of a solenoid actuated ball valve. A relay has been placed in between the user-actuated switch and the valve to handle the relatively high current loads required by the solenoid. Throughout the electrical design of the device, safety and ease of use were the utmost priorities. The device is designed to be actuated using only three switches. These switches are large push-button style and are easily managed by the client. The circuit design assures that the device would return to an off state after a set period of time without user intervention.

The cup is a 14 ounce model and the cup holder is constructed from 6061 T6 flatstock, which is easy to form and heat treat in the desired shape. An electrically controlled ball valve is the dispense valve. The exterior casing is fabricated from stainless steel, for looks and durability, as well as ease of bending.

Total Cost $1262.79.

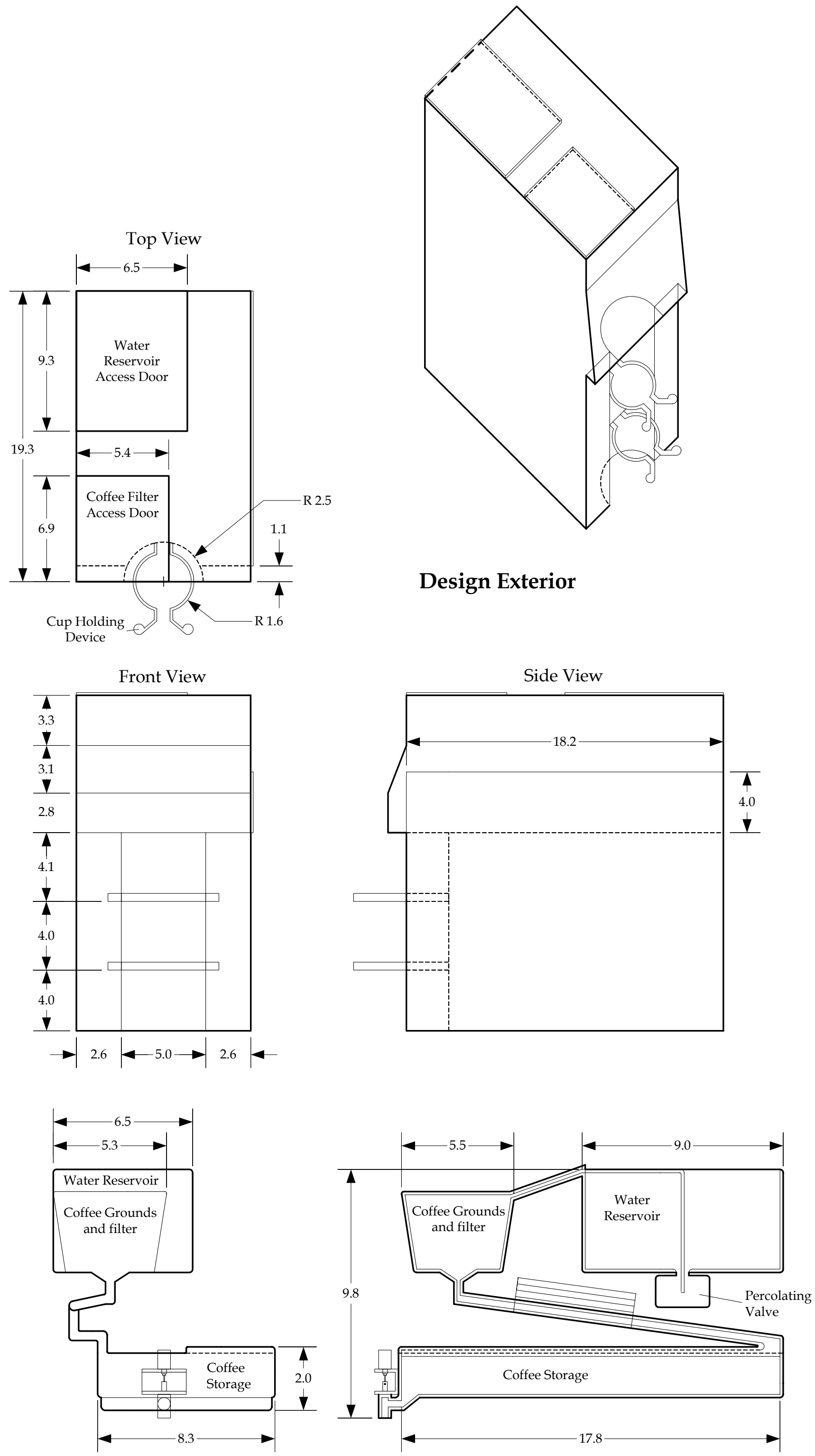

Figure 14.3. Coffee Brewing System Schematics for Exterior Casing (top) and Internal Brewing/Dispensing System (bottom). All Units Shown in Inches.

CHAPTER 15
UNIVERSITY OF CONNECTICUT

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UPDATED ASSISTED MUSICAL LEARNING DEVICE

Designers: Luz Perez, Geriel Ettienne-Modeste
Client Coordinator: Jennifer Canavan
Supervising Professor: Dr. John D.Enderle
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University of Connecticut
260 Glenbrook Road, Storrs, CT 06269-2157

INTRODUCTION

The Assisted Musical Learning Device (AMLD) is an electronic device that combines both musical and educational applications, and is specifically developed for a child with cerebral palsy. However, the AMLD can be used by any child with a learning or physical disability. The inspiration for designing the AMLD arises from the desire to provide individuals with disabilities an opportunity to improve their academic skills and musical creativity.

The AMLD provides three things. The first is to give the client the enjoyment and satisfaction of playing a musical instrument. Second, it acts as a learning tool with which the client has the opportunity to recognize and learn some of the most basic educational fundamentals. Third, the AMLD acts as a form of exercise by developing good hand-eye coordination skills and strengthening the muscles in the arms by performing small movements required to operate the device.

The AMLD can be operated as either a musical instrument or an educational device. When in its musical mode, the AMLD produces five different piano sounds and drumbeats. When operated in its educational mode, it gives an audible output response of the alphabet, the number system, and of five different shapes.

SUMMARY OF IMPACT

The updated Assisted Musical Learning Device is an electronic device that combines musical creativity and educational applications into one. The AMLD allows a person to play a musical instrument, and makes learning basic hand and eye coordination skills through a unique control panel an enjoyable experience.

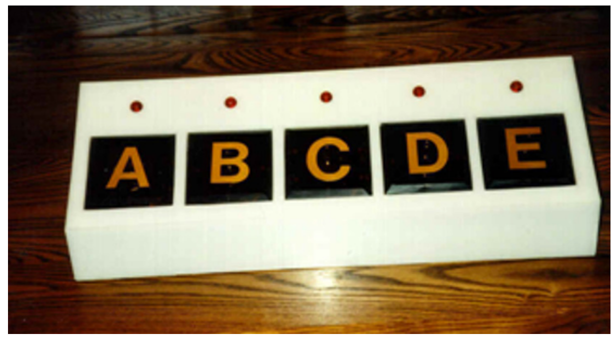

Figure 15.1. External Features of the AMLD.

TECHNICAL DESCRIPTION

The AMLD utilizes 52 large descriptive console control buttons measuring approximately 3.5 inches by 3.5 inches. The large size of the buttons act as larger targets offering the client greater ease of use compared to like devices currently on the market. The buttons can be removed and replaced by the other buttons corresponding to the alphabet, numbers, shapes, and/or musical buttons. Fig.15.1 displays the external features of the AMLD.

The original design of the AMLD suffered malfunctions due to certain electrical and mechanical problems. A peg system attached to each of the 52 buttons was used along with five ISD chips in order to output the corresponding audible sound when each button was depressed. The AMLD now incorporates wireless technology, optical bar code readers, and a microcontroller. A single, more advanced ISD chip that holds and stores more memory has replaced the five ISD chips. The main component or 'brain' of the AMLD is a micro-controller that coordinates the sensors, compares inputs with reference data, and sends a final output to the ISD for the audible sound.

The AMLD was originally designed for a child with cerebral palsy. The child's parents and/or therapist aids the client using the device by pressing one of five buttons on a wireless remote control (consisting of a Transmitter, TXM) corresponding to one of the five buttons on the device's console (as indicated by the lighting up of the red circles on Fig.15.1). When the operator presses the button on the remote, the appropriate control button lights up (a letter, number, shape, or musical sound), requesting the child to press the specific button. When the button is pressed, an assigned bar code is detected, and the corresponding functions occur to display the final audible output. The educational mode is implemented by using control buttons that display the alphabet, the number system, or five different shapes. The musical mode can use the same buttons, but the audible output is five different piano or drum sounds rather than a number, letter, or name of a shape. Whichever mode the client wishes to use, however, the AMLD operates in the same way.

The interchangeable control buttons in the AMLD combine to perform a digital logic meaning of each of the 26 letters, 11 numbers, 5 shapes, and 10 musical sounds. When depressed, optical reflective sensors determine logical input unique to each of the above mentioned designed buttons. Binary logic is programmed in a PIC16F877 micro-controller and the output goes into an Audio Voice Detector or ISD chip. In order for the signal to be heard clearly, LM386 amplifiers, along with two speakers, are used in the device.

Because of the large number of control buttons, each button is given an eight-bit binary code for identification. The eight-bit binary code is given by using a special black and white sequenced tape that can be detected by the sensors, OPB606A. When a single control button is pressed, the binary sequence makes contact with eight sensors, each detecting a single bit of the corresponding eight-bit sequence. The output of each sensor is then connected to the input of an amplifier, LM386 to amplify the signal.

Once a button has been pressed and the eight-bit signal has been detected, an eight-bit sequence is sent from the operational amplifiers to the PIC16F877 micro-controller. The PIC16F877 has 8192x14 words of FLASH program memory, 256 data memory bytes, 368 bytes of user RAM, and an integrated eight-channel 10-bit Analog-to-Digital converter. This component of the AMLD is in charge of acknowledging that a button has been pressed and identifying the eight-bit binary sequence corresponding to the pressed control button and whether it is the correct choice. Once the micro-controller has detected the signal and arranged the sequence, it then sends the eight-bit sequence out to an Integrated Signal Detector, ISD 1110. The ISD's record and playback features convert the digital output micro-controller to an analog signal that lasts for 10-second duration. The ISD 1110 chip then recognizes the sequence and stores it in an eight-bit address. The output from this chip is then amplified and played as an audible sound, allowing the client to enjoy its educational as well as its musical characteristics. A schematic of this action is shown in Fig 15.2 below. The total cost is approximately $500.

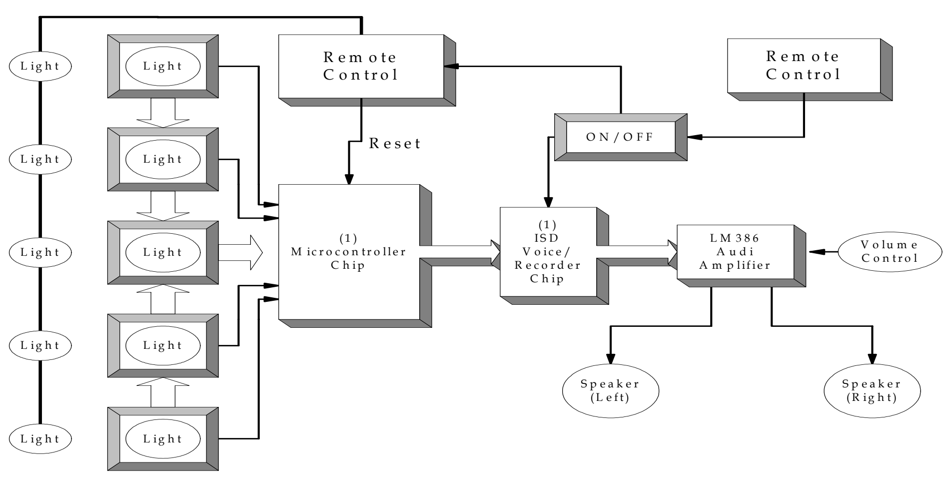

Figure15.2 – Block Diagram of AMLD.

VOICE REGOGNITION MODULE FOR VOICE ACITIVATED ELECTRONIC GRIPPING DEVICE

Designers: Peter Flosdorf, Jay Maciorowski
Client Coordinator: Dr. Brooke Hallowell
Supervising Professor: Dr. John D. Enderle
Biomedical Engineering
University of Connecticut
260 Glenbrook Road, Storrs, CT 06269-2157

INTRODUCTION

The E-Grip grasping device enables its user, who has limited manual strength and dexterity, to grip implements with handles. The gripping element provides the additional strength needed to perform these actions. The glove is voice activated and user specific. It works on four basic commands, which open and close the glove and make it very easy to operate.

SUMMARY OF IMPACT

This device is designed for a client who has weakness on the left hand side of his body due to a stroke. The client desires to partake in activities that he can no longer perform including golf and yard work. This device allows the user to selectively activate the glove by voice command in order to produce a variety of grip strengths. This device makes it possible for the client to become more independent.

TECHNICAL DESCRIPTION

The E-grip is a five-digit exoskeleton glove that facilitates a full range of motion from the fingers to the wrist. Two externally mounted stepper motors controlled by a microcontroller provide power for this motion. The motors facilitate motion by either extending or retracting a thread that is woven into the fingers of the glove. The glove used for the E-grip is a leather sport glove, similar to a golf or batting glove. The E-grip has four different levels of grip, which allow the user to manipulate the strength of grip needed. All of the actions are controlled by a voice control module, which can store up to 15 words or phrases. The module is speaker dependent, which allows only the user the ability to activate and deactivate it.

The voice recognition system used for the E-Grip is a VOICE DIRECT 364 IC speech recognition kit. This kit contains a speaker dependent module, an omnidirectional electret microphone element, and an external speaker. The functional capability of the IC is determined by the configuration of specific I/O pins. The pin inputs (-TRAIN, -CL TRAIN, and –RECOG) generate the specific pin outputs and actions. Each word that is to be recognized must first be trained. During this training, the VOICE DIRECT system builds a template representing the individual's unique sound pattern for each word. The templates are then stored in the serial EEPROM. During recognition, the new pattern produced is compared to the stored templates to determine which command was spoken.

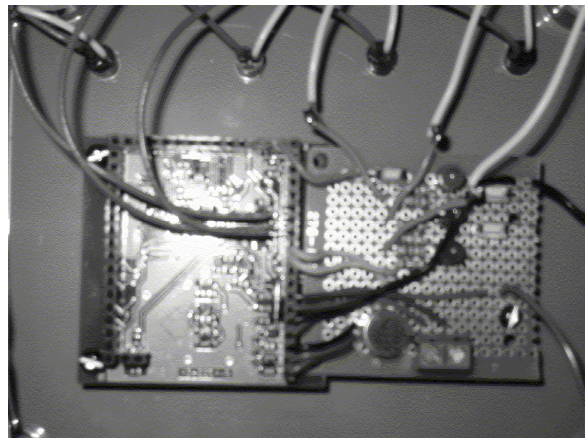

Figure 15.3. Voice Control Module.

After the voice control module has been trained, speech recognition is accomplished through several steps. First, the signal from the external microphone is amplified and filtered to the analog inputs, which converts the analog waveforms to digital samples. The VOICE DIRECT 364 then generates a pattern of information, representative of the significant speech elements. Using a neural network, the pattern is then compared to existing patterns in the serial EEPROM. After a small number of candidate templates are chosen, they are further processed to determine which one is the best match. If this match gives a score over a predefined threshold then the recognition system chooses the word associated with that template. The associated output is then produced and gives the signal for the microcontroller to perform a specialized action.

The cost of this part of the project is about $50.

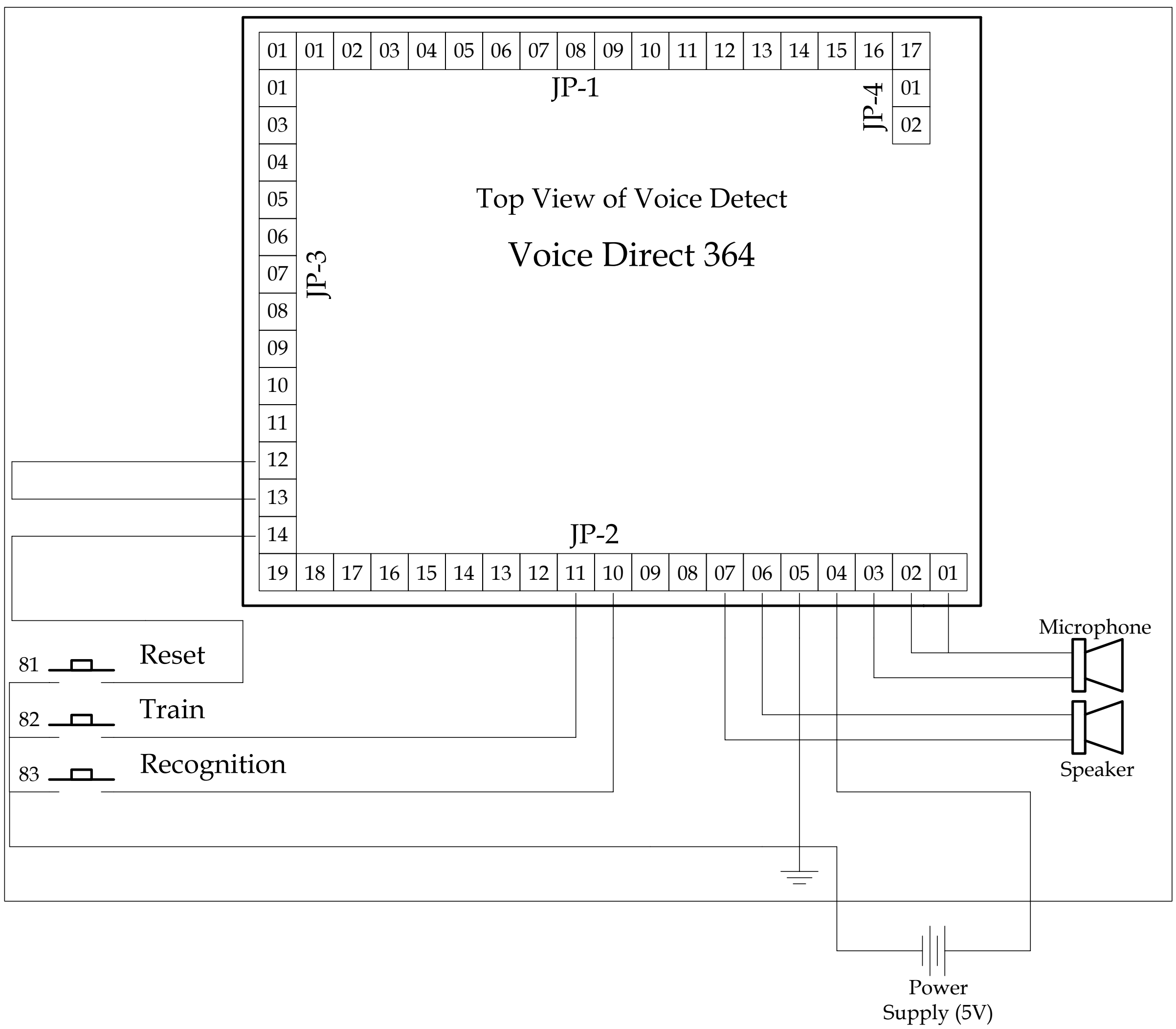

Figure 15.4. Module Stand Alone Schematic.

VOICE ACTIVATED ELECTRONIC GRIPPING DEVICE

Designers: April Dixon, Jay Maciorowski
Supervising Professor: John Enderle
Biomedical Engineering
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260 Glenbrook Road, Storrs, CT 06269-2157

INTRODUCTION

The E-Grip is designed for persons who are not able to fully grasp and release objects. It is intended for someone who has had a stroke and wishes to participate in activities such as golf, yard work, or simple household chores. The glove performs four functions, designated by the client's voice. The commands are loose grip, tight grip, open, and off. These choices allow the wearer to designate the force of the grip depending on what he or she wishes to grasp. The E-Grip facilitates a full range of motion of the fingers and wrist in a natural manner.

SUMMARY OF IMPACT

This glove is designed to replace an existing device devised for a client who had a stroke. The client has limited movement and strength in his left hand and has trouble gripping devices with handles. The E-Grip allows natural movement of the hand and will make it easier to grip objects without manual strength. This glove grants the client independence in performing everyday tasks.

TECHNICAL DESCRIPTION

The glove itself is a leather sport glove such as a golfing glove or a batting glove used in baseball. It is lightweight and has tiny ventilation holes to prevent the hand from sweating. The original design included Shape Memory Alloy actuators but, due to limited resources, clear fishing line was used instead. Two strands of the line are threaded through the holes in the glove- one strand for the top motor and one for the bottom motor. The separate strands are gathered at the end and tied to a washer on the individual stepper-motors. The motors are securely placed in a stretchy band attached to the glove. Relative to the arm, they are just above the wrist area on the top and bottom of the forearm.

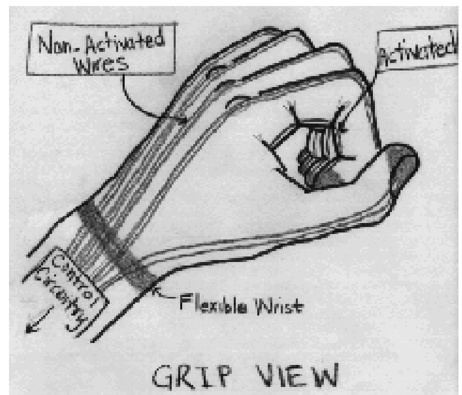

Figure 15.5. Top view of closed glove assembly.

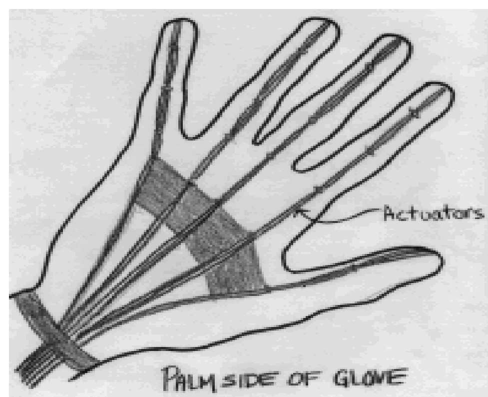

Figure15.6. Bottom view of open glove assembly.

All components of the E-Grip are controlled by the microcontroller. The microcontroller receives its command from the voice control module. The output from the microchip is sent to one of the motor control chips, depending on the necessary action. These stepper-motor drivers consist of 16 pins, and the inputs are compatible with CMOS and TTL circuits. The drivers are capable of disabling outputs in case the temperature exceeds that of the chip limit.

The three inputs are the square wave that controls the frequency, the input that turns the motors on or off, and the direction input that controls which way the motor turns. The output current would ordinarily go from here to the motors. The drivers do not, however, supply the current needed for operation of the grip, so an amplifier must be added. Once the current is increased, it can then power the motors. A schematic of the stepper motor driver chip is shown in Fig. 15.7 below with its interaction with a stepper motor drive shown in Fig. 15.8.

The cost of this portion of the project is about $250.

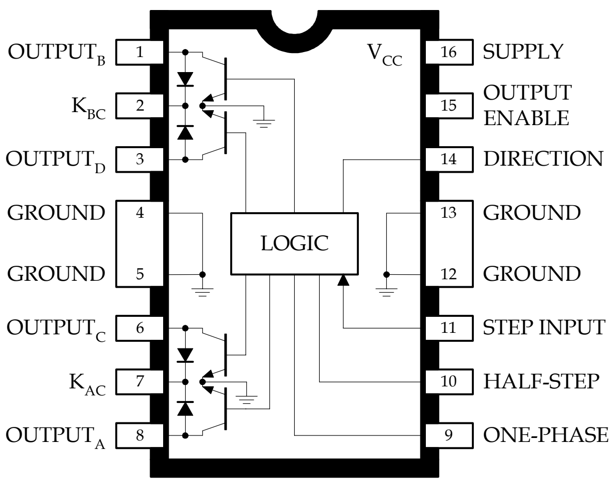

Figure 15.7. Schematic of Stepper Motor Driver Chip.

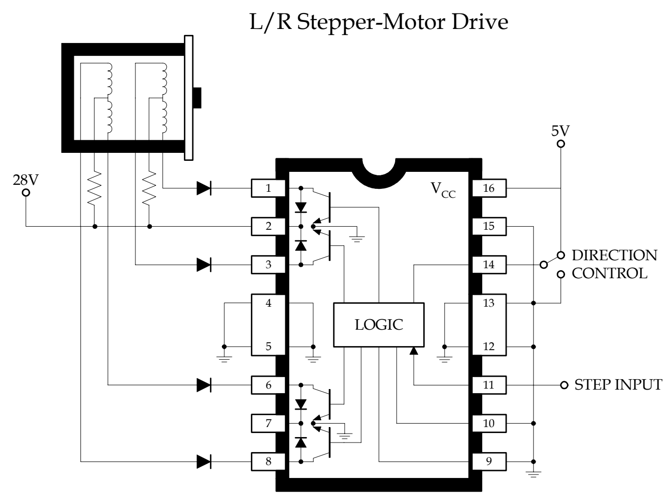

Figure 15.8. Stepper Motor Driver Chip Layout.

HEAD CONTROLLED WHEELCHAIR

Designer: Jay Maciorowski
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Biomedical Engineering
University of Connecticut
260 Glenbrook Road, Storrs, CT 06269-2157

INTRODUCTION

The LED Head Directed Motorized Chair is designed to assist a client with cerebral palsy. The wheelchair uses an LED display panel in coordination with a head switch as a control apparatus to drive the wheelchair under the control of the client. This design uses a microcontroller to coordinate sensor information and to enable the motor driver circuits. The client depresses the head switch when the appropriate direction on the LED display appears, thus engaging the motor driver circuit. The motor circuits consist of two, pulse width modulators that control forward or reverse direction, and speed of the motors. These are the central drive circuits that control the motor direction.

SUMMARY OF IMPACT

This design differs from other motorized wheelchairs in that, unlike other control systems that use joysticks for control, this uses a head switch/LED display for movement. This design is suitable for all persons, including those with cerebral palsy, who have little to no control of their arms and hands.

TECHNICAL DESCRIPTION

The Microcontroller circuit consists of a Microcontroller, five LEDs, five pre-LED resistors, a head switch port, and two operational amplifiers. The microcontroller is the backbone of the design. The PIC used in this application is a 16C74a microcontroller, and its timer is set to produce 30 direction options per minute. The controller is used to integrate the head switch/LED display circuit to the motor circuits.

Two motor control circuits control the motors of the wheelchair. The basis of these controllers consists of a pulse width modulator. This circuit directs the motors by using forward and reverse biases. The device implements two motors, and each motor controls an individual wheel. The motors are connected to the wheels by a gear/V-belt motor drive system. Two power supplies power the entire electrical system. The entire system is placed under the wheelchair.

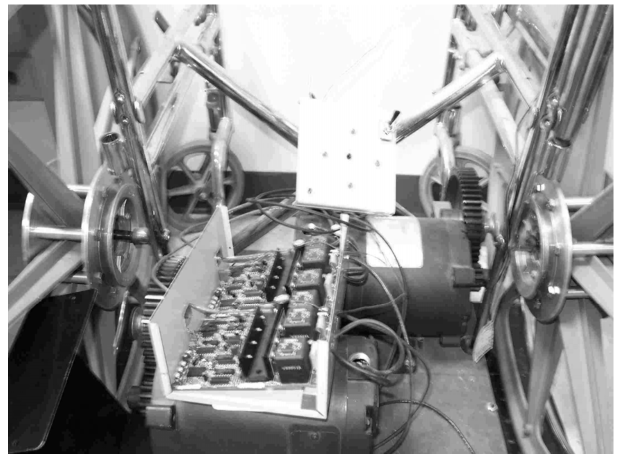

Figure 15.9. Motor Drive Circuit and LED Display.

A pulse width modulation circuit drives the motors. The main function of this circuit is to drive the motors in a forward or reverse bias direction utilizing an H-bridge circuit. Typical H-bridge circuits use MOSFET's for biasing. However, since this device requires such a high current draw, relay switching is used. Two operational amplifiers are used at the output of the PIC microcontroller to increase the magnitude of the PWM waves. The peak-to-peak PWM outputs that come directly from the PIC are too small to be used for the motor control circuits.

The head switch port is used as a means to input connect the head switch to the PIC microcontroller. It is a common jack used with most headphones.

The LED display has five directional options [forward (F), backward (B), left (L), right (R), and stop]. The five LEDs are used as a visual aid to assist in movement control. Four green LEDs are designated for the FORWARD, REVERSE, RIGHT, and LEFT directions and a red LED is used for stop. The circuit uses five pre-LED resistors of 630 ohms for voltage and current regulations. The display is controlled by the PIC microcontroller. When the direction that the client desires to travel is illuminated, the client compresses the head switch and the chair performs the desired action. During the action, the LED display remains on stop until the head switch is compressed showing that the action that is being performed wants to be ended. Every other option in the sequence is stop for precautionary reasons.

For this specific design, it is necessary to use a program that integrates two independent programs. The first consists of the directional LED cycling and the second implements the motor control outputs. These two programs are linked by the compression of the head switch.

The first part of the program is needed to control the directional LEs. It is in charge of the LED cycling through output pins D0-D4 of the PIC microcontroller. The order in which the lights cycle are FORWARD, RIGHT, LEFT, and BACKWARD. This process continues until the head switch is pressed. The head switch is the only input to the system and uses pin D5 of the microcontroller. The primary purpose of this is to notify the controller when to switch programs (either to toggle through the LEDs or to control the motor drive circuits).

The second part of the program is implemented when the head switch is compressed in LED cycling mode. The STOP LED is illuminated and remains so until the head switch is compressed again. Then, depending on which LED was illuminated when the head switch was pressed, outputs are sent to the two motor control circuits, which in turn control the movement of the motors (FORWARD, REVERSE, or no movement). This control is done via duty cycles. There are two PWM outputs on the PIC 16C74a controller. Due to independent wheel movement (specifically for left and right turns), two outputs are needed. The microcontroller outputs duty cycles of 25 percent for forward motor movement, 50 percent for no movement, and 75 percent for reverse motor movement. The motors are mounted in opposite

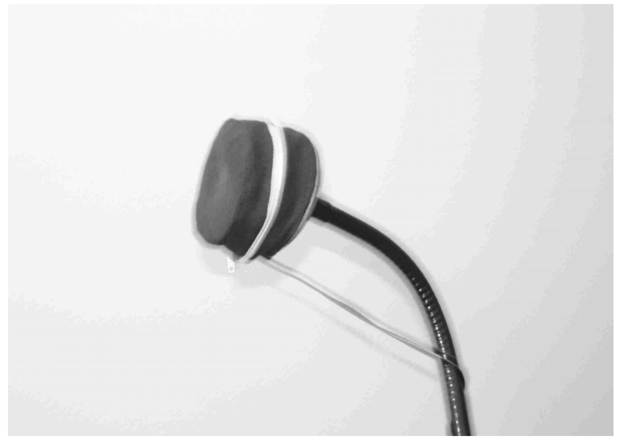

Figure 15.10. Head Switch.

directions, so for FORWARD movement, one motor will need to go forward while the other goes in reverse. Opposite motor movement is necessary to go REVERSE.

The LED display lights the directions the chair travels. When the desired direction the client wishes to travel illuminates, the user compresses the head switch. The control circuit reads input and then outputs information to the motor circuits. The motor control circuits then forward or reverse biases the motors. The motor drive system connects the motors to the wheels of the chair, which turn according to the direction the motors are programmed to run.

The cost of this project is about $1150.

MULTI REMOTE COFFEE MAKER

Designer: Keith M. Fludd
Client Coordinator: Dr. John Enderle
Supervising Professor: Dr. John Enderle
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INTRODUCTION

The Multi Remote project is a device that automates the process of making coffee. Although there is a wide market of coffee makers that can be bought in most stores, there are few total automated coffee makers that are available for private use. Commercial use on automated coffee machines can be seen in the form of a vending machine; however, a compact version of such is not commercially available. The Multi Remote coffee maker serves as a means for the average person to have the advantage of the conventional automated coffee vending machine from the comfort of home. The Multi Remote Coffee Maker is illustrated in Fig. 15.11.

SUMMARY OF IMPACT

The Multi Remote Coffee Maker can be a valuable tool to the lives of many people. The coffee maker helps persons with motor control problems who may not be able to coordinate the process of adding the ingredients needed to make coffee. The machine can help physically people who might have a difficult time gathering all the elements needed to produce a cup of coffee.

TECHNICAL DESCRIPTION

The coffee maker can be broken down into two macro systems: one to distribute the proper amount of dry ingredients and one to heat and add the correct amount of water.

The ingredients the coffee maker distributes are instant coffee, powdered cream, and sugar. The dry ingredients are respectively stored in three cylinder bins at the top of the coffee maker labeled accordingly. Under the three cylinders is a platform that contains discs that rotate and drop a specific amount of that ingredient to a funnel, which then drops it into the cup. Three stepper motors power the discs. The motors are controlled by a series of integrated motor control driver chips.

Figure 15.11. Multi Remote Coffee Maker.

For brewing of water, the user must connect a water supply at a valve via a ¼ inch diameter hole. The water supply can either be standing water that is placed above the coffee maker or a pressurized source. From the input valve the proper amount of water flows in the heating container. The heating container is an insulted cup with a heating coil and a thermistor placed in it. The coil heats the water; the thermistor and a coordinating temperature controller monitor the temperature. At the desired temperature, the coil is turned off, and a second valve is opened to let the water flow from the heating container to the cup.

The two sections are controlled by a PIC. The initial inputs to the PIC come from a remote that is hard wired to it. The input to the PIC is the desired amount of dry ingredients that the user wishes, varying from no sugar and cream to very sweet and light and all combinations in between.

Total cost for the project is $319.11.

MULTI REMOTE AUTOMATED BLINDS

Design: Keith M. Fludd
Client Coordinator: Dr. John Enderle
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INTRODUCTION

The automated blind portion of the Multi Remote project electronically controls a set of blinds through the use of a motor.

SUMMARY OF IMPACT

Along with the other parts of the Multi Remote project, the Automated Blinds is a tool that eases the tasks of the everyday user. This product is especially useful for those who have a problem gripping pull cords that operate blinds and/or curtains. This condition might result from arthritis, carpal tunnel syndrome or a number of other disorders.

TECHNICAL DESCRIPTION

The motor is activated by simply turning the toggle switch (shown on the right in Fig. 15.12) to the on position. If the switch on the motor is already in the on position, the user must turn it off and then back on to reactivate it. The blinds will move up or down depending on the position on the actuator and continue in that direction until it reaches its fully open or closed state. If the user desires the blind to go in the opposite direction that it is set to go, he or she must push the actuator switch to the opposite side. To turn stop the blind in any position in between, the user simply turns the switch off at the desired location.

Referring to Fig. 15.13, the stop switch 2c is similar to a light switch, however it only stops the motor. This switch cannot start the motor. The stop switch is operated automatically by actuators 2a and 2b. It can also be operated by hand. When the motor runs, one actuator moves towards the stop switch while the other moves away. When the actuator pushes the stop switch from one side to the other, the motor stops. After the motor stops, the motor will not run again until power is turned off for at least two seconds, and then back on. When the power is turned back on, the motor runs in the opposite direction until the other actuator moves the stop switch. The user adjusts the actuators closer to or farther away from the switch to set desired open and closed positions. The user starts by setting both actuators close to switch 2c as shown.

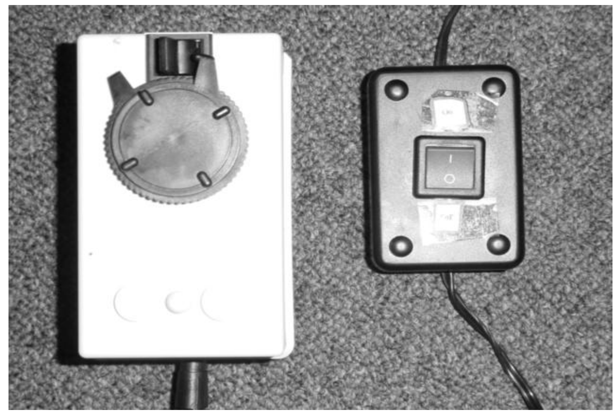
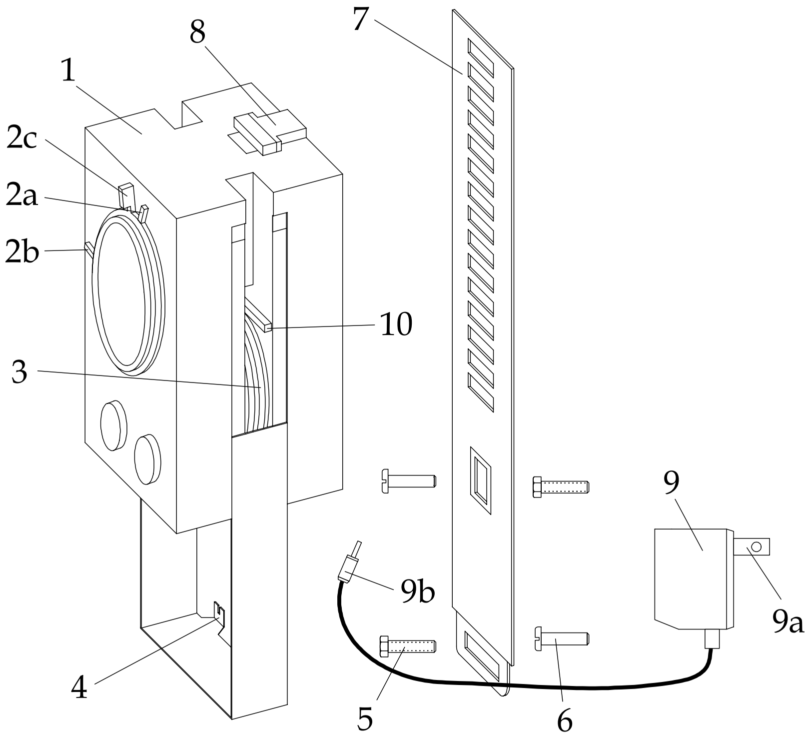


Figure 15.12: The Multi Remote Automated Blinds Controls.



Components

1. Housing
2a. Actuator (Tipped)
2b. Actuator (Flat)
2c. Stop Switch
3. Drive Wheel and Grove
4. Safety Shield and Interlock Peg
5. Wall Screws (2)
6. Wall Anchors (2)
7. Wall Bracket
8. Lock
9. AC-DC Adapter
9a. AC plug
9b. DC plug
10. Bar

Figure 15.13: Mechanical Schematic of Control Device.

ELECTRIC GROCERY TRANSPORTER

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Client Coordinator: Dr. John Enderle
Supervising Professor: Dr. John Enderle
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INTRODUCTION

The couple who use this device are elderly and, although generally healthy, requested an elevator of some sort to help them bring groceries into their house. This elevator would prevent them from having to carry their groceries (or other items) up a short flight of stairs. The proposed location for this device is in the garage of their house with the elevator lifting groceries up to a higher level, about eight feet above the garage floor.

This project entails the design and implementation of an electrical grocery lift for loads up to 150 pounds. The completed Electric Grocery Transporter is shown in Fig. 15.14. The device is essentially a reinforced metal plate attached to a set of wheels, which glide along two vertical rails. The lift is controlled by one up and down switch and two limit switches, which engage when the lift has reached the end of the rails.

SUMMARY OF IMPACT

The Grocery Transporter enables the clients to raise heavy objects into their house.

TECHNICAL DESCRIPTION

The Grocery Transporter is installed in the clients' garage. The Transporter requires ascending and stopping at an exact level of the top ledge of a three-foot wall in a raised foyer at the entrance to the main portion of the house. The lower limit places a loading box at a height of three feet off the garage floor; this configuration leaves a total travel distance of about six feet. Also, since the house is modular in its construction, the main sill the modular unit rests upon is midway of the travel of the device and inaccessible, requiring that all electrical conduits, etc. be mounted on the outside of the wall.

The mechanical design centers on a winch-pulley system wherein a winch raises a dolly up or down a vertical track. The track is mounted in a vertical position on a wall using one-inch thick veneered plywood acting as a medium to ensure solid attachment of the tracks. The track is fabricated from standard channel normally found in overhead sliding doors. These two channels are set at a certain gage sufficient to allow free motion of the completed dolly, in this case, about two feet. Through these channels, the dolly traverses on four sets of double wheels. Consideration is given to ensure these wheels do not bind since they are originally manufactured for overhead use in the above-mentioned tracks. Attached to each pair of wheel sets is a one-inch by three-inch aluminum bar. These two assemblies are attached to each other using equal angle aluminum channel. The length and setting of these two members determine the gage of the track.

Figure 15.14: The Grocery Transporter.

A plate, manufactured with ¼ inch thick aluminum, is attached to these two cross members via two triangular shaped members. On top of the plate, a wooden box is attached. This wooden box has a front and rear door allowing easier access. Ribs are installed inside this box to prevent young children from using the Grocery Lift as a ride.

Power to raise and lower the dolly is provided by a Dayton Winch capable of providing a one-ton force. The particular winch used operates on 120V house current. This configuration is used to avoid the cost of a transformer and ancillary circuitry required to step down to 12 VDC, a more typical configuration for hoisting winches. The winch utilized winds its cable on a spool using a gear motor with gearing aligned so the winch can rest within the gage of the track. The wire rope from the winch passes under the dolly and thru a pulley mounted on the wall at the top of the track. The pulley also has a planetary pulley mounted above it to prevent the wire rope from falling off during operation. The wire rope is then attached to the dolly using a hook and eyebolt. The wire rope configuration is a simple pulley system; there are no compound pulleys attached.

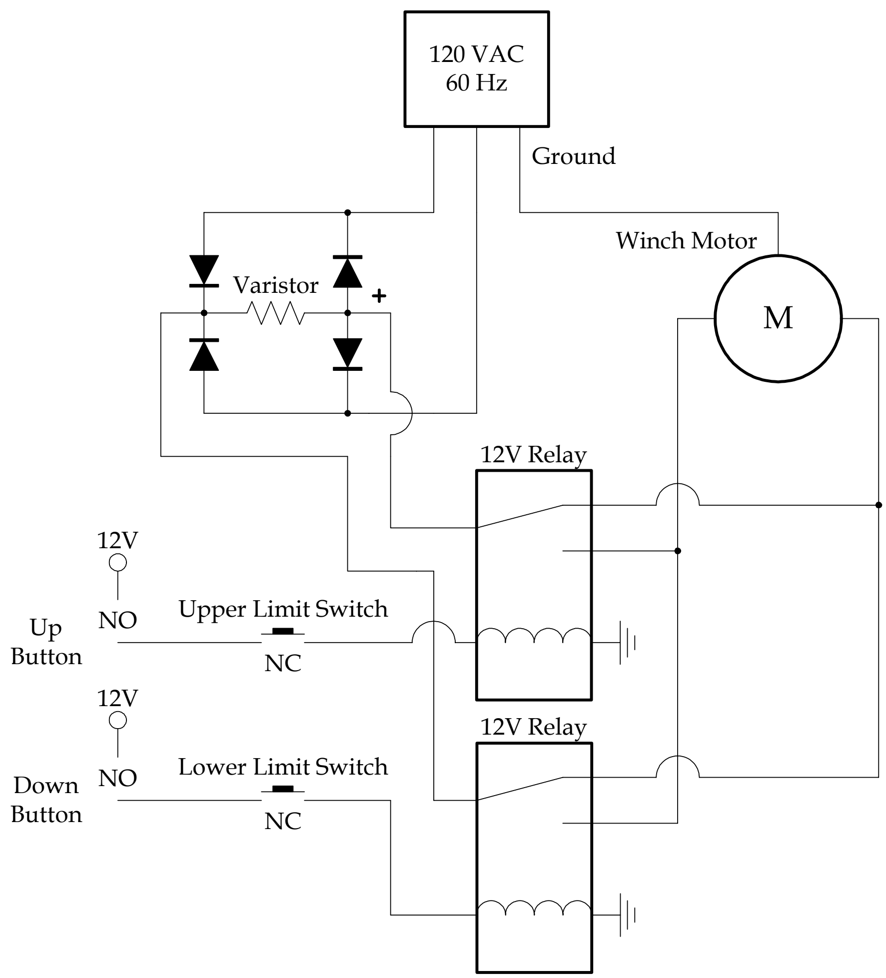

Figure 15.15: Schematic of Grocery Transporter Electrical Circuit.

The circuitry that controls the Transporter consists primarily of two relays and two limit switches. Power is supplied by 120V AC house current. One relay circuit of the bidirectional winch controls ascent movement with the second relay circuit controlling descent. The internal circuitry of the winch is not altered; however, the dynamic brake of the winch is set, via an internal switch in the winch, in the ascending direction, providing a precise stop location at the top of the track that is in line with the unloading platform. The device circuitry is mounted in a separate housing at the bottom of the track. All system wiring conforms to local codes and is protected by conduit when traversing outside the wall.

A detailed review of the circuit (Fig. 15.15) shows that 120 VAC power is supplied to both relays. A 12 Volt switch controls the travel of the dolly alternately by opening or closing the two relays. For example, if the dolly is descending, the relay that activates the winch to unwind is closed. When a lower limit switch is activated, the power from the 12V switch to the relay is cut thereby opening the descent relay that in turn stops the winch. Since the internal brake of the winch is set for the ascent direction, there is some settling of the wire rope and dolly, but further descent is arrested by stops placed in the track. In the meantime, the second relay that would activate the winch to wind the rope is open. When the dolly is in its lowest position, both relays are open preventing the winch from either winding or unwinding; this also holds true when the dolly is in its fullest ascent position. Raising the dolly is accomplished electrically in the same manner, considering of course that the dynamic brake immediately stops the winch when the upper limit switch is touched. Control of the 12V switch is through a mounted wall switch that the operator utilizes to raise or lower the dolly.

The limit switches are standard Cherry sub-miniature limit switches. These switches are mounted on brackets protruding from the walls. Small brackets that protrude from the dolly touch the activator arms of the limit switches to activate them. The upper limit switch is spring-loaded to facilitate setting since the Transporter is required to stop at an exact location.

To raise or lower the transporter, the user is first required to activate system power using an installed wall switch. The user then loads whatever is required to be lifted into the transporter and utilizing a second switch, the user signals the transporter to rise. Rise time to full height is approximately 15 seconds. The transporter is lowered in the same manner. The power switch also acts as an emergency power cut-off. If this switch is activated during transport, the unit stops immediately and holds position.

The cost of this project is approximately $700.

CHAPTER 16
UNIVERSITY OF MASSACHUSETTS AT AMHERST

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SINGLE HAND BRAKING FOR MOUNTAIN BIKES

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INTRODUCTION

Current bicycle brakes are not designed with a one handed rider in mind. The bicycle braking system typically consists of two levers, one attached on each side of the handle bar. The left-hand lever is attached to the front brake by a cable. Similarly, the right hand operates the rear brake.

Considering the needs of a one handed rider, a braking system was designed to allow the rider to use both the brakes independently with one hand (Fig. 16.1 and Fig. 16.2). The CES software was used to select the material and determine the manufacturing process for the brake. This design implements an innovative idea to integrate both the front and rear levers in a single housing, thereby allowing independent actuation of both the brakes with one hand.

SUMMARY OF IMPACT

If a person lacks the use of one arm, to apply brake he or she will either have to choose between the front or rear brake. As in an automobile, the front brake provides the most stopping power. On a bicycle however, the rider can potentially be thrown over the handlebars if too much front brake is used. This is especially true when mountain biking down a steep hill. By using a single hand brake lever that can independently control front and rear brake distribution, the hazards of using a single brake are eliminated.

TECHNICAL DESCRIPTION

In addition to simultaneous brake control, the brake is compatible with current mountain bike components such as shifter pods. The mounting clamp is able to accommodate the standard handlebar diameter. Additionally, the price, performance, and weight are similar to the currently available, mid-range brake levers. The lever is aesthetically appealing, as well as ergonomically correct.

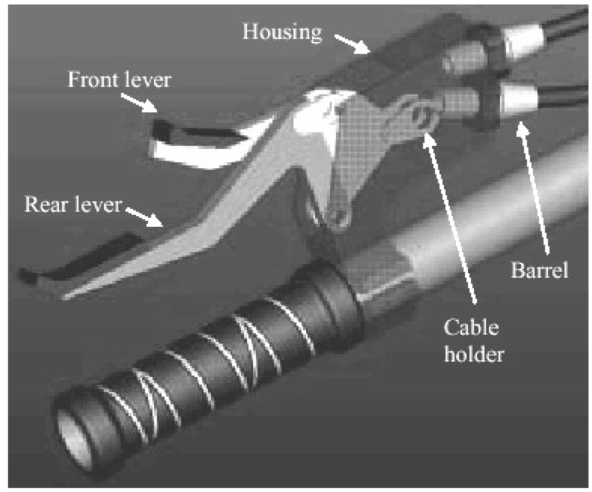

Figure 16.1. Pro-Engineer™ Rendering of Brake Prototype.

When the rear lever is applied, only the rear brake becomes active. When the front lever is applied, both front and rear brakes will be active, and the user can independently control the distribution to each. Typically, a combination of front and rear, or only rear brake application is used, so this design should not restrict the rider in his ability to maximize stopping power. The front lever allows for use of one finger, either the index or middle finger. The rear lever can accommodate one or two fingers, the middle and ring finger or ring finger and the little finger (Fig. 16.3).

The hinge pin serves as a pivot point, allowing the levers to rotate freely. A torsion spring attached to the levers ensures that they will return to the rest positions after being released (Fig. 16.4). To accommodate for varying finger length, reach adjustments are provided for each lever. These allow the rest position to be moved closer or farther away from the handle bar. The brake cables are connected to the levers by means of cable attachments (Fig. 16.5). The barrel adjustment allows the user to individually control the initial brake pad positions by tightening or loosening the brake cable (Fig. 16.6).

The single hand brake lever satisfies all the design requirements including the cost and weight of the component. The material used for the brake is Al 6061-T6. The weight of the prototype was 187 grams as opposed to 190 grams for a pair of standard levers. The production weight of the brake was estimated as 130 g.

Approximate production cost is $6 plus hardware. The prototype cost was $27.

Figure 16.2. Mounted Prototype.

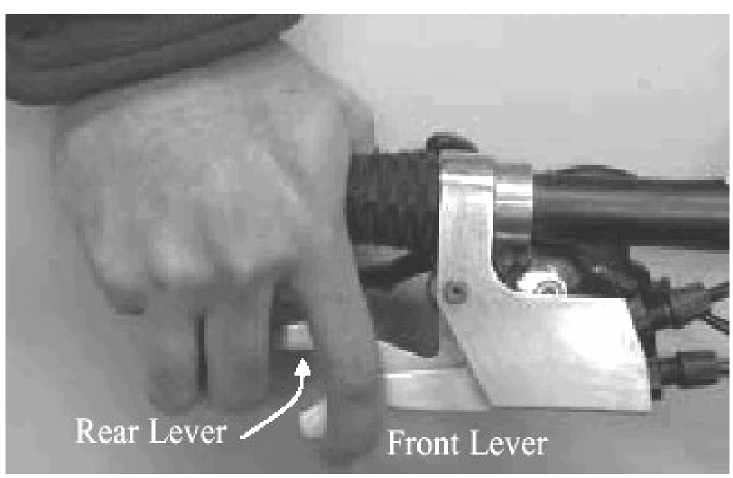

Figure 16.3. Finger Placement.

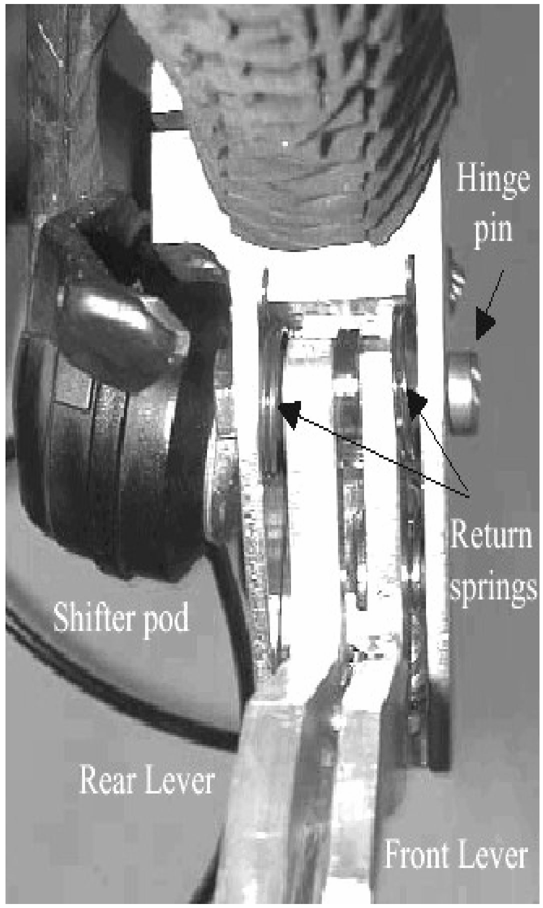

Figure 16.4. Placement of Return Springs.

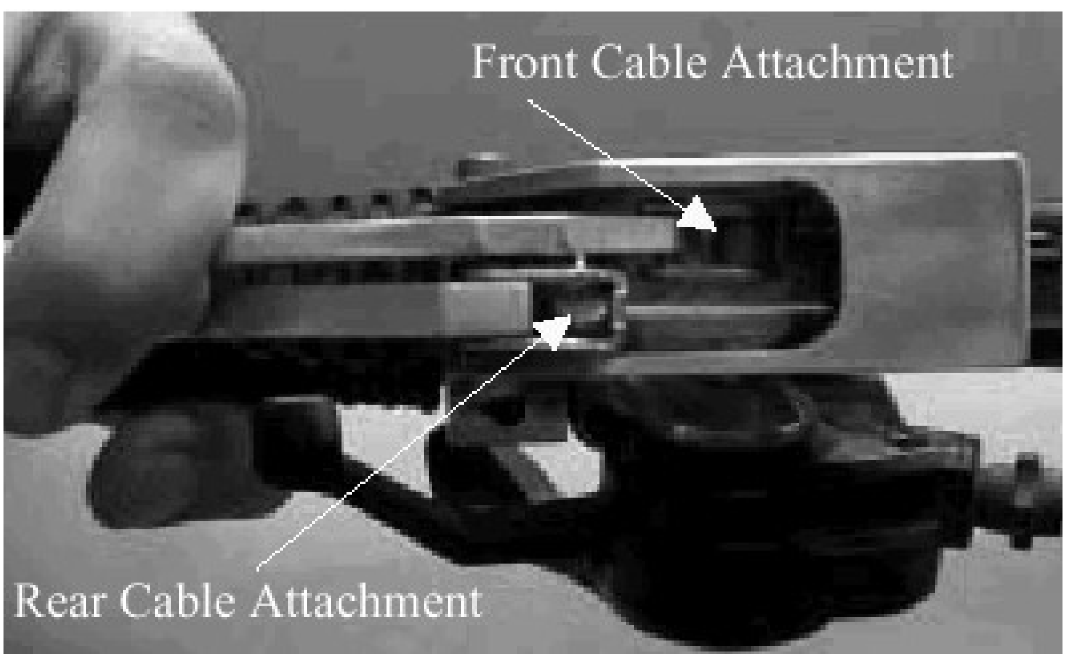

Figure 16.5. Cable Attachments.

Figure 16.6. Barrel and Reach Adjustments.

SIGNAL PROCESSING IN A CANE FOR THE BLIND

Designer: Matthew Atwood
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INTRODUCTION

It is estimated that there are over six million blind people in this nation's population, and many more who have severely impaired vision. For people with such disabilities, activities such as walking down the street can be dangerous because of overhanging objects. The ultrasonic cane for the blind helps reduce these hazards.

The goal of this project is to detect overhanging objects that cannot be detected by the traditional long cane (which is tapped against the ground immediately in front of the user). The ultrasonic cane sends out an ultrasonic signal and records the time it takes this signal to deflect off the surroundings and return. This information enables the cane to take a virtual picture of its surroundings. It alerts the user of any target within a range of three meters.

SUMMARY OF IMPACT

A comprehensive survey indicates that there are currently a few "smart" long canes on the market. These canes use everything from lasers to ultrasonic signals to detect objects. However, all of these canes are very expensive and do not "feel" like a traditional long cane. This aspect of the cane is incredibly important to the user, and is a major flaw in the design of these canes. The ultrasonic cane around which this data processing was done, aims to solve these problems and not alienate the clientele that the cane is designed to assist.

TECHNICAL DESCRIPTION

The work presented here includes the analysis of the data collected from the ultrasonic transducers. The data were collected using an experimental setup that consisted of a PC with a National Instruments DAQ card using LabView Software. The signal was sent from one transducer and received by two ultrasonic receivers.

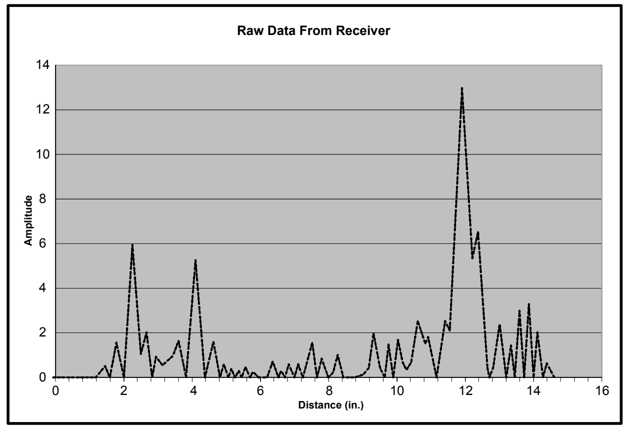


Figure 16.7. Raw Data from Receiver.

The data from both receivers was analyzed in order to discern the peaks from the other noise that is collected during data acquisition (see Fig. 16.7 and Fig. 16.8). These peaks were found through a number of steps used in detection. The first step was finding the local peaks in the data. It was seen from certain "ideal" echoes that there are certain side lobe characteristics that were found empirically and used for final differentiation of the peaks. An example of this data filtering is seen below.

As seen, this data analysis filters out the peaks efficiently. This \ analysis was then carried out using two receivers. This enabled new data processing techniques. There is an acceptable detection range above the cane of one meter. Objects higher than one meter above the transducers are to be rejected because the user will not run into objects that are this tall. In addition, the user tapping his cane on the ground can feel objects one meter in front of the cane. This one by one meter distance in front of the cane sets up a 45° angle at which the closest possible object can be detected as seen in Fig. 16.9.

A relation can be found between the distance to the object and the angle to the transducer plane. As the distance in the X direction is increased, this angle, α, decreases, as is logically deduced. The maximum detection distance of the cane has been determined to be three meters, so it is seen that this acceptable angle (given the one meter height requirement) can be found to be a function of distance, and therefore the sample number. This function is found to be:

$$\theta = \frac{(18.44 - 45)}{(3-1)} \cdot X = -13.28 \cdot X \text{ in degrees}$$

where, X =(sample #) * (sample rate) * (speed of sound)

Therefore, θ= -(π/180°)*(13.28)*(sample#)*(sample rate)* (speed of sound), in radians

With this knowledge of the acceptable angle, as well as having data from the two transducers, a synthetic aperture could be established. This synthetic aperture limits what the cane sees in the vertical direction based on this θ. The way that this was carried out was through converting this angle to the time difference that it would take an echo to hit the respective transducers. It was found that the time difference between the two transducers would be:

$$\Delta t = \frac{d}{c} \sin \theta$$

where, d is distance between transducers (0.1 m), c is speed of sound in air (343.2m/s), t is the time difference between sensors (sec), and θ is the angle as found above (converted to radians).

This time difference can be converted to number of samples using the sample rate, and this can be used to compare the two transducers' signals. Because transducer one is above transducer two, a sample "window" *n* samples wide can be inspected in front of transducer one's echo peaks in order to see if there was an echo peak from the transducer two data. If there is not a peak within this sample "window" (alarm zone), then this indicates that the object is either outside of the synthetic aperture described earlier, or that the object is below the plane of the transducers and is to be rejected since this can be detected by tapping the long cane.

This "Alarm Zone" technique as shown in Fig. 16.10, can be used to effectively detect overhanging objects within the synthetic aperture. The implementation of this data processing will be done in the smart cane prototype.

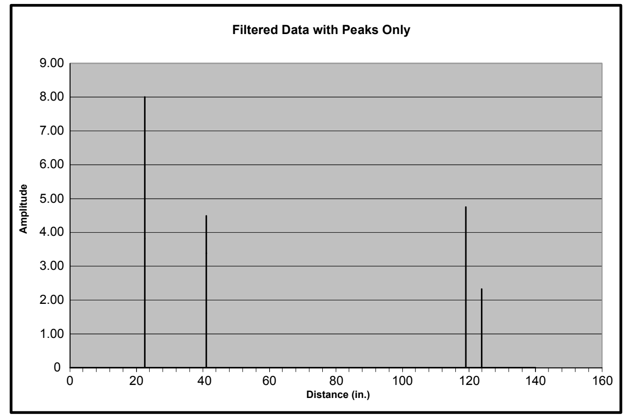


Figure 16.8. Filtered Data with Peaks Only.

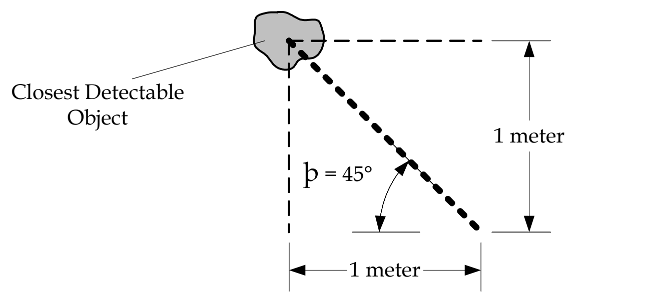


Figure 16.9. Obstacle Detection Geometry.

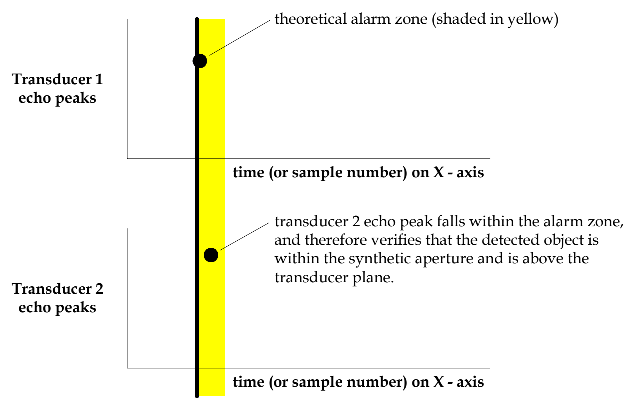


Figure 16.10. "Alarm Zone" Technique for Obstacle Reporting.

THE TROUSER ASSISTANT

Designers: C. P. Canty, A. C. Dossantos, and J. S. Petrie
Supervising Professor: John E. Ritter, Ph.D.
Department of Mechanical and Industrial Engineering
University of Massachusetts
Amherst, MA 01003-3662, USA

INTRODUCTION

The Trouser Assistant is an adaptive-technology dressing tool that will allow individuals with limited reach and mobility to pull up their pants successfully without assistance. Based on interviews with individuals who have a lack of mobility, it was determined that there is a need for such a device, and a variety of members of the community would benefit from owning the Trouser Assistant.

A design was conceived and developed that would successfully lift an individual's pants from his ankles to approximately waist height. A material and manufacturing process analysis was then conducted to create a product that was not only lightweight but also inexpensive.

SUMMARY OF IMPACT

Currently, there is no product on the market similar to the Trouser Assistant despite a large market base. There are approximately half a million Americans who are affected by cerebral palsy alone. Cerebral palsy is one of many conditions that would limit a person's mobility. The Trouser Assistant would give individuals with limited mobility more freedom to function independently. The Trouser Assistant is small and compact. It will therefore draw little attention to the owner or the owner's disability.

TECHNICAL DESCRIPTION

The design of the Trouser Assistant was dictated by the design objectives and constraints that were established based on the needs of the client. The device must hoist a pair of pants from an individual's ankle to his waist without requiring the operator to reach to the floor or supply a significant amount of force. The objective was to create a device that would successfully meet the needs of the user. To do so, the device must be lightweight, inexpensive and resist failure under standard operating conditions.

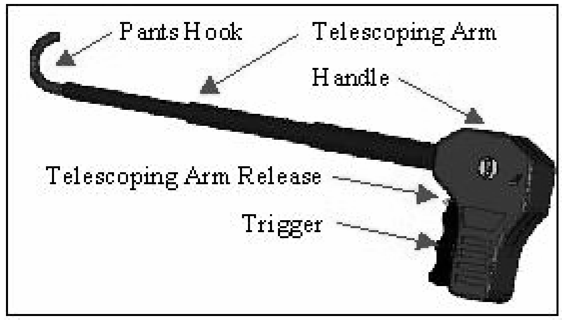


Figure 16.11. The Trouser Assistant.

The final design of the Trouser Assistant can be seen in Fig. 16.11. As can be seen, the final design is compact and discrete.

The operation of the Trouser Assistant is simple. First, the user applies pressure to the telescoping arm release lever and extends the telescoping arm with the opposite hand. The operator then uses the pants hook on the end of the arm to snare the belt line of his pants. The operator must then repeatedly pump the trigger, which in turn retracts the telescoping arm. Once the pants have been hoisted to within reaching distance, the operator can grab the pants with his opposite hand and secure them around his waist.

A cable powers the retraction of the Telescoping

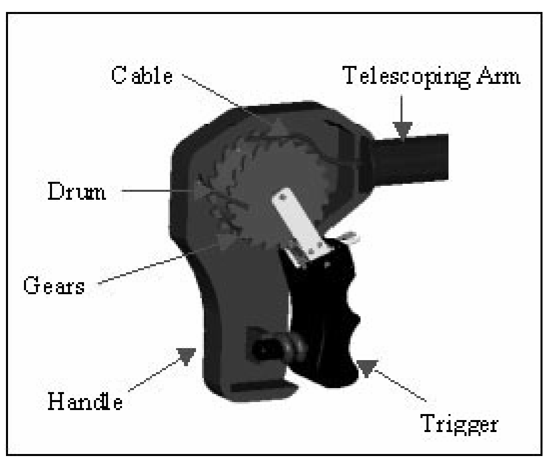


Figure 16.12. Handle Cut Away of the Trouser Assistant.

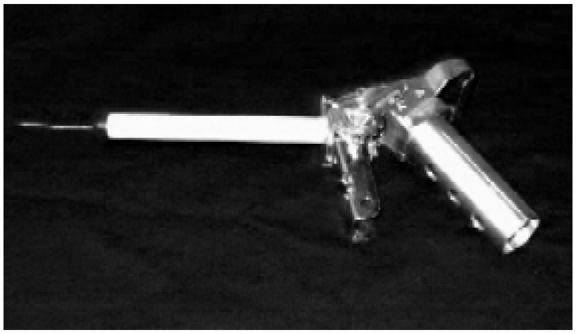


Figure 16.13. The Trouser Assistant Prototype.

Arm. When the trigger is pulled, it acts against a gearing mechanism. As the gears turn, so does a cable drum, which coils the cable retracts the arm. A cross section of the handle, which makes the various mechanical components of the trouser assistant visible, can be seen in Fig. 16.12.

A full-scale prototype of the Trouser Assistant was used to test operation (Fig. 16.13). The prototype demonstrated that such a clothing assistant would be beneficial to individuals who need assistance pulling up their pants. It was easy to use and greatly reduced the distance that the person dressing needed to reach. The Trouser Assistant in use can be seen in Fig. 16.14.

Performing a thorough material and manufacturing method selection procedure completed the design of the Trouser Assistant. The Cambridge Engineering Selector software was used to select the appropriate material to construct each component and process by which each component could be manufactured. The results of the search determined the best material for the handle, plastic trigger and drum was polypropylene. The gear is nylon, and the telescoping arm is high density polyethylene. The spring and cable can be commercially bought and are made of steel.

Figure 16.14. The Trouser Assistant Prototype in Use.

It was also determined that all of the components would be formed by injection molding. After the selection of the ideal materials to construct the Trouser Assistant, the device was sized to resist failure.

The resultant product will cost approximately $8.81 and will weigh approximately 0.28 pounds.

THE AUTO BRAKE FOR A BABY CARRIAGE

Designers: A. F. Blodgett, D.S. Horton, and J.M. LaFlamme
Supervising Professor: John E. Ritter, Ph.D.
Department of Mechanical and Industrial Engineering
University of Massachusetts
Amherst, Ma 01003-3662

INTRODUCTION

An automatic braking system for a baby carriage was designed. This system was designed to retrofit a Cosco® Scamper™ baby carriage and engages brakes as soon as the user releases the carriage handle. The design was targeted at people who experience sudden loss of grip or weak grip. It was found, using the Cambridge Engineering Selector software, the material of choice for the brakes was Glass/Fiber Composite and the material for the braking handle (hoop) was low alloy steel. Using the same software, it was found that the best processes for manufacturing the brake and the hoop were BMC molding and bending of standard bar stock respectively.

SUMMARY OF IMPACT

Baby carriages available in the market today have brakes that can be set so that the carriage will not move. Unfortunately, these brakes cannot be set during motion of the carriage and are only set when the user is aware that the brake is necessary. There are many cases where a brake would be more effective if it was automatically activated when the user is not at the carriage. This prompted the design of the auto brake for the baby carriage in order to increase the safety of baby carriage use and make the user more confident that the baby is safe.

TECHNICAL DESCRIPTION

The automatic brake for the baby carriage was designed to have a braking handle (hoop) that will be pressed against the existing handle when in use. When the handle and hoop are released, springs will engage the brake onto the wheel. Fig. 16.15 shows the solid model of the design as it is on the Scamper™ carriage. This assembly must be very resistant to the environment, since it will get most use while outdoors. Thus, the carriage must be resistant to wear, water and ultra violet light. The components must also pass all mechanical criteria. All stresses and forces were calculated for the case of a carriage loaded with 50 pounds that must be stopped in two meters with an initial speed of one meter per second. It was found that the torque required to stop the carriage with the requirement was 2.41 N-m.

Figure 16.15. Solid Model of Auto Brake.

Figure 16.16. Solid Model of Brake.

The brake was analyzed and optimized with regards to size, material and manufacturing process, using stiffness as the failure criteria and 100,000 units. With the CES software, the material and process chosen for the brake shown in Fig. 16.16 was found to be a glass/fiber composite manufactured by BMC molding. The other component, the hoop, shown in Fig. 16.17, was made of low alloy steel that could easily bend into shape.

Fig. 16.18 shows the prototype of the carriage with the braking system in its intended use. It shows the user with the hoop depressed into the handle as seen in Fig. 16.17.

Shown in Fig. 16.19 and Fig. 16.20 are close up views of the hoop and the brake, respectively. As shown in Fig. 16.19, the hoop was bent to the shape of the existing handle so that it would fit, and it shows the brake used in the prototype. The mass of the brake was found to be 21 grams with a total production cost per brake of $2.52.

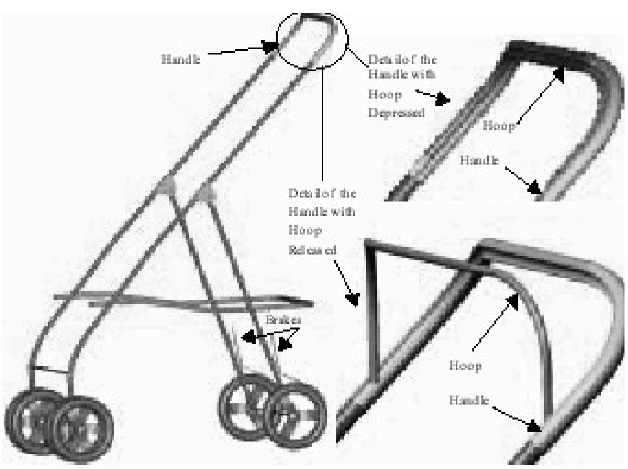


Figure 16.17. Hoop Component.

Figure 16.18. The Auto Brake in Use.

Figure 16.19. Hoop Component Close-up.

Figure 16.20. Brake.

PRESSURIZED SLEEPING BAG (PSB)

Designers: Rajesh Luharuka
Client Coordinator: Community Resources for People with Autism, Easthampton, MA 01027
Supervising Professor(s): Robert Gao, Ph.D. & Sundar Krishnamurty, Ph.D.
Department of Mechanical and Industrial Engineering
University of Massachusetts
Amherst, MA 01003-3662

INTRODUCTION

Autism is a developmental disability that occurs in approximately one in 500 children and is four times more prevalent in boys than in girls. Pathological anxiety related sleep disorder is commonly reported in people with autism. Though there is no cure for autism, treatment may reduce symptoms increase function levels. Pressure stimulation, a sensory integration therapy, has often been found helpful in reducing anxiety in a variety of clinical settings. On the basis of this hypothesis, focus of this project is the design and development of a Pressurized Sleeping Bag (PSB) that provides pressure stimulation to people with autism. The pneumatic pressure inside the sleeping bag is controlled manually using a handheld module. The Galvanic skin response (physiological feedback) of the user and the pressure inside the sleeping bag are sensed, and the data are stored in memory for further analysis.

SUMMARY OF IMPACT

Sensory integration is a much-practiced therapy in children with autism. Some of the popular products available on the market are the “Squeeze machine” (see Fig. 16.21) and weighted vests/blankets. These devices, though inexpensive, are difficult to use and cause fatigue because of heavy weight. One of the major concerns in using such products is the high risk of desensitization to pressure. The PSB addresses these issues and aims to design, develop, and test a pressure stimulation device that is ergonomically pleasing and functionally advanced.

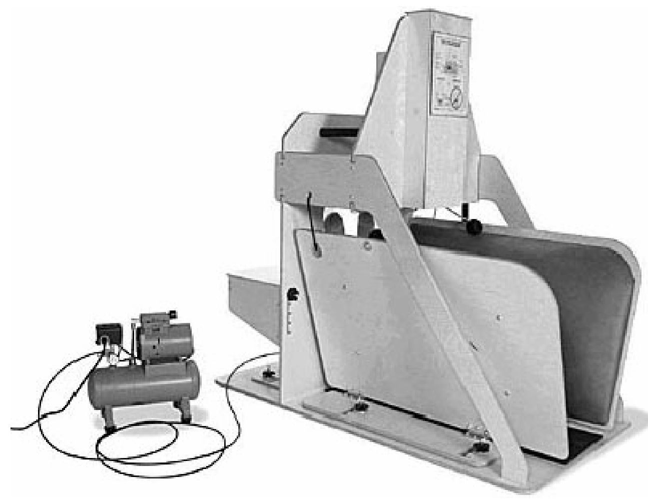


Figure 16.21. Squeeze Machine.

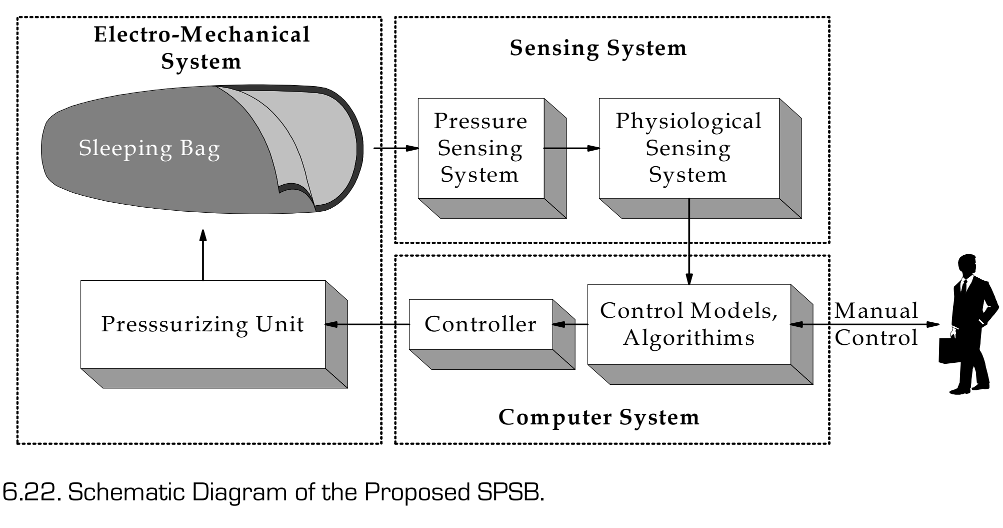


Figure 16.22. Schematic Diagram of the Proposed SPSB.

TECHNICAL DESCRIPTION

The criteria for the design of the device are safety, low noise level, uniform pressure distribution, and high controllability. The device should be able to apply pressure in the range of 0.50 psi and the physiological sensing system should be least intrusive and robust. Based on the functionality, the device is divided into different modules as shown in Fig. 16.22.

A mummy shaped sleeping bag is considered to be best suited for the proposed development. An inflatable cover is used inside the sleeping bag to apply pneumatic pressure. Galvanic Skin Response (GSR) sensor is used to monitor the physiological state of the user in the sleeping bag. GSR is the result of changes in electric conductivity of the skin caused by an increase in activity of sweat glands when the sympathetic nervous system is active, in particular when the subject is anxious. It is considered to be the most robust measure of a person's physiological state. The control system receives air pressure and physiological feedback from the sensing module, which is then stored in the non-volatile memory for future analysis. The stored data can be uploaded to the computer to further study the effects of pressure stimulation. The prototype of the device is shown in Fig. 16.23. Sample data, showing the GSR and pressure readings, are presented in Fig. 16.24.

The prototyping cost is $2000.

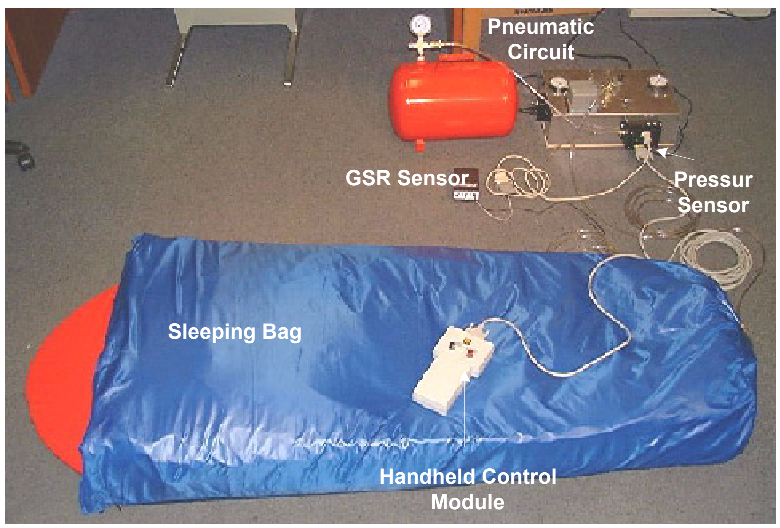


Figure 16.23. System Prototype of the Pressurized Sleeping Bag (PSB).

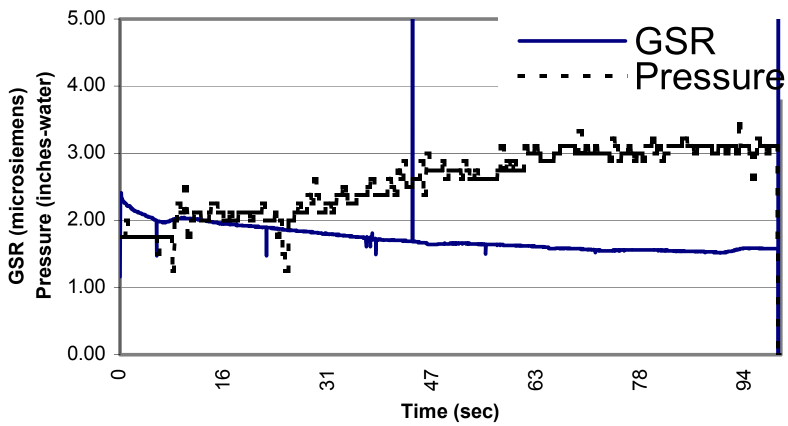


Figure 16.24. Sample Data Collected Using the PSB.

TABLE TOP ACTIVITY CENTER

Designers: J. Messinger and N. E. Valcrcel
Supervising Professor: John E. Ritter, Ph.D
Department of Mechanical and Industrial Engineering
University of Massachusetts
Amherst, MA 01003-3662

INTRODUCTION

A tabletop activity center was designed in response to a kindergarten teacher's demands. The activity center was targeted at children between the ages of five and six who have poor motor skills. Using the Cambridge Engineering Selector software for material and processing analysis, the final design specifies Acrylic as the material of choice and compression molding with additional drilling as the manufacturing processes. This design meets all mechanical constraints and child safety requirements while still sustaining a low cost of about $28.58.

SUMMARY OF IMPACT

Currently, tabletop activity centers on the market only attempt to enhance coarse motor skills while ignoring the fine motor skills. The goal of this project was to create an activity center that could be used by kindergarten-level children with and without disabilities, while providing a fun, game-like experience that enhances fine motor skills. The ability to put the thumb, middle, and index fingers together was the fine motor skill with the main focus. This is an important skill because it is the first step in holding a pencil. With this activity center, the children will learn to hold a pencil sooner, which could aid in their future writing skills.

TECHNICAL DESCRIPTION

Design criteria for the tabletop activity center included containing activities that will strengthen the motor skills of young children, such as hand strength and coordination. The center was to be used by any student and needed to be easily portable, ergonomic, aesthetically pleasing and child safe. It was extremely important to choosing the appropriate material and manufacturing process that met all requirements for the design. The Cambridge Engineering Selector (CES) software allowed for a thorough review of many types of materials and their properties in order to obtain the final choice.

Figure 16.25. Solid Model of Tabletop Activity Center.

In Fig. 16.25 (above), the final design for the tabletop activity center is shown. The center is easily placed on any tabletop and includes several activities that will teach as well as entertain. There are several switches, lights, and noises, as well as a steering wheel that will provide the child with many stimulating activities requiring the use of many motor skills and senses.

The lights and noises are connected to several colorful buttons and switches. However, not every switch has a light or sound connected to it. The simple movement of a switch is adequate to improving a motor skill. The eight lights that are located on the top are connected to a 9.6 V rechargeable nickel-cadmium battery. The sounds that the activity center makes are connected to three AA batteries. The nickel-cadmium battery needs to be recharged daily if used for extended periods of time, but the other batteries will last for weeks.

The activity center housing is made from acrylic polymer, which is a tough, strong material with very good wear characteristics, and can be easily formed to have smooth surfaces and round edges. The acrylic is formed into the shape of the housing through compression molding, and the required holes for the switches and lights are machined after the molding process.

The activity center is 0.4517 meters (18 inches) wide by 0.341 meters (15 inches) deep by 0.2032 meters (eight inches) high, and has a uniform wall thickness of 19.9 millimeters (0.7835 inches). These dimensions allow the activity center to fit on a table comfortably, and at the same time allow the child to reach all the activities. It has an ergonomic curved front edge, which enables the child to get closer to the activity center.

This activity center will be used in a kindergarten classroom to enhance the children's fine motor skills. A picture of the prototype activity center is shown in Fig. 16.26.

Figure 16.26. Prototype of Tabletop Activity Center

WHEELCHAIR LIGHTING SYSTEM

Designers: Heather Bohacs, Patrick Cashman and Michael Chopchitz
Supervising Professor: John E. Ritter, Ph.D.
Department of Mechanical and Industrial Engineering
University of Massachusetts
Amherst, MA 01003-3662

INTRODUCTION

Performing errands or miscellaneous tasks at night could pose a problem to a person in wheelchair. It is difficult to hold a flashlight while propelling the wheelchair forward. The often-used solution is to use bike lights, although mounting is difficult due to differences in bar sizes. Additionally, the bike light does not have the option of aiming the light to a chosen position without moving the entire wheelchair. Since bike lights are not the ideal solution, it was decided to design an inexpensive wheelchair lighting system that can simply be attached to the wheelchair.

SUMMARY OF IMPACT

Current wheelchair lighting systems are only available on the top-end, expensive wheelchairs. Most people in wheelchairs use existing bicycle lighting systems, which are also expensive and designed to fit only bicycle tubing with specific mounting requirements. Currently available bicycle lighting systems are also large and impede the wheelchair operators' range of motion. The new wheelchair light design incorporates a low profile design and adjustable positioning, which allows the light to be mounted almost anywhere on the wheelchair.

TECHNICAL DESCRIPTION

Several attributes for the wheelchair lighting system were considered important. Included were a low profile battery case that would not interfere with the operation of the wheelchair, an adjustable positioning system so the beam of light may be aimed, and a remote switch for ease of use. The final design consists of four main components: battery case, light housing, flexible coupling and remote switch (see Fig. 16.27). The design incorporates a split clamp held together by two screws, which mounts the main battery case to the tubing of the wheelchair. The lighting system is capable of being mounted to virtually any part of the wheelchair with this clamping system. In addition, it is compact enough so it does not interfere with the operation of the wheelchair. Located within the battery case are two C size batteries. It was decided that this power source would provide adequate run time while maintaining the compact design. The lamp housing is similar to that of the common flashlight but utilizes a krypton bulb for superior light output. The lamp housing, mounted to the battery case through the use of a dual ball joint coupling, allows the light to be aimed up to 90 degrees in any direction. The final feature of the lighting system is the remote switch. Attached to the main body by a thin wire, the remote switch can be mounted anywhere on the wheelchair using the provided Velcro strap. This remote switch provides easy on/off control of the light while remaining within reach of anyone with limited mobility.

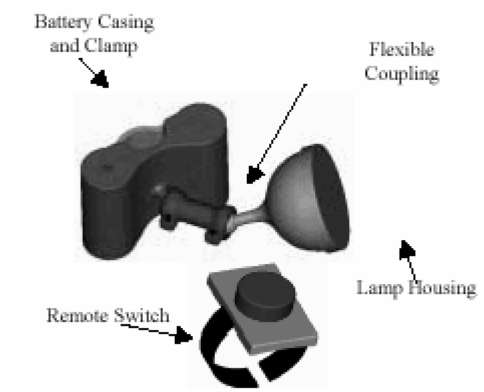


Figure 16.27: Lighting System Components.

The main parts of the lighting system, the battery case, light housing, flexible coupling and remote switch, are made of injection-molded polypropylene. The Velcro strap, bulb, hardware, wiring, and electronic components are all common parts that can be purchased from a supplier. Thorough analysis and elimination proved polypropylene to be the best material for this design. Injection molding of all parts would be a cost-effective manufacturing method.

Fig. 16.28 shows a prototype of the wheelchair lighting system, and Fig. 16.29 shows the lighting system mounted on the wheelchair.

The capital costs of purchasing a molding machine could be divided between all required parts. The estimated cost of the entire system is approximately $6.

Figure 16.28. Lighting System Prototype.

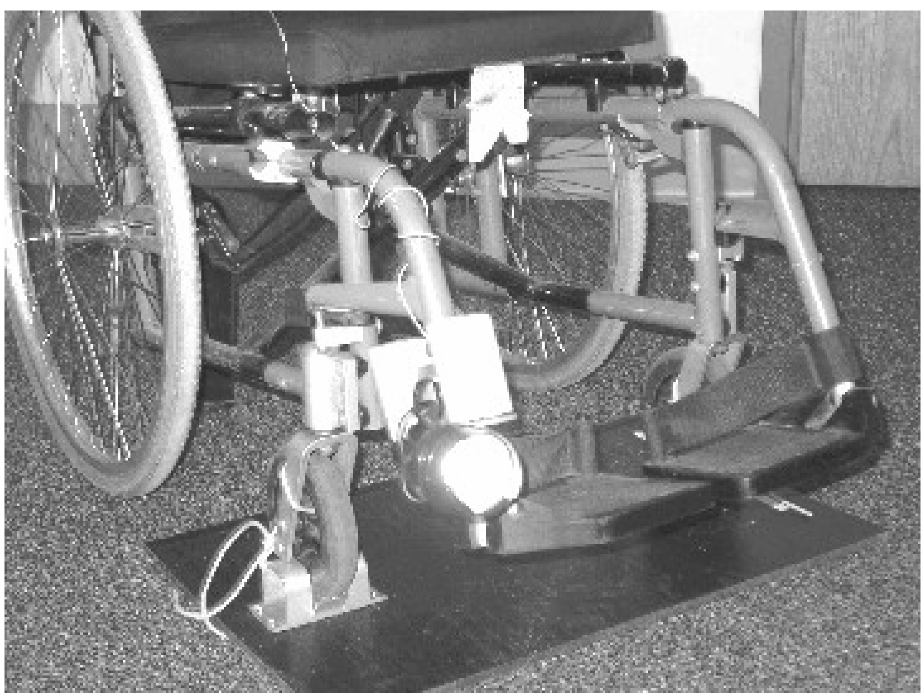


Figure 16.29. Mounted Prototype.

ASSISTIVE WALKER

Designers: Jeremy Paskind, Richard Kowalski, Michael Doe
Supervising Professor: John E. Ritter, Ph. D.
Department of Mechanical and Industrial Engineering
University of Massachusetts
Amherst, MA 01003

INTRODUCTION

The design of this Assistive Walker is different than current walker models on the market today. Built for people with limited upper body usage and strength, this walker aids a person by increasing his mobility without requiring use of his hands. This walker allows the user to rest his weight onto his underarms, similar to the way a crutch is used. The wheels on the bottom allow the frame to be pushed along as it supports the person. A small hand brake can be placed anywhere on the unit's frame for versatility and safety.

With the aid of the Cambridge Engineering Selector Software, the optimal materials and manufacturing processes were chosen to best suit this type of device. By analyzing the anticipated loads the walker would have to withstand, it was built to be as light as possible without sacrificing any strength. After these two criteria were accounted for, materials and processing costs were minimized to yield the most economical design possible.

SUMMARY OF IMPACT

The basic design of current walkers and similar aids has remained somewhat unchanged for a number of years. While adequate for most people, these devices require the user to lift the walker and edge it along as they walk or, if it has caster, to roll it along. For people who have little or no usage of their upper arms, however, these walkers simply cannot be used effectively. The design of the new Assistive Walker overcomes this limitation by supporting the user's weight by his underarms. The walker can then be slid with them without having to be lifted or maneuvered by hand.

TECHNICAL DESCRIPTION

A design was created to accomplish the need of the Assistive Walker to support the user under his arms. Because this design concept had to incorporate support under the armpits, adjustability and sizing issues had to be addressed. In particular, the upper frame had to adjust inward to accommodate the varying width of different users. A CAD model of this concept can be seen in the Fig. 16.30. The new design, not seen in existing walkers, is used in a different manner that brings about new adjustability and sizing issues.

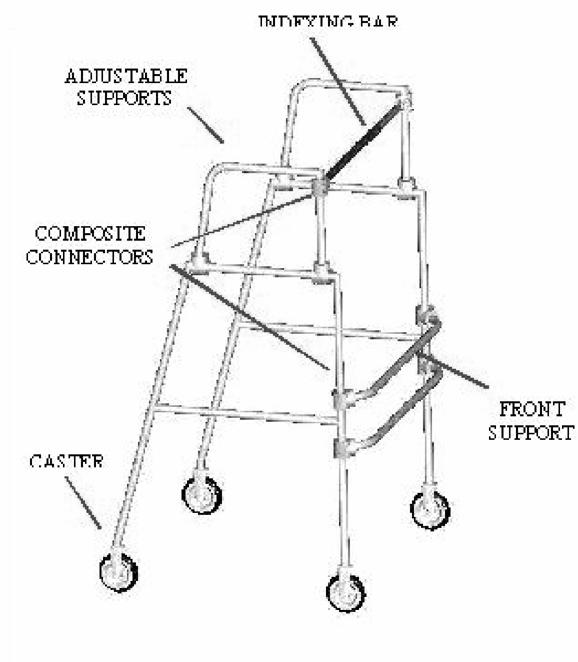


Figure 16.30: Assistive Walker Model.

By analyzing the design to find the most critical loading scenarios most likely to be encountered, the precise modes of failure for different components were found. With this data, material and shape requirements were derived and CES plots were generated to guide the selection of the optimal material for each major component. From the original design specifications, each part was to be both failure resistant and lightweight. Only after these two criteria were met was the cost to be minimized. Functionality, not cost, took priority in the construction to result in a safe and highly useful product.

Figure 16.31: View of Prototype.

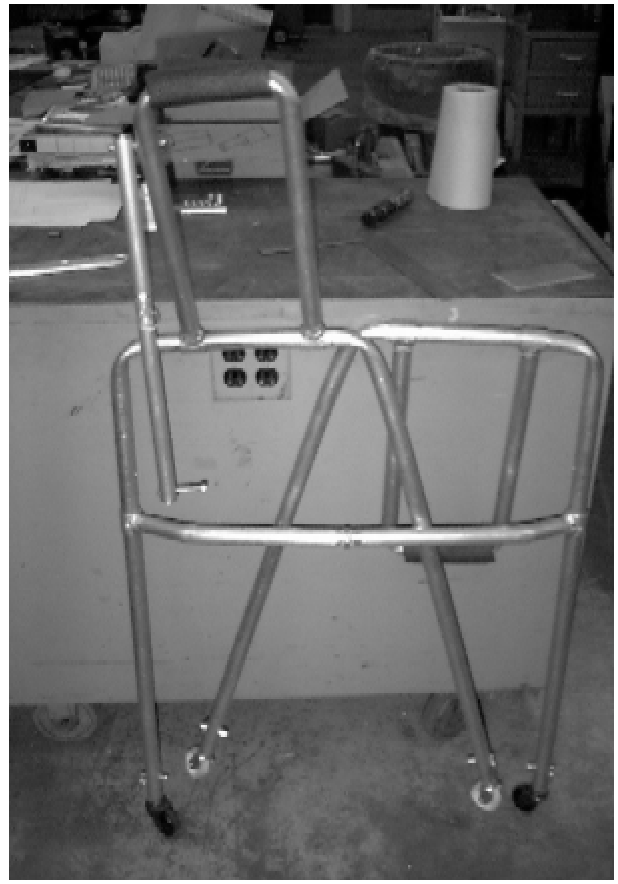


Figure 16.32: Folded View of Prototype.

Using the results from the stress and failure analysis conducted on the frame of the walker, wrought Aluminum Alloy tubing with a one-inch outer diameter was chosen. Used in most current models on the market, alloy tubing provides a lightweight, strong, and aesthetically pleasing alternative to other possibilities. Due to its availability, standard alloy tubing could be purchased for the construction of the frame to save money on manufacturing and overhead costs.

To allow for rotational movement of certain parts of the frame and facilitate folding and size adjustment, some of the joints were not welded. Instead, small connecter pieces were designed. By analyzing the parts at the most critically stressed location, the probability of failure was reduced almost completely. Designed to be lightweight and strong, the CES software led to a material selection of an injection molded, Phenolic Matrix Composite connector hinge. The wheel housings were also analyzed for failure criteria and found that stiffness was the dominant factor.

Using the derived material index for the part, it was decided that the part be injection molded out of Glass fiber reinforced ABS plastic. Once sized, the part was then checked for other modes of failure to insure that the original assumptions were correct. Many other parts in the design of the walker were found to be standard, commercially available products. All of the hardware, the caster wheels, and the caliper brake mechanisms were purchased to reduce the overall cost of the product.

The final design weighs less than nine pounds. The walker's maximum rated user weight was 250 pounds with some additional safety factors built in. Materials were chosen to not only support the applied loads, but also to withstand most typical environmental factors. Overall, this design addressed all of the specifications, while remaining within a close weight and cost range of the existing walkers.

The cost was about $59 dollars.

THE BAR ON THE T

Designers: Tricia Deleporte, Matthew Fuccillo, and Sarah Stilgoe
Supervising Professor: Dr. John Ritter
College of Engineering
University of Massachusetts
Amherst, MA 01003

INTRODUCTION

This design addresses the issue of the safety and security of people in wheelchairs riding city trains. This device is self-contained, can be easily added to the trains already in existence and requires no assistance from anyone other than the user.

SUMMARY OF IMPACT

This design provides security to an individual in a wheelchair riding on the train. Once the passenger has boarded the train, he situates himself behind the lap bar. The bar and the existing brakes on the wheelchair work together in resisting motion parallel to the motion of the train.

TECHNICAL DESCRIPTION

This design has three major components that can be installed on any of the MBTA's one hundred Green Line trains: the lap bar, hinge and track. The bar is constructed from long hollow wrought aluminum alloy tubing and is covered with foam. Both are stock parts that can be purchased from most material supply companies. The foam padding is used for ergonomics and is aesthetically pleasing in its environment. The bar rests on either the lap of the user or the armrest of the user's wheelchair.

The hinge is constructed using cast wrought aluminum alloy. This plate slides vertically in the track allowing various positions for the various size users. The plate also contains two holes where the clevis pin is positioned. The clevis pin attaches the forged steel yoke assembly welded into the bar, and allows the bar to move from a horizontal position to a vertical position when not in use. The yoke and clevis pins used are locally purchased parts.

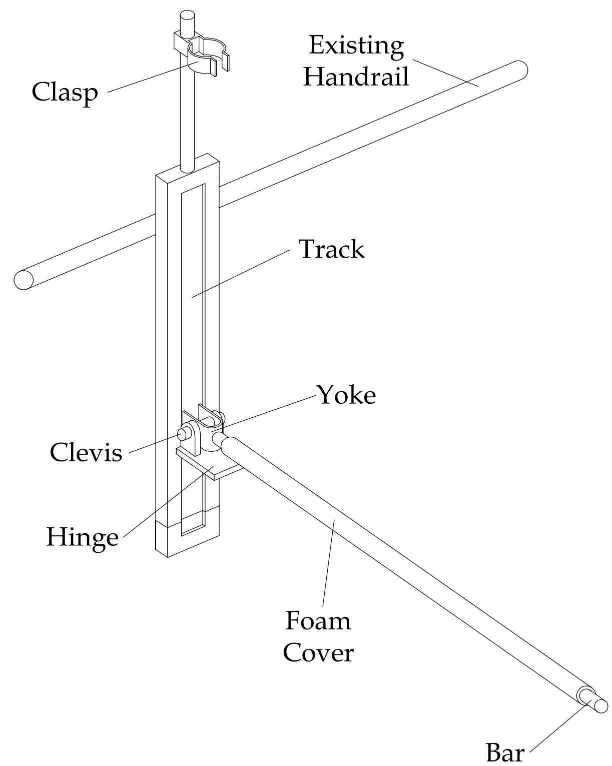


Figure 16.33. Pro-E Drawing of Design.

The track is the component that allows the hinge to slide vertically, allowing it to adjust to the height of the user. It is easily attached to the already existing handrail on the trains. The track is a medium carbon steel manufactured part that requires a small amount of machining for proper sliding. A PRO-E drawing of the design is given in Fig. 16.33. The prototype constructed can be seen in Fig. 16.34 and Fig. 16.35.

The cost of the Bar on the T is $295.96.

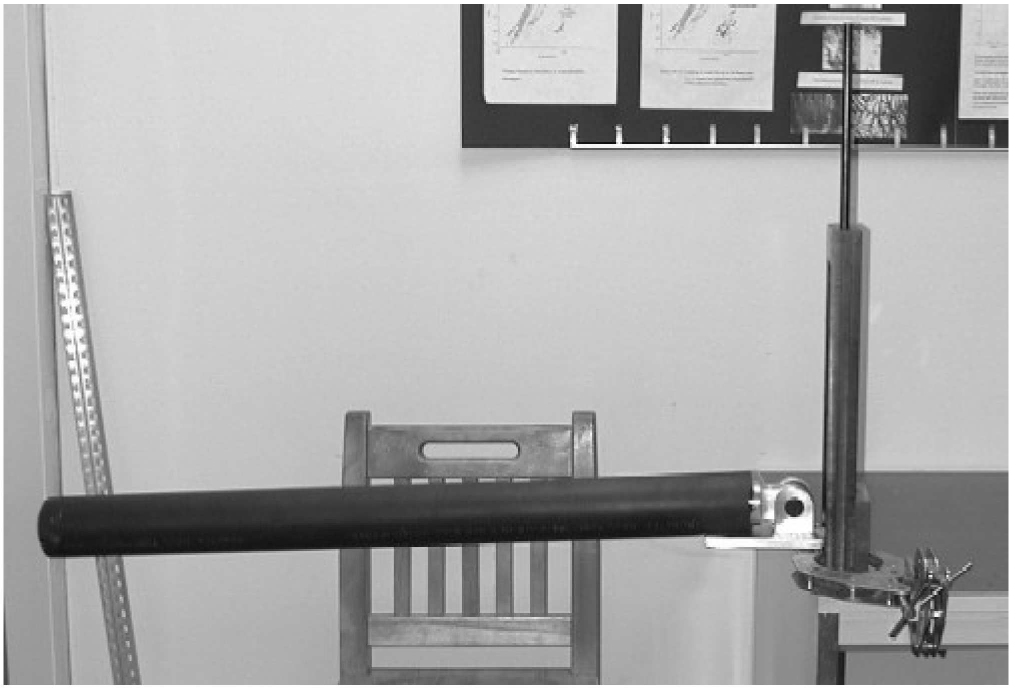


Figure 16.34. Side View of Lap Bar in “Down Position”.

Figure 16.35. Side View of Lap Bar in “Up Position”.

THE FISHER ASSISTER

Designers: J. Foulis, R. Gallagher, B. Ewing
Supervising Professor: John E. Ritter, Ph.D.
Department of Mechanical and Industrial Engineering
University of Massachusetts
Amherst, MA 0.003-3662

INTRODUCTION

A person who has only one arm or hand may have difficulty performing everyday tasks taken for granted. Some sports or hobbies may be difficult or even impossible to perform with the use of only one arm or hand. People with disabilities still have a desire to participate in sports such as fishing. However, for a person with only one usable hand, it is difficult to fish since two hands are required to operate the fishing pole. One hand is needed to hold the pole, while the other is needed to work the reel. A design has been devised to eliminate the need to hold the rod while fishing (see Fig. 16.36).

CES software was used to find out what material should be used in the design. It had to be lightweight, inexpensive and strong enough to hold a fish while reeling it in. GFRP was selected for the attachment, and polypropylene 40 percent glass fiber was selected for the harness.

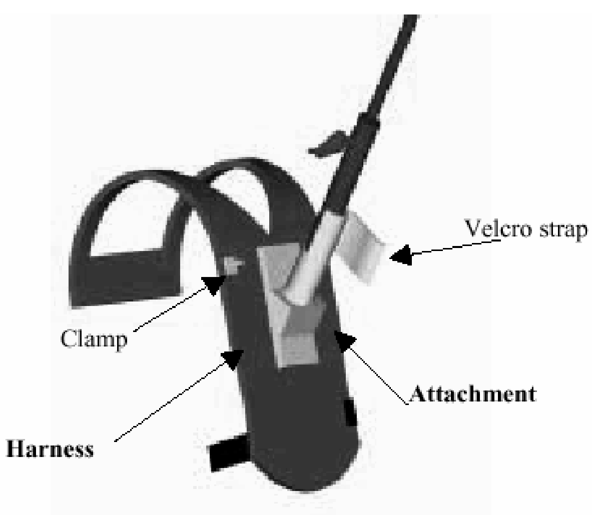
SUMMARY OF IMPACT

There are few products currently available for fishing with the use of only one hand. These products were found to be unstable and awkward to wear. The Fisher Assister was designed to allow a person with one hand to successfully fish with ease. The Fisher Assister holds and stabilizes the fishing rod while reeling, and it allows for easy and quick release of the fishing rod for re-casting. The clamp located on the upper portion of the harness provides the user with another "hand" in order to perform tasks such as tying a hook or removing a fish.

TECHNICAL DESCRIPTION

The essential characteristics of our product are that it will be lightweight, easy to wear and easy to use with one hand. The device will hold the fishing rod secure and stable during reeling, while allowing the rod to be removed from the holder quickly and easily with one hand.

The design consists of two main components: the harness and cylinder attachment (as shown in Fig. 16.36). The harness portion of our design is similar to the harness a drummer in a marching band would use to support drums. The harness is one solid piece that slides over the head and rests on the shoulders. The cylinder attachment of our prototype (Fig. 16.37) is secured to the front of the harness with 4-1/2 inch



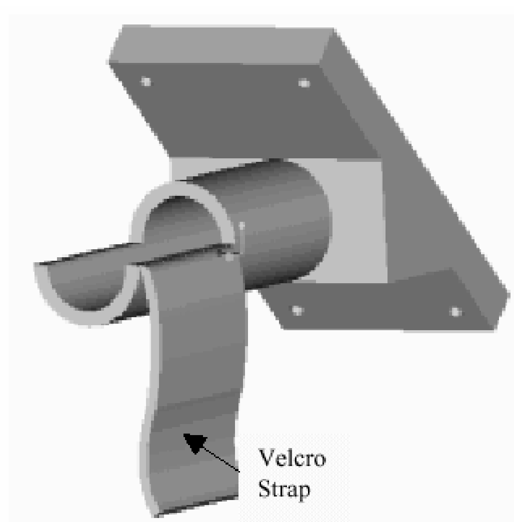


Figure 16.36. The Fisher Assister Components (left) and Close up of Cylinder Attachment (right).

bolts. It is 12 inches long, and has an inner and outer diameter of 1.25 and 1.38 inches, respectively. A quarter of it is cut out and has a loose strip of Velcro to wrap around it, keeping the pole secure when it is being reeled in. The cylinder is positioned at a 45 - degree angle from the user's chest. The harness also has other features added to assist a person while fishing. Shown in Fig. 16.37, a clamp on the side of the chest will assist a person in tying a hook onto a line, baiting the hook and removing a caught fish. A beverage holder attached to the harness completes the Fisher Assister.

CES was used to find the best material for a lightweight, inexpensive and strong cylinder attachment and harness. Glass fiber/polymer (GFRP) laminate is the material chosen for attachment. The harness is made out of polypropylene. The process used to make these parts was also determined from CES and was narrowed down to compression molding.

It is a simple device to operate with only one hand. The user casts the pole with his operable arm, and then places the rod in the cylinder of the Fisher Assister. The pole is then secured in place by means of a Velcro strap (Velcro is also on the pole). The user can then reel in the rod with his operable hand. Fig. 16.38 shows how the design is worn by a person.

The price of the two main components had a total cost of $12.76 per unit. Adding the cost of the other items, such as the Velcro strap on the attachment, Velcro strap and clip on the harness, the total cost of the unit is about $13.

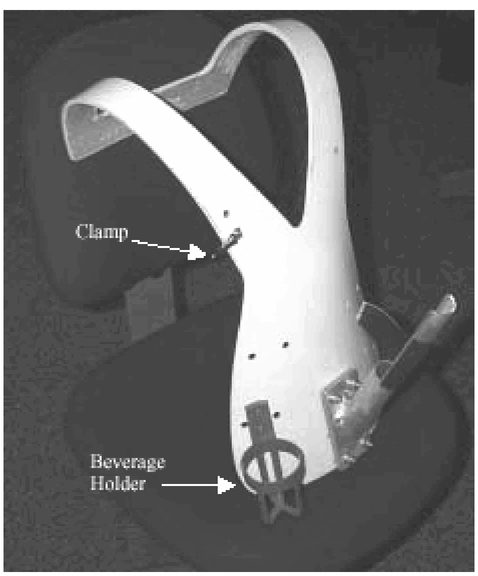


Figure 16.37. The Fisher Assister.

Figure 16.38. Testing Prototype.

SANDY WHEELS CONVERSION SYSTEM

Designers: M .S. Ingalls, J. Labrie, and J. Piccirillo
Supervising Professor: John E. Ritter, Ph. D.
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INTRODUCTION

A conversion system was designed to modify standard wheelchairs to provide the ability to travel over soft terrain. The system was designed to be compatible with most modern wheelchairs, and through a ratcheting device, the users can propel themselves either forward or backward. The design had enlarged rear wheels and a sled that was placed under the front caster wheels, all of which were made from injection molded high density polyethylene. A ratcheting system attached to the rear wheels, and a ratcheting arm made from wrought aluminum provided users with a means of propelling themselves (see Fig. 16.39).

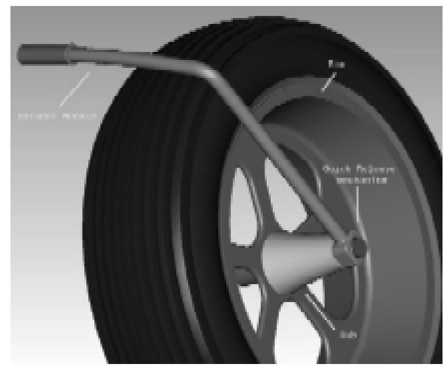

Figure 16.39: Rear Wheel and Ratchet Arm.

SUMMARY OF IMPACT

Standard wheelchairs are designed to be used in buildings and on sidewalks but are not meant to be used on soft terrain such as the beach. Specialized wheelchairs exist specifically for beach use, but these items are expensive and most often require a second person to push the chair. The Sandy Wheels Conversion System allows people to quickly modify their every-day wheelchair for beach use for only a fraction of the cost of a specialized wheelchair. Even with a 100 percent markup in price, this system will cost approximately one fourth of what an entire beach wheelchair costs.

TECHNICAL DESCRIPTION

The design centers around two very important necessities. First, the design had to be consistent with many of the universal and interchangeable parts employed in newer wheelchairs. Second, the user had to be able to operate the chair independently. These design features were obtained by optimizing stiffness when selecting materials and by minimizing cost and weight, so the system would be easy to install and affordable.

Using the quick release system that is incorporated into most modern wheelchairs, the standard rear wheels are removed and replaced with eight-inch wide wheels that distribute the weight over a larger surface area and keep the chair from sinking into the ground. The pin on the outside of the ratchet arm is part of this quick release system (see Fig. 16.40).

The caster wheels are placed into the sliding base, which is located on the sled. This sled distributes the load on the caster wheels over a larger surface area to keep the chair from sinking into soft terrain, much like the wheels above. In a one-time setup, a sliding dovetail permits proper location of the two caster-to-sled connections. The connections are to be located so the casters will roll into the wheel grooves shown below (see Fig. 16.41). Moreover, they can then be permanently affixed with easy-to-install set screws. Then each time the user wishes to use the Sandy Wheels system, the casters are then strapped

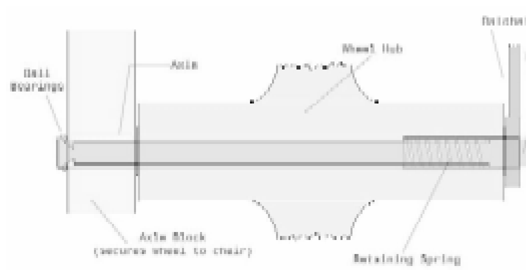

Figure 16.40: Quick Release System.

firmly to the caster-to-sled connections with a quick tie system or strap.

Strapping the wheelchair casters onto the caster-to-sled connections is done with an adjustable hook and chain. Tension on the chain is facilitated by the use of a comealong. A very general diagram of a comealong is shown in Fig. 16.42. Once the device is in its closed position, it becomes locked in place and cannot be unlocked without pulling the two handles apart.

Finally, the user of the chair is ready for travel over soft terrain. By pushing the ratchet arms forward, the chair moves forward. By pushing only one arm at a time, the chair is able to turn. Finally, there is a switch on the ratchet that will allow the chair to move in reverse.

The wheel hub, sled, and sliding base will be made out of injection molded high-density polyethylene. This material was chosen based on maximizing stiffness and minimizing cost and weight. It was also important that the material had good environmental properties against fresh water, seawater, and UV radiation. The rubber tires, aluminum ratchet arms, and other standard parts such as the ratchet, comealong, and screws will be purchased from vendors. The Pro-E drawing of wheelchair is given in Fig. 16.43 and Fig. 16.44 shows the prototype that was built.

The Sandy Wheels System can be manufactured for about $125.00

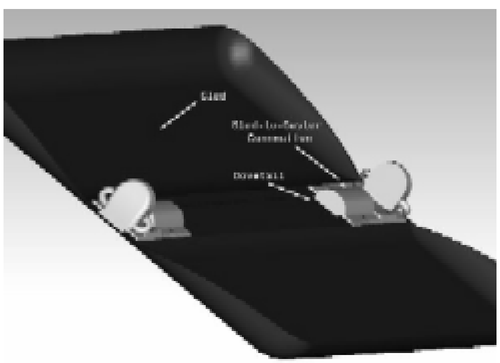

Figure 16.41: Sled that Supports Caster Wheels.

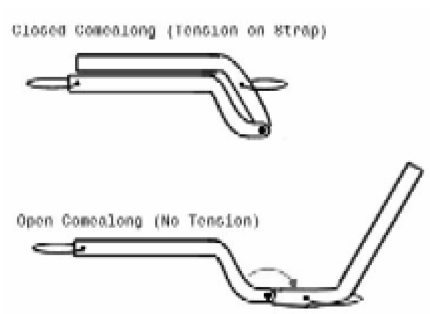

Figure 16.42: Operation of Comealong.

Figure 16.43: Wheelchair with Sandy Wheels System.

Figure 16.44: Sandy Wheels System Prototype.

HELPING HAND CAR DOOR CLOSING ASSISTANT

Designers: Matthew Atwood, Christopher Beebe, Fyodor Grechka
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INTRODUCTION

A mechanical system was designed to aid in closing a car door. An ergonomically driven material design process was employed for the handle of the system using Cambridge Engineering Selector software. The optimal material for the handle was discovered to be Polyvinylchloride (UPVS) a rigid material produced by injection molding.

SUMMARY OF IMPACT

Current car door designs require a large amount of applied force at the handle to close a fully opened door. This novel design would create an ergonomic product that would reduce the force needed to close a car door while at the same time not interfering with unassisted closing of the door. Market research indicates that there is currently no similar product available.

Being able to comfortably close a heavy car door would allow elderly individuals and those with physical disabilities to be more self-sufficient and would prevent discomfort and possible injury.

TECHNICAL DESCRIPTION

The primary components of the car door assistant are the handle and its retaining clip, as well as the chain retraction mechanism and its holding bracket. Metal cable secures the handle to the cable retraction mechanism that houses the excess cable, as seen in Fig. 16.45. The primary design criteria for the handle involved ergonomics and cost. In addition, the handle had to be able to withstand the largely varying temperatures of a car interior (0° F to 120 °F). Cambridge Engineering Software (CES) enabled an optimal material to be selected based on these criteria. This material was found to be rigid Polyvinylchloride (UPVS). The cable retraction mechanism is commercially available, retailing at $8 at a local hardware store. The brackets can be made

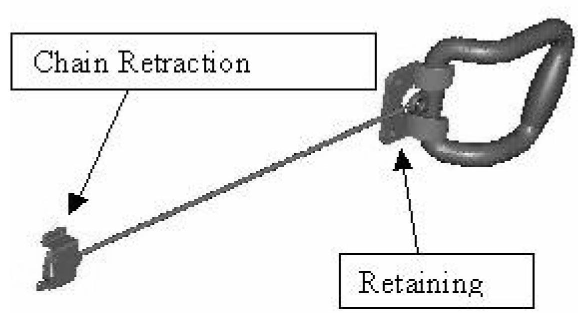

Figure 16.45. Solid Model of Door Closing Assistant

of polypropylene and the chain and its retracting spring can be bought commercially.

To use this design, the user gets into the car normally, but instead of pulling the conventional handle to close the door, he or she instead grabs the helping hand handle secured to the door via the retaining clip. The user then removes the handle and pulls the handle (see Fig. 16.46). When initially pulled, the chain retractor lets the cable spool out to approximately four inches in addition to the 10 inches let out in the storage position, before the spool reaches its end stop. The user can then pull on the handle to close the door as a result of the force caused by the cable in tension. After the door is closed, the user returns the handle to its storage position on the retaining clip (Fig. 16.47).

Special attention was paid to the ergonomics of the handle. The grip bulges in the center, conforming to the natural contours of the palm. In addition, the grip is angled at 35°, the neutral angle of the human hand. In addition, the material of which the polymer hand grip is made has a low thermal conductivity, leading to an acceptable grip temperature. The ergonomics of this handle leads to comfortable use by the operator (see Fig. 16.48).

Static analysis shows that to reduce shoulder stress in car door closing, either the application force's line of action has to be changed (thus creating a longer moment arm), or the force has to be supplied from somewhere other than the person's shoulder. After construction of the prototype (Fig. 16.49) it is seen that this design successfully accomplishes both of these goals by reducing the necessary force by 41 percent and involving the use of the biceps instead of the shoulder in applying this force.

The assistive car door closing system can be produced for about $17.00.

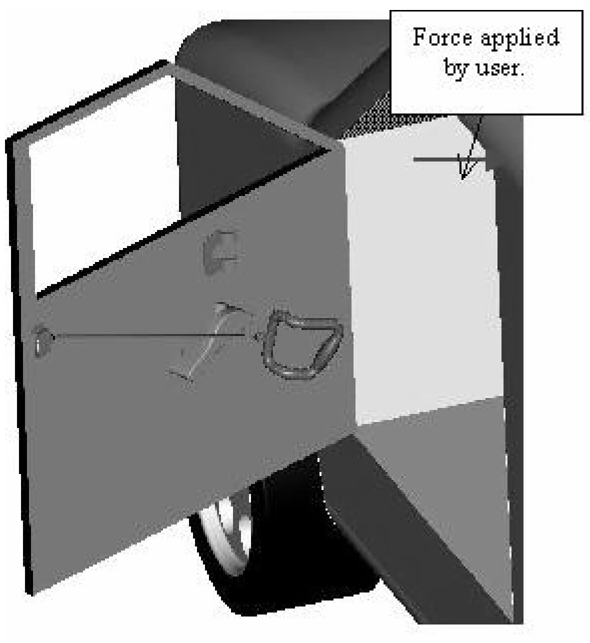

Figure 16.46. The Car Door Assistant in Use.

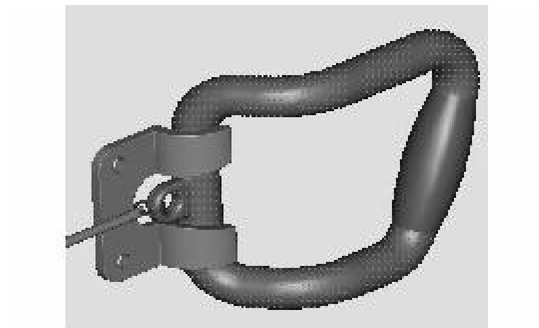

Figure 16.47. The Handle in Storage Position.

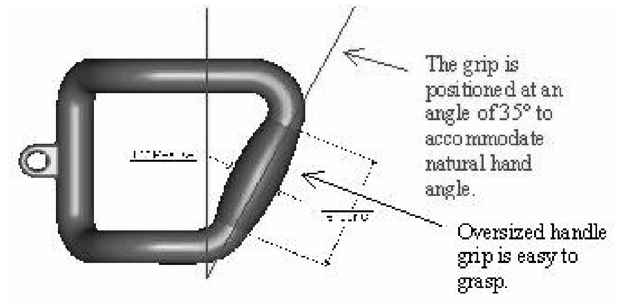

Figure 16.48. Ergonomic Design of the Handle.

Figure 16.49. Prototype Model of Helping Hand.

GAS-SPRING ASSISTIVE CANE

Designers: W.Abad, J.Lapointe, and S.Nualpring
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INTRODUCTION

An assistive walking cane was designed to aid a person to lower and raise himself in a controlled manner. The design will allow the client to lower himself to a kneeling or seated position and vice versa. The gas-spring provides the mechanism by which the cane can be lowered or raised in a controlled manner. The materials and processing analysis was completed with the assistance of the Cambridge Engineering Selector software, the design uses Cast Aluminum Alloy and Low Carbon Steel as the material and gravity die casting as a suitable manufacturing process.

SUMMARY OF IMPACT

Over five million Americans need the assistance of a cane or crutch. In certain situations, the user needs to sit down or reach to the ground. The current canes do not allow the user to safely accomplish these tasks.

TECHNICAL DESCRIPTION

The primary design criterion is minimizing the load applied on the user as he lowers himself. The use of a padded handle and assistive brace will produce a comfortable feeling for the user. The design must provide a sense of balance and sturdiness. A secondary design parameter is maximizing the number of cycles the gas-spring and cane can endure. It is specifically designed to hold a maximum load of 250 pounds. Another secondary parameter is minimizing weight since users want the lightest possible canes. A third parameter is minimizing cost to keep the system affordable. An optimal material was chosen using the Cambridge Engineering Selector (CES) software, which lets the designer explore what materials meet or exceed these requirements.

Fig. 16.50 shows the solid model of the gas-spring assistive cane. The lever that controls the release of the gas spring is right below the handle.

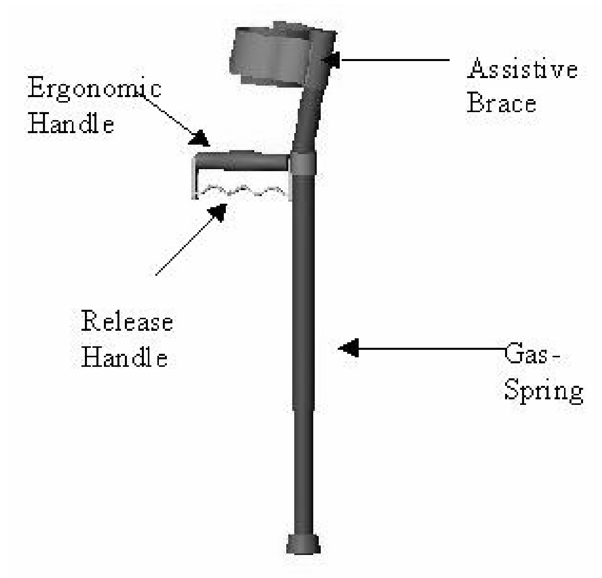

Figure 16.50. Solid model of Gas-spring Assistive Cane.

The proof-of-concept of the cane is shown in Fig. 16.51. The proper use of the cane is shown in Fig. 16.52. The fingers are applied to squeeze the release handle. The lever is then retracted and the cane with the assistance of the gas spring lowers it self at fixed rate till it locks into the next lower level of teeth.

The use of the CES materials analysis features yielded two materials, cast aluminum alloy, and low carbon steel for the stopping teeth and pull lever. Assuming a production volume of 100,000 units, the CES manufacturing process analysis yielded one process for the stopping teeth and pull lever: gravity die-casting. After analyzing business factors such as power and space usage, tooling, labor and capital costs, as well as purchasing of the aluminum alloy gas-spring, brace, and handle from outside contractors, the total manufacturing cost of the assistive cane came to $16.69.

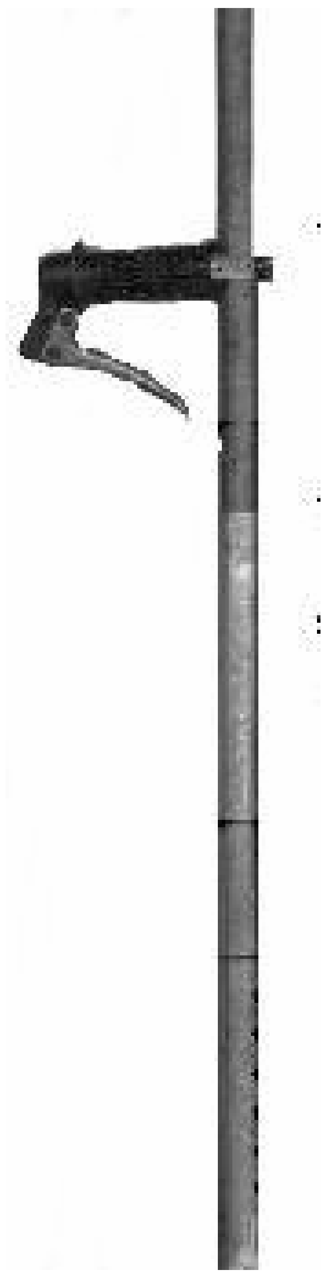

Figure 16.51. Proof-of-Concept of Assistive Cane.

Figure 16.52. Proof-of-Concept of Assistive Cane Collapsed.

ONE-HANDED MOUNTAIN BICYCLE BRAKE

Designers: A. Bail, D. Quimby, and C. Taylor
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INTRODUCTION

A one-handed mountain bicycle brake was developed in response to bicycle safety issues. The only one-handed brake system on the market is unsafe because it forces the user to apply both front and rear brakes simultaneously, which can cause accidents. This improved design employs two brake levers that allow the user to apply both brakes safely and independently from each other. All other standard brake materials such as cables and brake pads are adaptable to the design. From a materials and processing analysis utilizing the Cambridge Engineering Selector software, the design uses Cast Aluminum Alloy as the material and die casting as a suitable manufacturing process.

SUMMARY OF IMPACT

There is a demand for braking systems for persons without the use of one hand. In some situations, the user needs to slightly apply the front brake, for example, during turns. The current one-handed brakes are unsafe because both brakes are applied instantly. The goal of this improved design is to allow the user the freedom to apply the brakes independently from each other.

TECHNICAL DESCRIPTION

The primary design criterion is minimizing brake lever deflection to provide a sense of sturdiness. One secondary design parameter is maximizing corrosion resistance, especially counteracting the effects of sweat. Another secondary parameter is minimizing weight since users want the lightest possible brakes. A third parameter is minimizing cost to keep the system affordable. An optimal material was chosen using the Cambridge Engineering Selector (CES) software, which lets the designer explore what materials meet or exceed these requirements.

Fig. 16.53 shows the solid model of the one-handed mountain bicycle brake design. The lever that controls the front brake is a short channel beam, which surrounds the rear brake lever. The rear lever is a solid member with an elliptical cross-section. Both of these members pivot about an axis, which is a pin. This system is secured to the handlebar by a bar mount. The brake cables and casings are attached to the brake assembly by standard barrel adjusters.

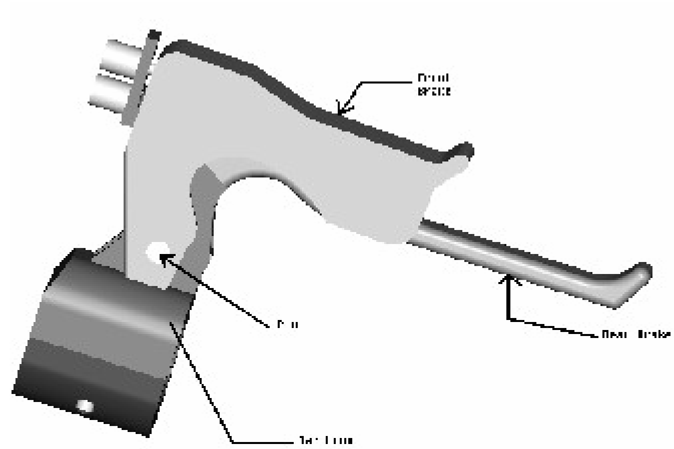

Figure 16.53. Solid-Model of One-Handed Bicycle Brake.

The proof-of-concept of the brake levers is pictured in Fig. 16.54. The proper use of the levers is shown in Fig. 16.55. The index and middle fingers are applied to the front brake and the ring and pinky fingers are applied to the rear brake. This is an ambidextrous design; it can be used on the left or right side of the bicycle handlebars.

The use of the CES materials analysis features yielded one material, cast aluminum alloy, which meets the primary and secondary design criteria. Assuming a production volume of 100,000 units, the CES manufacturing process analysis yielded one process, die casting, that meet all volume, shape and tolerance criteria. After analyzing business factors such as power and space usage, tooling, labor and capital costs, as well as purchasing pins from outside contractors, the total manufacturing cost of the braking system is $8.61.

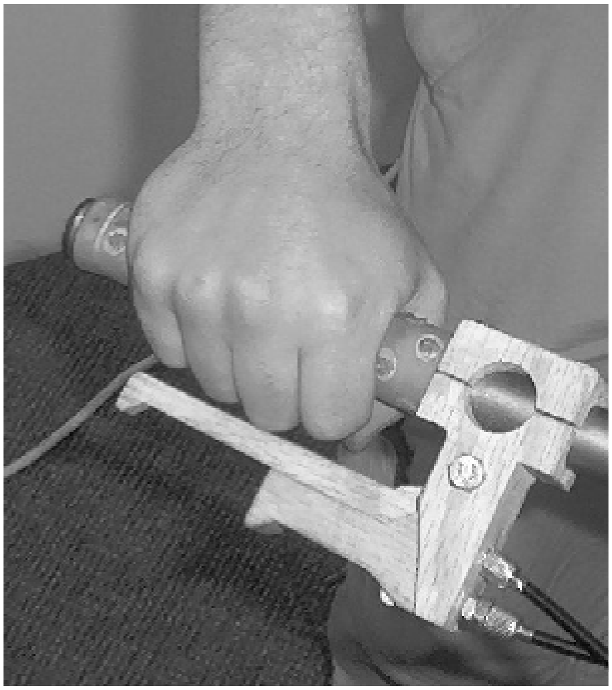

Figure 16.54. Proof-of-Concept of One-Handed Bicycle Brake.

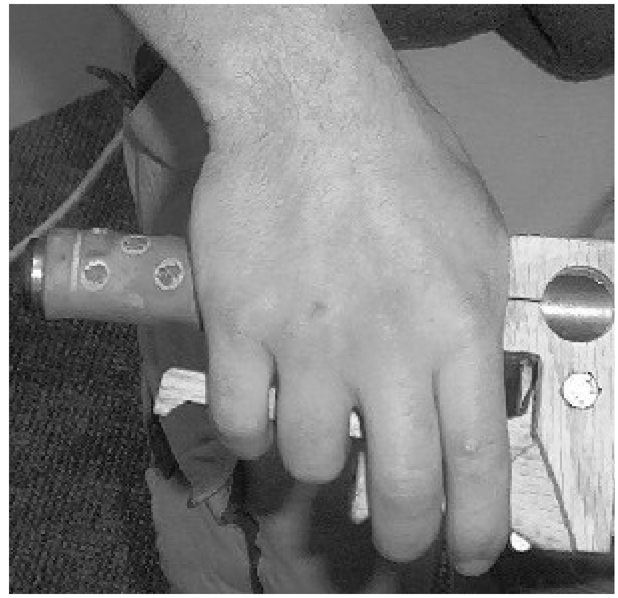

Figure 16.55. Proper Use of One-Handed Bicycle Brake.

HANDY GARDENING TOOL FOR DISABLED GARDENERS

Designer: Sheng Chou, Manza Masamuna, and Patrick Cushna
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Amherst, Massachusetts 01003

INTRODUCTION

A handle was ergonomically designed to permit people with disabilities in their arms and hands to use a variety of garden tools. The design is focused on allowing these individuals to enjoy gardening without discomfort or unnecessary difficulty. The design consists of a pair of Velcro straps that allow the user to exert a large force without placing too much stress on the hands and fingers. A rigid frame disburses the forces through the arm instead of the wrist and fingers. The handle is universal, so multiple gardening tools can be fitted into its head.

Materials were compared and evaluated using the Cambridge Engineering Selector (CES). Polyvinylchloride (UPVC) was selected as the material to be used for the handle. Also using the CES software, injection molding was selected as the primary manufacturing process. For the shovel, high carbon steel was chosen as the material, and stamping as the forming process. A series of secondary processes were also selected to complete the design. These include drilling holes, cutting of the UPVC tubes, and assembling of parts.

SUMMARY OF IMPACT

Unfortunately, when people lose strength in their hands, it becomes difficult to hold the handle of the typical small gardening tools. Thus, a need exists for a set of gardening tools that have a handle to assist people with limited hand strength. This handle must be lightweight, inexpensive, ergonomically designed and aesthetically pleasing.

Our design handle allows for an interchangeable tool head so that users can change from shovel to rake and other existing gardening tools. Also, people with a wide range of disabilities including weak hand strength, weak wrist, and arthritis, can use this handle.

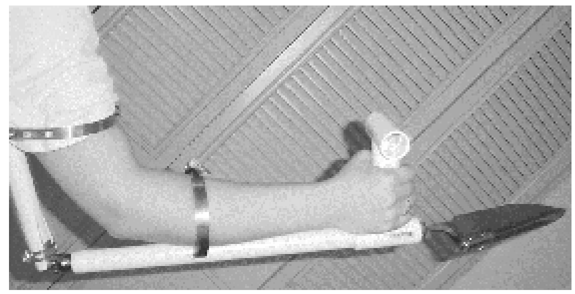

Figure 16.56. Assistive Gardening Tool.

TECHNICAL DESCRIPTION

The gardening tool had to be lightweight, ergonomic, and inexpensive. A concept has been designed that will not only target people with limited strength, but also people with disabilities who might only have one hand, no fingers, or very weak hand strength. A prototype of the assisting gardening tool is shown in Fig. 16.56.

The main body of the gardening tool is PVC tubing. Velcro is used to strap around the bicep muscle and the forearm. This configuration allows the transfer of the arm's motion and strength directly to the shovel. An ergonomic handle is used to assist the user who is not able to grip firmly. It will also add security and comfort in the maneuvering of the tool. A foam grip will be placed on the handle. The added diameter and softer material will make gripping easier for people with hand and wrist disabilities. Fig. 16.57 is a PRO-E drawing of the handle.

The joint of the assistive gardening tool must be as flexible as an actual elbow. This required the joint to be able to rotate on two axes. It was determined that an off the shelf, double-jointed hinge could be used as the joint. This joint allows the user to rotate in two planes similar to an elbow, while also transferring the force from upper to lower. The joint is fastened to the tubing by way of a pin. The pin will be placed through holes drilled across the diameter of the PVC tubing. Once in place the pin aligns the two holes and secures the body and joint in place.

Aside from the versatile usage among the different disabilities, our design has included a changeable tool head (see Fig. 16.58) that will allow the user to easily change from spade to rake or any tool head available. The advantage of having a universal tool head is that once a person has the handle mounted on the arm, he or she may change between tools without having to take off the handle. A pin securing system, similar to the pin used to secure the handle and joint, is implemented to allow for easy interchangeability between tools. The pin is slid through aligned holes in the handle and tool, and can be removed when the tool is no longer desired. This allows for a quick exchange between various tools. This pin, unlike the pin used for the joint, has a spring-loaded ball that expands when the pin is in the correct position. The expansion prevents the pin from sliding out unexpectedly. The force needed to remove the pin is relatively small, allowing someone with limited strength to use the pin without difficulty.

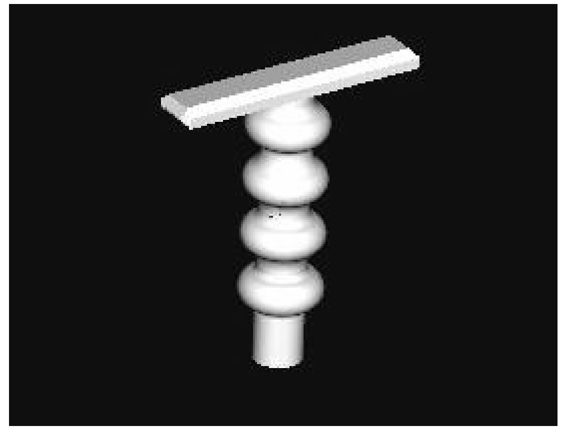

Figure 16.57. Ergonomic Handle.

A cost analysis determined that it would cost $6.40 for each handle.

Figure 16.58. Interchangeable Tool Head.

DESIGN OF A ONE-HAND KAYAK PADDLE

Designers: R. Robert, A Duquette, C. Mitchell
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University of Massachusetts
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INTRODUCTION

A paddle attachment was designed to allow a person with the use of only one arm to paddle a whitewater or flat-water kayak. The product was designed under the input of a kayaker with one arm and other experienced kayakers. Pro-Engineer solid modeling software and Mechanica finite element analysis software are used to optimize the design. Material and manufacturing selection was analyzed with the Cambridge Engineering Selector software. Injection molded epoxy glass fiber composite was chosen for the forearm attachment and injection molded polypropylene for the handle.

SUMMARY OF IMPACT

Currently, it is not possible to use a kayak paddle with only one arm. The only device available today is a hand paddle, which does not allow the kayaker to gain enough speed or maneuver easily. The client is a kayaker with one arm, who is having difficulty advancing to more challenging rivers because of his hand paddle's limitations. The goal of this project was to design an attachment for a kayak paddle that would allow the client and other people with disabilities to paddle a kayak without difficulty.

TECHNICAL DESCRIPTION

The primary focus of the design is functionality. The performance of the paddle using one arm must be comparable to a regular paddle using two arms. The paddle cannot be much heavier than a regular paddle. It also has to be a simple device, easy to install and use. It has to be durable and withstand any force applied in normal use. Safety is also very important in this design. Kayaking can be lethal if a person cannot roll or exit the kayak after he or she flips upside-down. Kayakers often have to swim after they escape from their kayak. For these reasons, the paddle must be removable. Also, the attachment must be affordable. Finally, it has to be easy to make using inexpensive material and manufacturing processes.

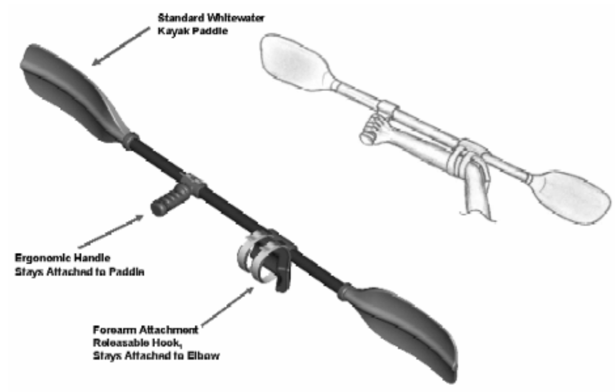

Figure 16.59. Solid Model and Hand Drawing of Paddle and Attachments.

It was determined that a two-component attachment (see Fig. 16.59) could perform the function of the proposed design. The handle is strapped to the paddle and remains on the paddle during use. The forearm attachment is strapped to the user's forearm. It hooks onto the paddle when the user is paddling and can be easily detached when the user wants to release the paddle.

The handle has several unique features (see Fig. 16.60). The grip has a large diameter and there are finger and thumb slots to fit the natural position of a person's gripping hand. The finger and thumb slots have a rubber-like material molded into them using a mold-over injection molding technique. There are enlarged areas behind the user's hand and between the user's thumb and forefinger. This will prevent

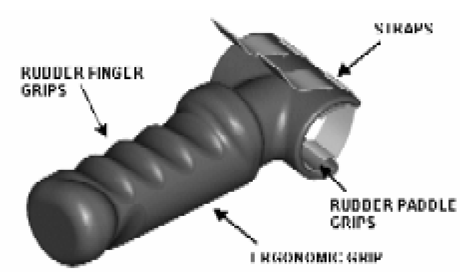

Figure 16.60. Handle Component.

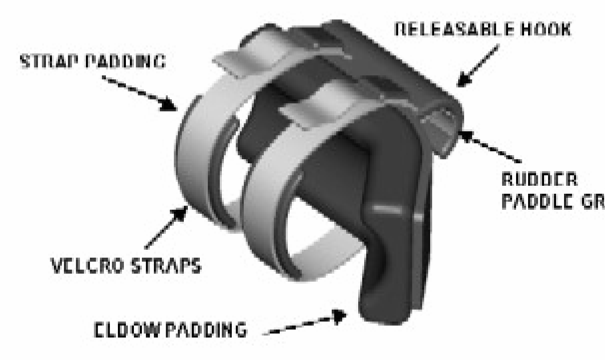

Figure 16.61. Forearm Component.

the hand from sliding forward or backward when the paddle is pushed in a right-hand stroke and pulled in a left-hand stroke. The handle has a C-shaped end, which allows the paddle to be pushed easily. The straps are tightened after the handle is in place.

As mentioned above, the forearm attachment (see Fig. 16.61) is strapped to the user's forearm near the elbow. It consists of elbow padding glued to a plastic "hook" component, which has two paddled Velcro straps and rubber paddle grips. The straps comfortably secure the arm to the attachment. The rubber paddle grips keep the paddle from twisting or sliding. The hook is allowed to deflect when the user twists the arm out of the paddle (see Fig. 16.62). The hook is designed to remain stiff under a normal paddle stroke, but allow the paddle to escape when the user wants to remove it or if it gets caught on something in the river.

The Cambridge Engineering Selector is used to determine the best material for each part. The handle is a stiffness-limited design and the forearm attachment is a strength-limited design. The indices are then used to determine a material with the lightest weight, lowest cost, and precise mechanical properties. For the forearm attachment, epoxy/glass fiber was chosen because of its excellent strength properties, since this part will carry much of the load from paddling. Polypropylene was chosen for the handle because of its low cost and ease of manufacturing. Data from the Human Strength handbook by Dreyfus was used to determine the correct forces that one could implement on this

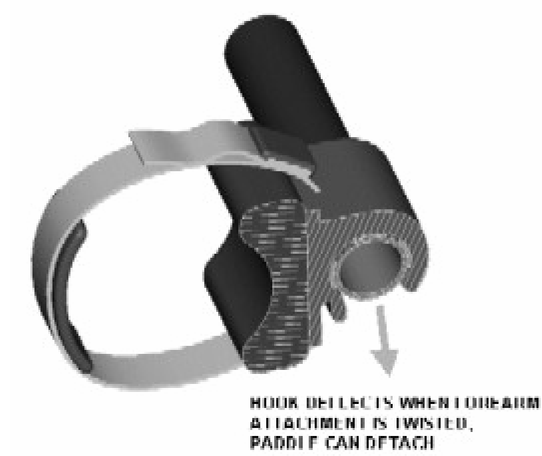

Figure 16.62. Forearm Component X-Section.

device. Sizing of each component was done based on the required strength. Once the parts were sized, a process selection was done to determine the best form of manufacturing. Injection molding was determined to be the most suitable process for making the handle and forearm attachment. A prototype was constructed and successfully tested (see Fig. 16.63).

The materials cost $10 and about four hours of machining and assembly time were required. The part production cost was determined to be $11.48 for 100,000 units.

Figure 16.63. Prototype Images.

THE ONE HAND WASHER

Designers: R. Lehtinen, G. Patel, M. Burgess
Supervising Professor: John E. Ritter, Ph.D.
Department of Mechanical and Industrial Engineering
University of Massachusetts
Amherst, MA 01003

INTRODUCTION

The one hand washer provides a means of hand washing for someone who has only one hand. The design concept was created, and then the material choice was optimized using the Cambridge Engineering Selector (CES) software in conjunction with a merit index. The processing was also selected using the CES software. Finally a cost analysis was conducted based on the optimal material and corresponding process. The result is an ergonomic, attractive, and inexpensive design (see Fig. 16.64) that will assist people with disabilities who have the use of only one hand.

Figure 16.64. One Hand Washer Design.

SUMMARY OF IMPACT

Hands are generally washed together, but for a one handed person, this task is challenging. The one hand washer provides a solution to this problem. It can be easily affixed to the counter or sink, and offers an array of cleaning modes (soft sponges, abrasive sponges, and scrub bristles) that can be used with only one hand.

TECHNICAL DESCRIPTION

The hand washer needs to be stiff, lightweight, and low cost. These three criteria were combined together to give a merit index. The hand washer was designed so it can be cleaned in a household dishwasher. Further material selection criteria were determined to be: corrosion in fresh water and maximum service temperature (165°C). The CES software was used to maximize this merit index and the other considered criteria, and find the optimal material for the one hand washer. The resulting optimal material was high-density polyethylene. The processing was also selected using the CES software. A proof of concept model was constructed (see Fig. 16.65).

By considering the mass range, the shape, the allowable surface roughness, and the required tolerances, the process of injection molding was determined to be the best. In conclusion, the one hand washer is ergonomic, attractive, inexpensive, and useful.

A cost analysis was conducted based on economic data from the CES software. The number of units produced was considered to be 100,000. The final cost of the one hand washer was $5.09.

Figure 16.65. Proof-of-Concept Picture.

LIGHTWEIGHT KNEE BRACE

Designers: P. Veiga, M. Mudawar, and B. Cerone
Supervising Professor: John E. Ritter, Ph.D.
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University of Massachusetts
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INTRODUCTION

Knee related injuries are one of the most common injuries that occur in sports. This causes a demand on the market for a knee brace that will protect people who are either recovering from an injury or wishing to prevent an injury. Products on the market now are either too expensive or bulky and are not aesthetically pleasing. The objectives were to design a product that would be lightweight, very protective, aesthetically pleasing, and reasonably priced.

SUMMARY OF IMPACT

Knee braces available on the market today range from $85 to $600. The most inexpensive products are bulky, not aesthetically pleasing, and do not function well. This design is rigid, compact, simple, and inexpensive. It will prevent knee injury by restricting unnatural movement, such as hyperextension, hyperflexion, and buckling. This product is geared to for athletes who are looking for an inexpensive but effective brace.

TECHNICAL DESCRIPTION

Design criteria for a preventive knee brace include following:

- The brace must withstand 300 pounds of force on the hinges due to hyperextension, hyperflexion or side impact with little to no deflection;
- The brace should be comfortable and easy to use;
- Materials must have good corrosive resistance; and
- Materials must have good wear resistance.

The brace consists of four major parts: the frame, the two hinges, the Velcro straps, and the foam padding (Fig. 16.66, foam padding not shown). Fig. 16.67 displays the design of the hinge. The hinge is designed to restrict the knee past 180 degrees and

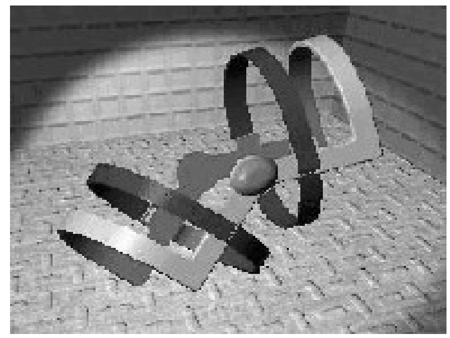

Figure 16.66. Solid Model of Preventive Knee Brace.

restrict flexion of no less than 15 degrees. These critical angles were determined to be the angles at which, when surpassed, injury may result.

Merit indices were derived to maximize strength while minimizing mass and deflection for the hinges. Using these indices, the Cambridge Engineering Selector (CES) software produced unidirectional Carbon Fiber Reinforced Polymer as the optimal material and that the process of injection molding of themosets would be used to create the desired shapes. After analyzing the stresses that could be applied to the pins, it was found, by CES,

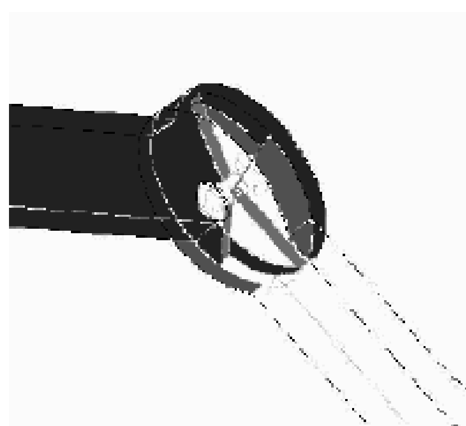

Figure 16.67. Hinge Design.

that the same material could be used. By limiting wear and corrosive resistance and accounting for comfort, closed cell polyurethane would be the optimal material used for the padding. The prototype is shown in Fig. 16.68 and Fig. 16.69.

A detailed cost analysis was done yielding a total cost per unit of $21.80 at production volume 100000 units.

Figure 16.68. Prototype in Full Flexion.

Figure 16.69: Prototype in Full Extension.

UNIVERSAL WHEELCHAIR SPLASHGUARD

Designers: Kevin Beaulieu, Tony Cheung, and Mike Ross
Supervising Professor: John E. Ritter, Ph.D.
Department of Mechanical Engineering
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Amherst, Ma 01003-3662

INTRODUCTION

Wheelchairs are a mode of transportation exposed to a wide variety of weather conditions and road surfaces. Beaches, salty streets and walkways produce a corrosive environment. When traveling over wet surfaces, water, snow, or mud, etc., debris can be thrown up from the wheel's rotational movement. This often soaks users. Although some wheelchair models come with splashguards incorporated into their design, most do not.

SUMMARY OF IMPACT

There are currently several different wheelchair designs on the market. Lack of standardization makes it difficult for most wheelchair users to find a product that can be used with any particular wheelchair design. An adaptable, symmetric design that incorporates corrosion resistant materials would be highly beneficial. The adaptable splashguard will be universal for most wheelchairs. Aluminum and low-density polyethylene parts allow the system to be manufactured and installed inexpensively.

TECHNICAL DESCRIPTION

The splashguard system was broken up into two main sub-assemblies for material selection (Fig. 16.70). The first assembly was the actual splashguard itself. It was determined that a material needed for its purpose would have to be light, tough against fast fracture, corrosion resistant, and cost effective. Strength was included so that a 75N pulling force could be withstood. This force was determined from the Human Factors catalog by Human Scale. Using the Cambridge Engineering Selector software, the material chosen was low-density polyethylene.

The second assembly included the bracketing clamp and swivel joint. The criteria for this included the same parameters as the splashguard, however stiffness was used to replace strength. Stiffness was included to assure that the system would maintain a stable position under any loading. The required load considered was the weight of a 250 pound person standing on the swivel joints. The material selected was aluminum. The two material selections were inexpensive, corrosion resistant and lightweight. The aluminum allowed standard parts to be included (aluminum tubing, and plate aluminum).

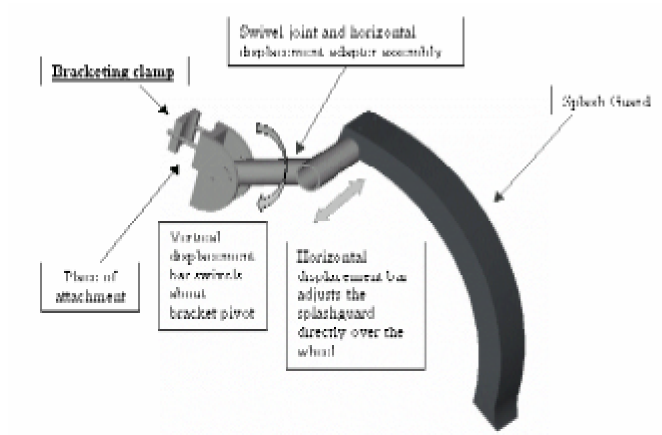

Figure 16.70. Universal Splashguard Design.

With known material properties and specified loading, sizing was done to ensure that the parts would not yield. Some dimensions were fixed due to geometry constraints. The swivel joints had specified lengths of 0.15m and 0.169m and this required that applied moments of 188 Nm and 167 Nm had to be supported respectively.

Manufacturing processes were considered for 100,000 units. The process selected for the splashguard was injection molding. The only aluminum part that needed to be manufactured was the bracketing clamp. It was determined that sheet form aluminum could be stamped to produce the bracket.

The system works by attaching the bracketing clamp to a vertical bar in the back of the wheelchair. The swivel joint can then be fixed into place with a series of pins. One pin allows the joint to pivot while the other allows the angle of the swivel to be secured at 15-degree increments. The bracket clamp and swivel angle should be set to give the proper clearance above the wheel. The horizontal adjustment bar allows the user to adapt to the necessary wheelbase, and is secured with a set-screw. Fig. 16.71 and Fig. 16.72 show the prototype of the splashguard.

Figure 16.71. Assembled View of Prototype.

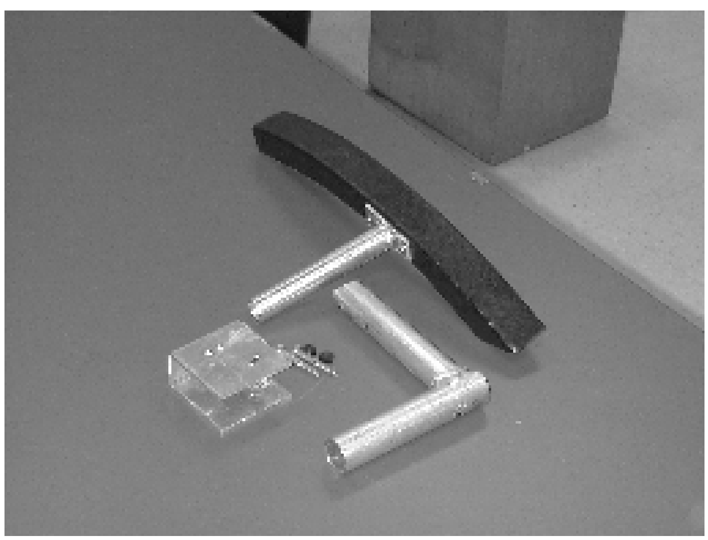

Figure 16.72. Unassembled View of Prototype.

PORTABLE INTELLIGENT DEEP PRESSURE VEST FOR AUTISTIC CHILDREN

Designer: Jeremy K. Paskind
Supervising Professor: Sundar Krishnamurty, Ph.D.
Department of Mechanical and Industrial Engineering
University of Massachusetts
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INTRODUCTION

Clinical studies have shown that the application of deep pressure around the upper body and shoulders of autistic children has a calming effect on them. These children in particular have difficulties adapting to their environment and remaining composed in normal every day settings. Little changes often set off elevated excitement states or in severe cases, seizures. Thus, a pressure vest was designed to provide autistic children with deep pressure stimulation around the upper body and shoulders.

SUMMARY OF IMPACT

Current products on the market that address this disability include weighted vests, used to simulate pressure on the upper body. These apply static pressure onto the shoulders of the user at all times while worn. Other large pressure devices also exist in limited quantity, convenience, and economical cost. Each current design has major limitations to their effectiveness or availability of use at all times when pressure is needed.

The Intelligent Vest will to some degree combine the two existing technologies. It will have the portability of the weighted vests, with the selective pressure application of the pressure machines. It will apply deep pressure instead of static pressure, similar to the "squeeze" machines, only when needed by the user.

TECHNICAL DESCRIPTION

Since the vest is to be worn on a regular basis, primarily by young children, one of the most important design considerations is its level of comfort. Since children vary drastically in size, the design of the vest must be able to be replicated for each individual user, regardless of the user's physical dimensions. The vest should also be aesthetically pleasing, which is an important feature of any clothing article designed for children. Both of these, along with comfortable, lightweight, and non-intrusive mechanics have to be taking into consideration for the creation of the device.

Figure 16.73. Air Containment Tubes on Deep Pressure Vest.

The design uses air to fill up the space inside the vest, causing pressure to be applied to the abdomen and shoulders of the child. The core of the vest design focused on the creation of the inflation bladders that contain the air inside the device. Along with the specifications derived from the recommendations of various parents of children with autism, the final design utilized two "L" shaped tubes fabricated from polymeric sheeting. The "L" configuration was found to reduce the total size of the inflatable while remaining highly effective. Inside each vest, two bladders link together with an adjustable elastic to form a "U" shape that wraps around the upper torso and over the shoulders. An elastic fabric connects the bottom half of each "L" tube to each other and is positioned at the back of the child. Base of the "U" wrap around the torso of the child, just beneath the armpits, while the upper portions extend over the shoulders. The elastic will not only leave room for error in the fit of the vest, but also alleviate unwanted pressure changes caused by normal breathing of the user. The air containment tube design is shown in Fig. 16.73.

The two optimal material films for the fabrication of the vest bladders were low density Polyethylene and vinyl, each with a standard material thickness range from four to eight mil for strength and weight considerations. The four-mil thickness provided more than adequate endurance to the pressure changes during use, while the eight-mil film was found to be necessary only if the user desired extra levels of durability. While the current prototypes were constructed out of the LDPE film, vinyl offered a slightly more durable and more flexible alternative. With UTS of 5800 psi, (about double that for LDPE) and a much more rubbery nature, the use of vinyl will ultimately insure both a longer lasting and more comfortable product.

The inflating and deflating processes of the vest is accomplished using a standard medical DC diaphragm pump. Two of the AA series miniature diagram pumps made by Sensidyne Co. were chosen for inflation and deflation. Both processes are controlled using two, three-way solenoid pneumatic valves. Following extensive research and testing, the series 34 MAC valves were chosen. This model was the thinnest and most economical of all standard OEM solenoids. When no current is applied to the device, the inlet port is connected to the exhaust port on the opposite side. When energized, the outlet ports are switched while at the same time plugging up the exhaust port. A picture of the inflation device is shown in Fig. 16.74.

The final component selection for the vest was the battery packs. Considering the many rechargeable cell types available today, Nickel Metal-Hydride "AA" size cells were chosen. These cells do not have any charge memory (as do NiCd cells) and are chemically more inert than other alternatives such as Lithium Ion or Nickel Cadmium. While Lithium Ion cells are much lighter, for the current vest design, they were not used for safety issues. More research

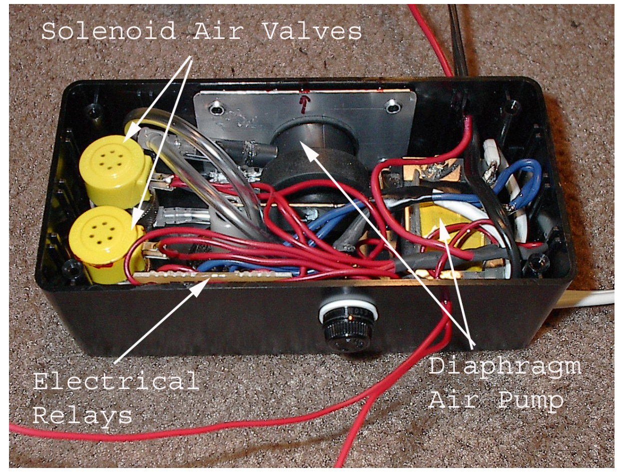

Figure 16.74. Vest Inflation Module.

needs to be done in this area to produce a lighter, safer battery pack. In an effort to distribute the battery weight, the pack was custom constructed in two, five-cell clusters, each to be worn around the hips of the child. The cells were connected with wire instead of normal battery tabs to insure that it was flexible and could follow the contour of the curves of the body. All the devices were then mounted to a belt that was incorporated into the vest, so as to make the power system removable from the rest of the unit.

The excitement levels of autistic children are known to be correlated with the output readings of a Galvanic Skin Response (GSR) monitor. GSR measures the conductance of one's skin. As the excitement level of a person increases, there is an increase in sweat production, thus causing increases in electrical conductance. Two small electrodes are placed on the fingers or soles of the feet to take the best measurements. A small computer analyzes the sensor outputs and returns a voltage that can be used to control the vest. The output of the GSR can be fed into a small computer chip, programmable to control the pressure in the vest.

CHAPTER 17
UNIVERSITY OF MASSACHUSETTS AT LOWELL

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Principal Investigator:

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VOICE-ACTIVATED TEXT READER

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Supervising Professor: Dr. Donn Clark
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University of Massachusetts Lowell,
Lowell, MA 01854

INTRODUCTION

A computer program was designed to input text from a scanner or web page and read it through speech synthesis. This system was created to allow a person who is legally blind to gain access to a wide range of written media, both in hard copy and online form. A voice-recognition command approach was used to allow the client to speak an Internet address directly, since he is unable to see the keyboard. This type of command input is not found on any other text reading software.

SUMMARY OF IMPACT

The text reader has allowed the client to read with greater ease and speed than he could before. Before he received the text reader, the client would read using a special magnifying monocle. This would cause eyestrain after long periods of time because only one eye was used to read. Now the client no longer needs his device for reading at home.

TECHNICAL DESCRIPTION

Several components were used to create the text reader. The Microsoft Speech API Software Development kit for Windows was integrated to enable speech synthesis and speech recognition. This free redistributable was installed on the client's computer; the program connected to it through a set of COM (Component Object Model) interfaces. A command-and-control grammar, as opposed to free dictation, was used for the speech control system to allow for better accuracy. The command-and-control mode allows SAPI to only recognize a finite set of words instead of the entire dictionary of the SDK. However, free dictation had to be used for the input of Internet addresses. To prevent the program from attempting to connect to a non-existent address, the user was allowed to listen to the URL he had spoken and confirm or reject it. The ScanSoft OCR development kit was used for the text input from the scanner. This component is a set of import libraries with entry points for image input, preprocessing, and optical character recognition. Its capabilities include recognizing columns and multiple pages, color inversion to read documents in white lettering on a black background (with a reduction in the recognition accuracy), and the rotation of images if a document was put on the scanner perpendicular or at an angle to the normal text direction. This kit interfaced to the client's scanner through the TWAIN protocol. For web page input, an HTML 2.0 compliant parser was created using a Windows implementation of the UNIX tools Lex and Yacc. These programs convert a text file containing a definition of the language to read into C++ source code. To actually retrieve web pages from the Internet required the WinInet API, which is part of Internet Explorer 4.0.

The total cost of the project was $1000 for the ScanSoft kit, and $45 for a headset.

Figure 17.1. Text Reader.

ELECTRONIC TRAVEL AID: A PROXIMITY DETECTOR FOR THE VISUALLY IMPAIRED

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Client Coordinator: Robert Steele, Perkins School for the Blind Outreach Satellite Program, Hyannis, Ma.
Supervising Professor: Dr. Donn Clark
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INTRODUCTION

An Electronic Travel Aid (ETA) is a name given to any electronic device that assists a person with visual impairment with mobility. In this case, the device is a handheld ultrasonic rangefinder that reports the range to an object that is in the path of the device. The report is given by a vibratory motor and with an adjustable volume speaker. The motor increases in revolutions per minute as proximity decreases; therefore, the user feels a more intense vibration as proximity to an object decreases. Similarly, the audible output increases in pitch as the proximity decreases. The audible output is adjustable for volume. Upon completion, The ETA will be presented to a visually impaired client His client coordinator considers him a good candidate for such a device since he is young enough to adapt to new technology. The student intends to use this device to help him familiarize himself to new environments and as a supplement to his cane. See Fig. 17.2 for a view of the device.

SUMMARY OF IMPACT

The design criteria for the ETA were defined by the client. The designer was able to demonstrate similar products to the client from which the client, under the supervision of his coordinator, determined his particular specifications. These include a handheld device, a minimum number of buttons and/or knobs, and a range of three meters.

TECHNICAL DESCRIPTION

The function of the device is broken down into the following different components: the ultrasonic sensor and receiver, the motor control module, and the amplifier circuit. The ultrasonic sensor component contains a crystal controlled oscillator that generates a 40 kHz ultrasonic signal that is sent through a crystal transmitter where a receiver

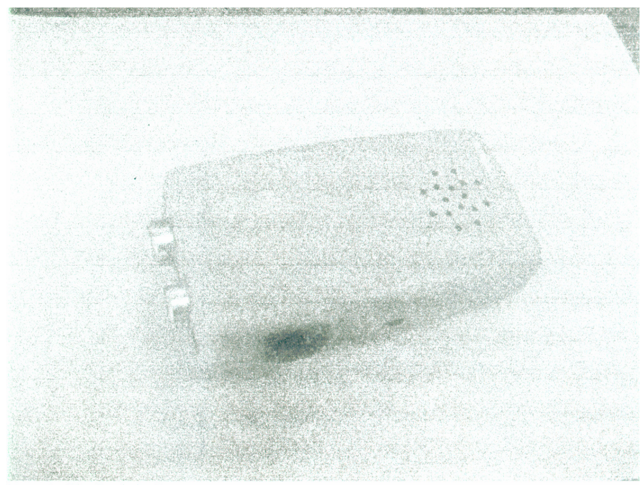

Figure 17.2. The Proximity Detector.

receives the reflected signal. Since the transmitter and receiver are both crystal sensors, tuned to 40 kHz with a bandwidth of ±1.0 kHz, there is no need for any noise filtering. A BASIC STAMP II microprocessor is used to control the output and measure the time elapsed for the signal to return which is stored as a variable. Using that time-elapsed variable, the microprocessor then calculates a distance. The distance value is stored as a variable which is then converted to a decimal value from zero to 255. The decimal value represents a percentage of pulse width modulation in approximately 0.39% increments and an audible frequency output from 30 Hz at its maximum distance to three kHz at its minimum distance. The motor control module is a microprocessor controlled h-bridge designed to work with a microprocessor. The audible frequency is sent to an internally mounted speaker through an amplifier circuit to increase volume and offers volume control. See Fig. 17.3 for a photograph of the internal configuration of the device. The ETA is packaged in a handheld instrument case measuring 12.5 centimeters x 7 centimeters x 3.3 centimeters. The transmitter and receiver are mounted through one end. The on/off and volume switches are mounted on the side of the device. There is an externally accessible nine-volt battery compartment. The speaker is mounted to the inside of the top face. See Fig. 17.2.

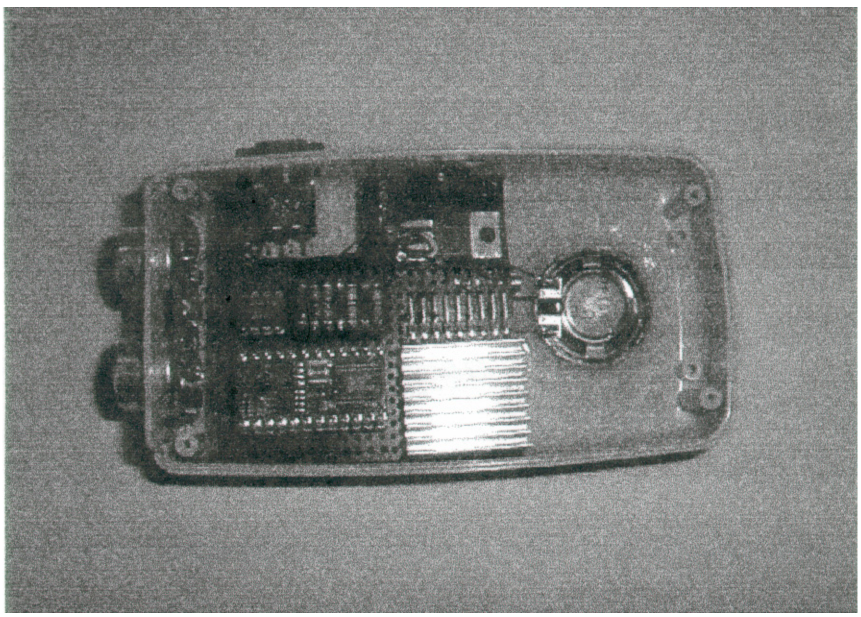

Figure 17.3. Internal Configuration of the Proximity Detector.

VOICE ACTIVATED TELEVISION REMOTE CONTROL

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INTRODUCTION

With a voice activated television remote control, a user speaks commands to the remote control, and the remote control executes the commands. A key focus of such technology is the visually impaired population with the verbal ability necessary to control such technology. This can free individuals from the cumbersome responsibility to constantly memorize exact locations of items. Fig. 17.4 shows the completed VR with its cover.

SUMMARY OF IMPACT

The VR is easy to use. The user first trains the kit to recognize the buttons on the remote: power, channel up, channel down, zero through nine, and enter (other options may be used depending on client's necessities). After training, the kit defaults to recognition mode. Then, whenever one of the trained words is spoken into the microphone, the kit recognizes the word and causes the interface circuit to connect appropriate leads. This simulates a button being pressed and the remote begins to transmit data.

The buttons on the remote can all be accessed using voice commands. For example, saying the word "power" causes the television to turn on/off, depending on its previous state. With design and parts in hand, a single person can assemble it in approximately 10 hours. Upon completion, the voice remote (VR) was presented to a visually impaired client.

TECHNICAL DESCRIPTION

The Technology involved in this design consists of three main parts: speech recognition circuit,

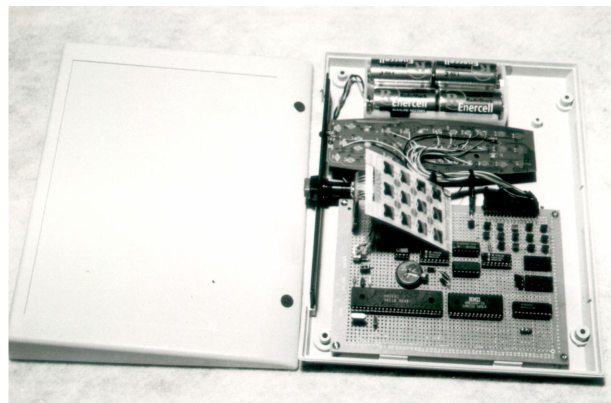

Figure 17.4. The Voice Activated Television Remote Control (VR)

interface circuit, and infrared remote transmitter. The completed speech recognition and interface circuit are shown in Fig. 17.5. The end product consists of the plastic case housing; a voice recognition circuit, a universal remote control, and a microphone. The complete product is 8x10x1.5 inches in size. It is designed to sit in view of the television and within approximately five feet of the user.

The HM2007 speech recognition integrated circuit was chosen because it operates in a stand-alone programmable speech recognition circuit. The IC is trained (programmed) to recognize the specified. It provides the options of recognizing either 40, 0.96-second, words or 20, 1.92-second, words. For memory, the circuit uses an 8K X 8 static RAM. Operating the chip (HM2007) in its manual mode allows the user to have a stand-alone speech recognition board that doesn't require a host computer to utilize speech control.

The interface design requires an eight-bit binary digital output to control the remote functions. This circuit will connect, or interface, the speech circuit with a universal television remote control. The circuit has to take a digital binary output from the latch, 74373, and use it to close specific contacts on the remote control for operation. Using multiple analog multiplexers, CD4051, and transistors, 2N3903, the binary output can be manipulated to control the remote. If the multiplexers common is tied to a positive biasing voltage, then the output can be pointed in the right direction by the binary input (select) lines. If any error messages do occur, a simple data logic circuit can be implemented to turn off the multiplexers, disabling any possible output.

The output from the HM2007 will not trigger the multiplexers because its data duration is too short, 480ns. It is necessary to use a pulse timer (LM555) in such a manner that can pulse the data latch and control the multiplexers. This will create the one second pulsed output that is necessary for the television's remote control. Since the data out of the HM2007 are clocked into the latch, the outputs are only enabled when the control goes low.

Total cost of design is around $70.00, including all parts, components and connectors.

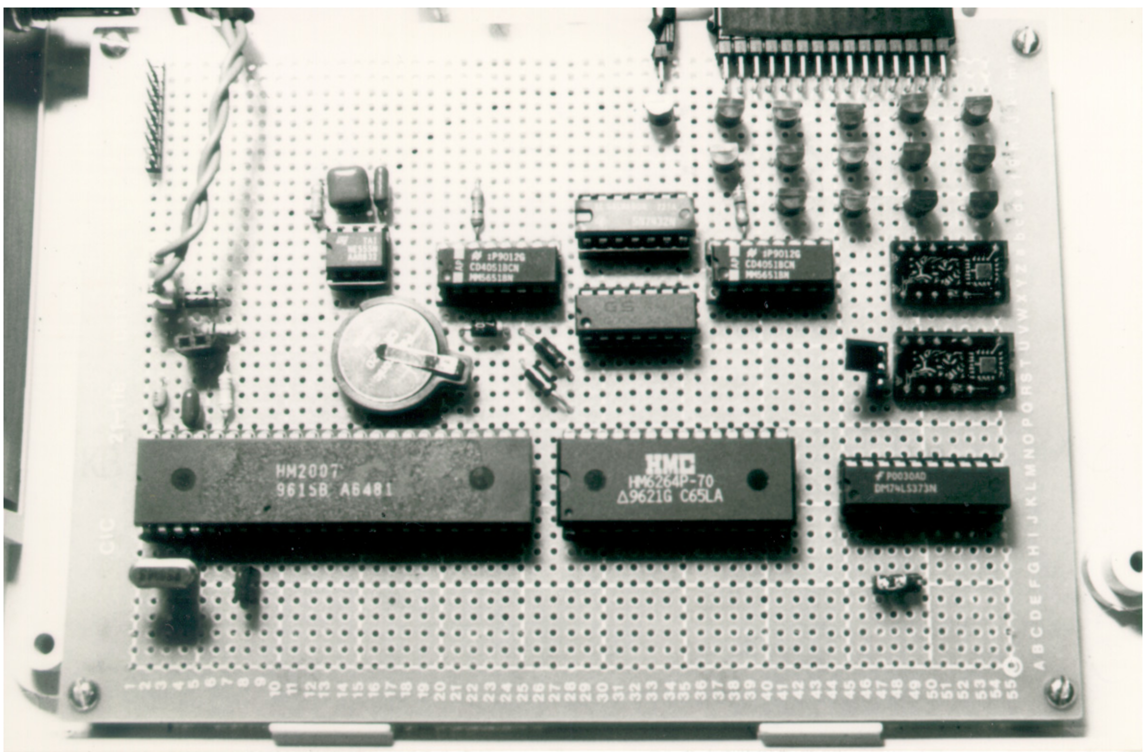

Figure 17.5. Completed Voice Circuit.

SENSORY SYSTEM FOR THE BLIND

Designer: Richard Castle
Client Coordinator: Paula, Lowell Association for the Blind, Lowell , MA
Supervising Professor: Prof. Donn A. Clark
Electrical Engineering Department
University of Massachusetts at Lowell,
Lowell, MA 01854

INTRODUCTION:

The sensory system was designed to provide a comfortable and discrete way for a visually impaired person to move around. This device is a combination of infrared sensors and vibrating motors that alert the person of upcoming objects. The sensors and motors are mounted on a pair of shoes to detect objects in proximity.

SUMMARY OF IMPACT

The system is to be presented to a local center supporting blind people. The people at this center have a strong lack of or no vision at all. Because of lack of sight, visually impaired people have to use a walking stick to find objects in their way. Ultimately, the sensor system will give them a way to "sense" objects.

TECHNICAL DESCRIPTION

The components consist of six infrared sensors, with a transmitter and receiver in each sensor, six vibrating motors, two battery packs (three AAA batteries in each pack), a pair of shoes, and the circuitry. All components are mounted on the pair of shoes. There are three sensors and three motors per shoe. Each sensor coincides with a particular vibrating motor, which will speed up as a object gets closer to it. This way, the client will know from to which direction the object is located and the distance to this object.

To get the sensor to communicate with the motor, a simple negative feedback op amp circuit was used to increase the output voltage coming out of the sensor. The sensor runs off of 4.7 Vdc, which makes three AAA batteries acceptable for the source. The three sensors detect the forward, front side, and upper front direction. The three motors coincide with a particular sensor; this way the client can distinguish what each sensor is taking in.

Figure 17.6. The Sensory System.

There is one battery pack per shoe, which contains three AAA batteries and all of the circuitry needed to power that side of the system. The circuitry consists of six op amps (LM124) and 12 resistors for the entire system. Therefore, in each battery pack there are four op amps (the LM 124 is a quad op amp, one not being used), three AAA batteries and six resistors (varying in value). The front and upper sensor are set and max distance (approximately one meter) and the side sensors are set at approximately half of the max. It seems to be more import to have good range on the front sensors than the side.

The cost of parts and material was just under $300.

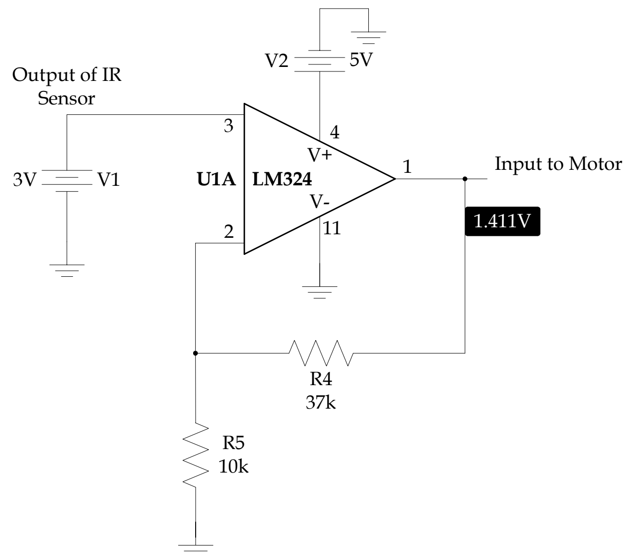

Figure 17.7. Op Amp Circuit of Sensory System.

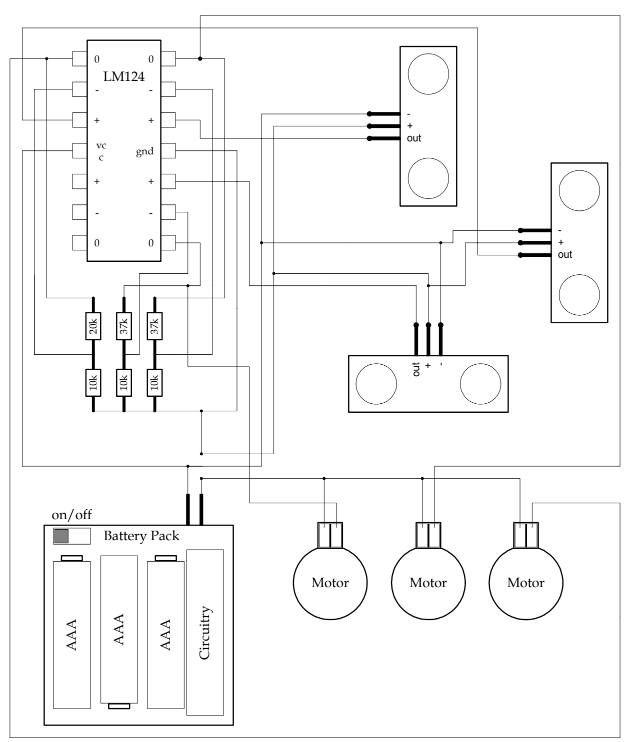

Figure 17.8. Wiring of Sensory System.

VOICE ACTIVATED CALCULATOR FOR THE COMPUTER

Designer: Katherine T. Gerrish
Client Coordinator: Nicole Buddenhagen- CASE Collaborative- John Glenn Middle School, Bedford, MA
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University of Massachusetts- Lowell
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INTRODUCTION

The voice activated calculator was designed to be a four function calculator: addition, subtraction, multiplication, and division. The calculator has an extra large number display, voice input, and voice output. The calculator was designed to be larger than the traditional Microsoft calculator, in order to help students who are vision impaired and/or those who lack the fine motor skills to operate a handheld calculator. The calculator takes up almost the entire screen with large numbers and symbols on each button. Its display consists of an interactive graphical user interface (GUI), which is controlled by one of three inputs: voice, mouse, or keyboard. The output is displayed on the screen like a regular calculator and is also verbalized.

SUMMARY OF IMPACT

This calculator was designed for any speaking child to use. No keyboard or mouse abilities are needed to use it. All controls for the calculator can be controlled by voice, once the voice recognition software is installed and properly trained.

The device was designed for a middle school class meant to meet the special education needs of students with moderate cognitive delay functioning at approximately the grade three to five level. Students in this class possess the ability to work independently for a significant period of time, to work in cooperative learning groups, and to manage the logistics of a typical environment. The predominant mode of instruction is auditory; the predominant mode of reply is verbal.

TECHNICAL DESCRIPTION

The calculator is developed using Microsoft Visual C++ 6.0. The graphical user interface is designed to be easy to see and easy to use. All buttons are large and the entire calculator takes up the majority of the computer screen. The input to the calculator can come from a combination of three sources: keyboard, mouse, or voice. The output of the calculator is shown on the screen of the calculator as well as spoken to the user. The calculator incorporates the four basic math functions (addition, subtraction, multiplication, and division) as well as a clear button, which resets the output to zero.

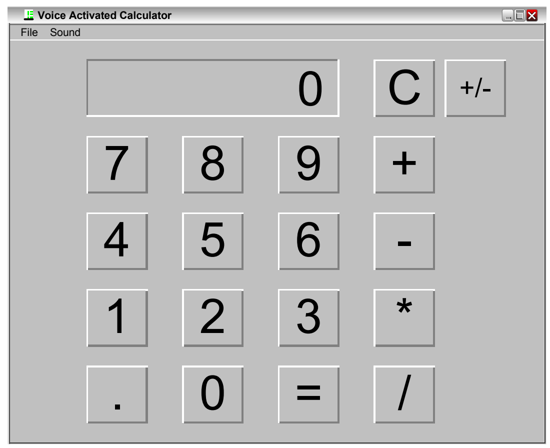

Figure 17.9: The Voice Activated Calculator.

The voice input is accomplished using a software program called Dragon Naturally Speaking Preferred 5. Before Dragon can be used for input to the calculator, the user must go through Dragon's training process to ensure accurate voice recognition. After training Dragon, the user needs to add a few dictation shortcuts so that the correct buttons are clicked when needed. The following words and symbols need to be added to the dictation shortcuts: "is" for '='; "decimal" for '.'; "plus" for '+'; "minus" for '-'; "times" for '*'; and "divide" for '/'.

The voice output is accomplished using the Microsoft Sound SDK package. The sound SDK came with a series of functions that can be used for both voice output and voice recognition. The help files depicted a series of functions that take a CString as input and send it to the speakers as output.

The only cost for this project was the Dragon Naturally Speaking software, which cost $180.

VOICE ACTIVATED REMOTE CONTROL

Designer: Yiu Wong
Client Coordinator: Alan Rux, Technical Coordinator at UMASS Lowell
Supervising Professor: Prof. Donn Clark
Electrical Engineering Department
University of Massachusetts Lowell
Lowell, MA 01854

INTRODUCTION

A voice-activated remote control (VARC) has been developed to assist an adult who has limited use of his hands (see Fig. 17.10). This controller allows the user to control the basic functions of TV, Cable and VCR entertainment system by using voice command. This hand free controller device allows people with limited use their hands to be able to control their entertainment system simply by speaking.

SUMMARY OF IMPACT

This VARC has allowed the client, who has no control of his arms and legs, to interact with the remote controller through voice command. For example, when he wants to select channel up on the remote controller, he will simply do so by speaking the phase "channel up" which causes the TV's channel to go up. Once the power is on, this device is always listening for commands, and the user doesn't need to touch the device at all. With the help of VARC, the client is able to control his entertainment system without assistance.

TECHNICAL DESCRIPTION

The final VARC structure consists of two parts as shown in Fig. 17.10. A three-in-one universal remote and a eight by five by four inch plastic box containing the voice recognition processor and the logic circuit. The single universal remote can control the TV, VCR and the cable box. There are several buttons located on the top of the box for word training purposes. There is also a speaker located inside the box. The purpose of the speaker is to use speech prompting to report memory status, provide training instruction and notify user when there an error occurs. A microphone is placed on top of the box for the voice recognition processor to recognize voice commands. The unit can be powered either by four AAA batteries or a five Volt DC adapter.

Figure 17.10. The Voice Activated Remote Control.

There are three key parts: a voice recognition system, a universal remote controller, and a logic circuit which connects the two. The remote is modified to have its control wires extending through its plastic cover into the box so that the logic circuit and the relays in the box communicate with the infrared signal processor in the remote. The infrared signal processor of the remote is packaged in a 28 pins IC chip. With correct pin-to-pin connection, an infrared signal corresponding to those pins connections is sent out to appliances. For example, if pin one and pin 11 of the processor are connected together, an infrared signal for POWER ON will be sent to the TV.

The voice recognition processor is the Voice Direct™ 364 from Sensory Inc (shown in Fig. 17.11). Voice Direct™ 364 is a speaker-dependent speech recognition module, allowing training of up to 15 words with duration of 2.5 seconds each. Therefore, the user can use voice commands to control up to 15 functions of the remote. Using sophisticated speech recognition technology, Voice Direct™ 364 maps spoken commands to system control functions.

Each time one of the words is recognized, output pins on the module are toggled high for one second.

A logic circuit is designed for decoding the eight outputs generated by the Voice Direct processor and signifying the specified relays for controlling the modified remote's circuit. Therefore, the remote circuit will send out the appropriate control signal to the entertainment system if corresponding relay is active.

The voice-activated remote is easy to use and is user friendly by providing Speech Prompting Technology. The VARC will tell the user about the current status of the unit such as memory full, word recognized or errors. The unit is small, portable and affordable.

The entire unit including the remote is cost around $120.

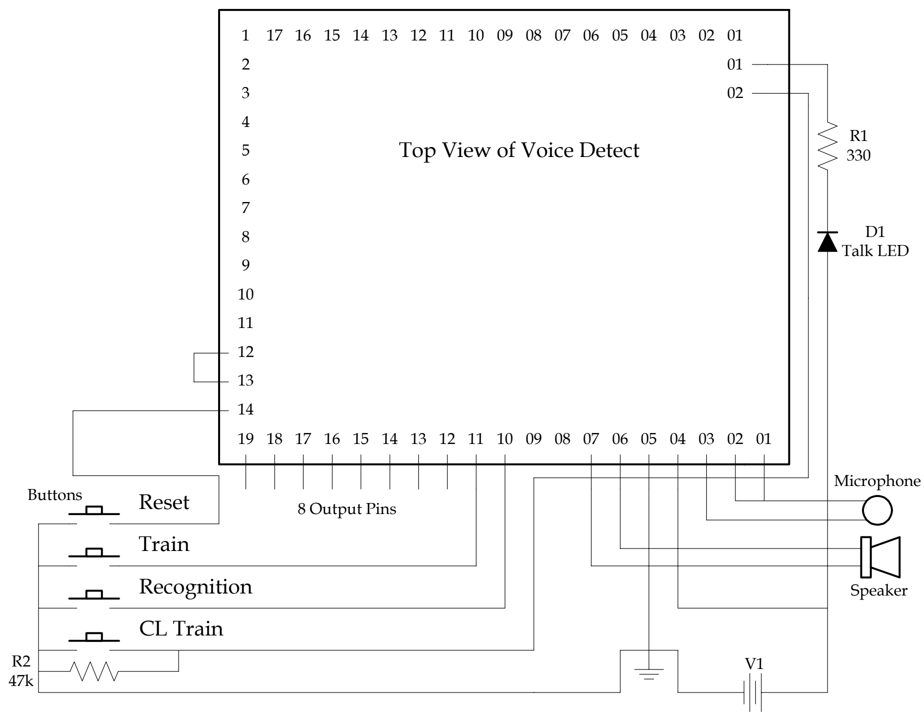

Figure 17.11. Voice Direct Processor Configuration.

VOICE ACTIVATION ENVIRONMENTAL CONTROL SYSTEM

Designers: Brian Hall and James Molloy
Supervising Professor: Professor Donn A. Clark
Electrical and Computer Engineering Department
University of Massachusetts at Lowell,
Lowell, MA 01854

INTRODUCTION

The voice activated environmental control system (ECS) was designed to provide voice activation and control of various household lights and appliances for persons with motor disabilities and to increase the awareness of cost effective means of providing such control. This device is simply an application of off-the-shelf components using the well developed but little known and misunderstood X-10 transmission technology combined with a basic voice recognition software platform. Once the system is installed, a person with a disability can the turn appliances and lights on or off by simply using speech commands. The ECS is intended to provide persons with disabilities a sense of independence and control over their surroundings.

SUMMARY OF IMPACT

The design criteria for the ECS were defined by the needs of a person with multiple sclerosis and muscular dystrophy. This person requires constant care, uses a wheelchair, and is incapable of motion outside extremely limited use of one hand. The primary care givers are the individual's parents, along with a state funded caregiver. For times when the individual is required to spend time outside of care, this system can provide him with a means of controlling the surrounding environment and increasing his sense of comfort and security. The client's mother expressed, "...this will make things so much easier for (my son)." Other persons in similar situations will have the capability of installing this type of system into their homes. Also, it can dispel the myths and alleviate the fears of the inner workings, the safety, and the cost of X-10 technology and devices.

TECHNICAL DESCRIPTION

The overall development of the ECS system was dependent upon the availability of standard off the shelf components using X-10 technology. Once the most important appliances were identified for automation need, research was conducted on the best manner and pricing available to obtain the appropriate units. The X-10 modules were easily ascertained via internet shopping at a reasonable cost. Several types of modules and communication interfaces were purchased for the system.

Again, with main focus of the project being the emphasis of simplicity and low-cost to install home automation systems, particular importance was placed on developing a system that was simple to install. Therefore, the core of the system was the CM17A computer interface module. This module is commonly referred to as the Firecracker. This module serves as a low cost X-10 transmitter that can be driven using free downloadable software from the distributor's well-maintained website. Installation of the module is as simple as plugging it into the standard nine-pin serial port on a home computer.

Aside from the CM17A, the core unit needed for the system was the TM751 transceiver module. These units receive a signal generated from the Firecracker module and transmit that signal onto the existing electrical lines within the home. Multiple TM751s were used because the individual's home had an extension built on with an independent electrical wiring circuit. Normally, homes can suffice with a single TM751, but because they cost less than $15 and serve as an appliance module, there is no loss to the benefits of the system if more than one is needed. The TM751 simply plugs into standard electrical home power outlets.

The remaining X-10 modules were all standard items that can be purchased in stores or on the Internet. All modules, regardless of manufacturing, are sufficient in accepting and reacting to control signals generated by the CK17A module and the CK18A Firecracker Control Software. These modules typically plug directly into the home's electrical outlets. Some lamp modules are screwed directly into the lamp socket. The lamp is then screwed into the module. All modules can be set to any of 256 individual address codes allowing for customization of the installation.

Voice recognition software was necessary to allow a person with disabilities to control the Firecracker software. Dragon Naturally Speaking voice recognition software was chosen after investigating currently available software in terms of dependability, availability, system requirements, and price. The voice recognition software was installed onto the system and the end user was trained only for the commands vital for using the Firecracker software and controlling the microphone.

The microphone was found to be the most important part of this system and the most expensive part. The system developed used a Sony WCS-999 wireless microphone with a range of 150 feet. The range is sufficient to allow a person with a wheelchair to travel within their home without loosing control of their ECS. This microphone, while maybe not ideal, is affordable and dependable.

The cost of parts/material was about $500. This included the voice recognition software, the wireless microphone, the X-10 starter kit, and a large hand-full of X-10 modules. Because many people with disabilities already posses voice recognition software and a microphone, wireless or otherwise, the system cost with the same number of modules could be reduced to about $170. Furthermore, a very basic and still very helpful setup could be achieved with just the X-10 starter kit, a few lamp modules, appliance modules, and one universal module for less than $100.

VOICE ACTIVATED TAPE DECK CONTROLLER

Designer: Richard L Roberts
Client Coordinator: Patricia Kirk, Talking Library, Perkins School for the Blind, Watertown, MA.
Supervising Professor: Donn Clark
Director of Assistive Technology
Electrical and Computer Engineering Department
Univ. of Massachusetts Lowell
Lowell, MA 01810

INTRODUCTION

The voice activated tape deck controller was designed to provide hands-free operation of the Talking Libraries tape decks, which are loaned out along with books on tape, through a mail order system to patrons who meet the eligibility requirements. The patrons of the Talking Library consist largely of individuals with visual and physical disabilities. The Library currently has some methods of assisting patrons with the operation of the tape deck, but they are limited. A remote control can be attached to the tape deck, but its only function is to turn the power on or off. Thus, the tape would already have to be in the play mode for it to start playing when the remote turns it on. The Library also has a mechanical adapter that makes use of levers of different lengths to ease in the operation of the tape deck. Both of these methods, although helpful for some patrons, do not meet the needs of the visually impaired or patrons with limited or no motor skills, such as people with paraplegia, or quadriplegia. Fig. 17.13. shows the voice activated tape deck controller positioned to control a tape deck.

SUMMARY OF IMPACT

For many of the patrons of the Talking Library, the act of enjoying a good book when alone is either impossible or so difficult that the joy usually obtained is lost by the difficulty it presents. The voice activated tape deck controller was designed to eliminate these difficulties. It allows people with visual and or physical disabilities to share in the enjoyment that can be found in literature. Due to its hands-free operation, an individual can operate the tape deck when desired without the need for a physical therapist or outside assistance. Not only does the device help provide a means of entertainment, but it also gives the individual a means of interacting and taking control of their environment. Upon completion, the voice activated tape deck controller was presented to the Talking Library, funded by the Library of congress.

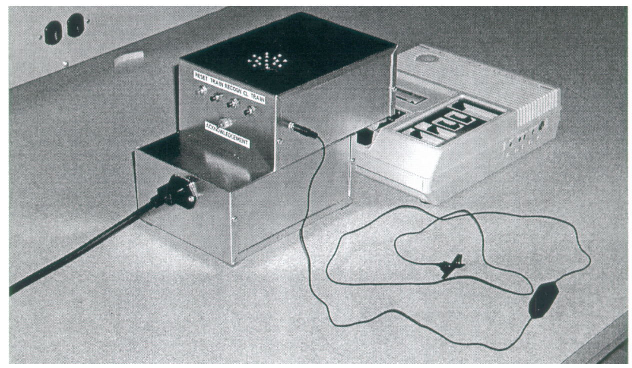

Figure 17.13. Voice Activated Tape Deck Controller and Tape Deck..

TECHNICAL DESCRIPTION

The design criteria for the controller were driven by the device with which it would be interacting and the individuals who would be operating it. Based on the criteria, the controller required four major sections. The first section consists of the Voice Direct 364, a commercially available voice recognition chip produced by Sensory Inc. The voice chip has the ability to store a limited number of voice commands into its memory. The voice chip creates templates by sampling audio sounds during its training mode. Once trained, the chip can then be set into the listening mode where it will sample sound from its environment and compare it to the stored templates. When a match is found, an eight bit output corresponding to the stored template will be transmitted out of the voice chip.

The second major section of the controller is the control circuitry. The voice recognition chip has an eight bit output (but only 16 distinct outputs) and the tape deck has five function keys: stop, rewind, play, fast forward, and eject. Thus, it is necessary to use digital logic circuitry to convert the chips outputs to ones that can be used to control the five function keys. The digital logic is also necessary to overcome two unfavorable behaviors of the voice chip. During initial power up and any time the reset switch is activated, the voice chip will set all of its outputs high for one second. This would result in all function keys being activated at the same time, which could in turn damage the tape player.

Fig. 17.14 depicts the logic circuitry that is used to drive the stop function of the tape player. This same design is used to control the other four functions with the only difference being the order of the inputs.

It can be see from the design that any time bit four is set high and no other bit is high, a high signal can be seen at the output. A high on bit four will operate the stop function. A high on bit five will activate the rewind function. A high on bit six will operate the play function. A high on bit seven will activate the fast forward function. A high on bit eight will operate the eject function. Any time more than one bit is set high, there will be no output on any of the functions. The output of each section of control circuitry is connected to a DC solid state relay which, when biased by the control circuitry, will switch power to the third major section of the controller- a bank of solenoids. Push-type solenoids are positioned over the keys of the cassette player. When the solid state relay is biased 12 volts @ eight amps is supplied to the solenoid providing the 96 watts required to product the force necessary to activate the key. Such a large amount of energy is required because the keys take an average of 2.5 pounds of pressure to be applied over a distance of 0.75 inches.

The final section of the project consists of the two components of the power source. The first component is a dual output switching power supply. The power supply has a five volt 3.5 amp output, which powers the TTL logic and the voice chip. The second output is rated at 12 volts at four amps. Due to size and cost constraints, it was not practical to purchase a power supply that could supply the entire 12 volts at eight amps to the solenoids. To work around this problem, a combination of a reduced power supply in parallel with an 8200 microfarad capacitor was used. The capacitor is charged by the power supply and when discharged, produces the required energy to drive the solenoid. Using this method the physical dimensions of the power supply were reduced from 10x7x3 inches to 5x3x1.5 inches. The power supply, the largest single component in the device, drove the minimum size requirements of the entire unit. Reducing the size of the power supply enabled reducing the overall size of the controller. Using this method also resulted in a substantial cost reduction of $110.00 or approx. ¼ of the total $410.00 required for all parts and materials.

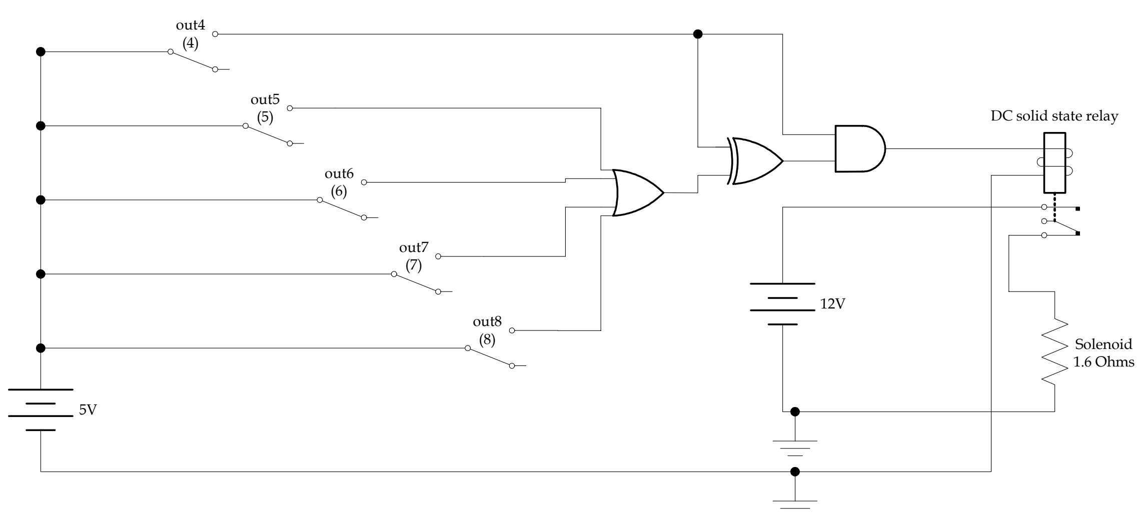

Figure 17.14. Digital Control Circuitry for STOP Function.

CHAPTER 18
UNIVERSITY OF WISCONSIN-MILWAUKEE

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ADAPTIVE CONTROL OF CHILD'S SEAT HEIGHT

Designers: Daniel McGowan, and Travis Schisel, Department of Mechanical Engineering
Crystal Bocher, Department of Occupational Therapy
Supervising Professor: Dr. Bertram N. Ezenwa
University of Wisconsin-Milwaukee, Milwaukee Wisconsin, 53211

INTRODUCTION

A height adjustable seat has been modified to enable a child with upper and lower limb deficiencies to safely control the raising and lowering functions of the seat for use in a classroom. Due to bilateral deficiencies, the client constantly needs the teacher or an aid to help him raise or lower his chair. The chair is equipped with a conventional control mechanism for height adjustment, and this causes constant distraction in the class. When he tries to operate the control mechanism himself, he assumes an awkward posture that puts stress along the spine, and most times he is unsuccessful with repeated trials. The request from his teacher, the school's occupational and physical therapists and the child was an assistive technology solution to enable the child to operate independently his height adjustable chair. The preferred implementation outcomes by the teacher include: (1) providing technology solution that does not make noise in class or draw attention to the client, (2) increasing differential adjustable height from two inches to four inches to enable the child reach his books below and the top of the classroom desk, and (3) implementing a control mechanism that is easily and safely accessible using the elbow. The solution involved the adaptation of a quiet actuator and switch control to modify a regular height adjustable office seat.

SUMMARY OF IMPACT

Adapting a quiet actuator made it possible to raise and lower the chair in class without being noticed by nearby classmates. Incorporating adaptive switching with mechanical advantage gave the child the ability to operate the chair independently. Increasing the vertical height adjustment from two inches to four enabled the child to reach the books below and above his desktop. The modified chair eliminated the need for the client's teacher to help him raise and lower his chair during class.

TECHNICAL DESCRIPTION

H is the maximum height of the seat from the ground, T the seat support that also provides telescoping capability for height adjustment, S the sitting area, R the rollers, B the back support and AS the seat assembly support with attached rollers. The technical solution of interest include substitute for T, coupling to AS, adaptive switch control, and the bracket.

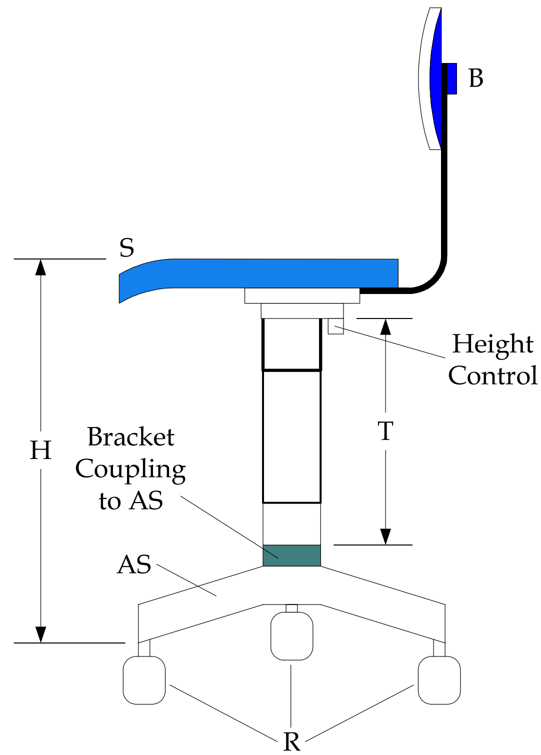

Figure 18.1: Functional Aspects of a Height-Adjustable Office Chair.

Substitute for T: A DC actuator (ECOMAG 20) by Magnetic Corporation shown in Fig. 18.2 was selected to provide the support the seat and provide telescoping functions to achieve required four-inch seat height adjustment. The actuator noise is very low, satisfying the noise condition to be used in a classroom.

Coupling to AS: A hollow interface is designed with inside diameter to match the end of the DC actuator pillar. The outside diameter is designed to fit inside an oval space at the center of the wheel base structure AS. The hollow structure is firmly attached to the end of the pillar with a tight press-fit nut. Modification is made to the seat metal bracket to provide an interface between the other end of the actuator and the seat base. This was accomplished through made-to-fit metal gaskets and tight fitting fastener. With the wheel assembly firmly coupled to one end of the actuator pillar, and the other end of the actuator firmly coupled with the seat base using the modified bracket, mechanical adaptation was completed.

Electrical Power and Switch Control: To supply electrical power to the actuator, an 18-volt rechargeable battery was mounted beneath the seat with the necessary electrical circuitry and a switch. The switch has the following characteristics: momentary double throw, double pole, and center neutral. To engage the switch as purchased requires strong effort and dexterity that client does not have. Also, the switch lever arm has limited length and surface area. Special adaptation was made to provide a mechanical advantage to overcome the limited lever arm length. This was accomplished by extending the switch lever arm by a foot, and the switch with modified lever arm was mounted from a standoff from the base of the seat. The surface area of the lever arm was then increased by a factor of 10 times from 0.2-inch diameter to two-inch diameter with surround flexible rubber. The final product is as shown in Fig. 18.3.

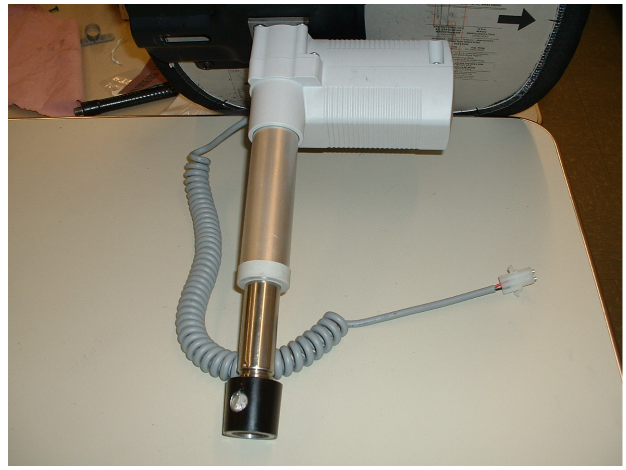

Figure 18.2: Low Noise DC Actuator and Coupling to AS.

The total project cost is $277 for the pillar and parts.

Figure 18.3: Adapted Height-Adjustable Chair.

WEIGHT-ASSIST WALKER FOR A CHILD WITH BILATERAL UPPER AND LOWER LIMB DEFICIENCY

Designers: Travis Schisel and Daniel McGowan, Department of Mechanical Engineering
Crystal Bocher, Department of Occupational Therapy
Supervising Professor: Dr. Bertram N. Ezenwa
University of Wisconsin-Milwaukee, Milwaukee Wisconsin, 53211

INTRODUCTION

A child with both upper and lower extremity limb deficiencies needs assistive technology to safely use bilateral prostheses for ambulation and play, including playing with kick balls. When the child uses his prosthetic device for ambulation, his ability to engage in normal heel strike, flat foot, and toe off are limited and abnormal because his femoral heads were separated from his hip sockets at birth. The immediate design task was to minimize weight transfer through the soft tissue, allowing just enough weight through his prosthetic device to be able to push off with improved gait during ambulation. Other design tasks include: to provide hand-free walker support so that his upper residual limbs can be used for other activities, to meet his desire to attend the urinal unassisted, and participate in kick ball.

SUMMARY OF IMPACT

The modified walker is lighter than a reverse walker and does not require pushing. Offloading the client's weight through the walker dramatically improved his gait, making the device an invaluable companion for activities of daily living. The psychological gain of participating in kick ball and to using the urinal independently will be beneficial. Further studies could apply the design for those with functional upper extremity and weak lower extremity limbs to ambulate independently for prolonged periods of time or stand to retrieve and place items above their reach from wheelchair without fear of falling

TECHNICAL DESCRIPTION

Overall Walker Weight and Height Adjustment: To limit the weight, round aluminum seamless extruded tube with a one-inch outer diameter was used. Aluminum was chosen because of good heat-treatment, weldability and formability characteristics, and good strength properties. Also, aluminum alloys have high resistance to corrosion. The aluminum stock used for the design is from Kaye Posture Control Walker. The design is lighter than Kaye posture control walker because the total length of tubing in the design is less than the total length used in that walker. To provide for height adjustment, as in Kaye products, the wheels are attached to a smaller diameter straight tubing that telescope inside wider diameter straight tubing. The tube incorporates spring-loaded pin that fits into holes drilled into the walker legs for height adjustments.

Figure 18.4: Weight Transfer Mechanism

Assist in Weight Bearing During Ambulation: To facilitate load-bearing assistance, the mid section of the walker was chosen for weight transfer from the user to the walker support wheels. Load transfer assist is accomplished through a combination of a wide belt with a Velcro end strip strategically attached to the middle of the rear side of the walker frame and a soft cushion covering the user side, as show in Fig. 18.4.

The belt used to secure the user to the walker is a modified weight lifter back support. The belt incorporates suspender straps, which positions the belt in an area that is easily accessible to the user, and Velcro hooking that allows the user to attach, tighten and remove the Velcro using the elbow.

Independence to Play (Kick Ball) and Use Urinal: Controlling backward movement is required when the user kicks a ball to prevent from falling backward as his weight is transferred in the natural kicking motion, and it also provides balance to use the urinal. The rear wheels are of a fixed design and do not swivel. They are equipped with ratchet mechanisms to prevent the walker from rolling backward during use, (Fig. 18.5). Each front wheel of the unit swivels 360 degrees about the point of attachment. This allows the walker to be steered by the user in any direction without lifting and repositioning the walker.

The front of the walker is made wider than the rear by implementing a five-degree curvature from the back support to the front. A U-tube is implemented at the back to provide continuous force transfer from the points of user support at the back to the wheels. Opening up the front area uniquely positioning the user with minimum hardware in front makes it possible to take part in kicking a ball or using a urinal for. Fig. 18.6 illustrates the design of the walker enclosing three sides of the user with the user facing the open side during use.

The total project cost is $566 for the reverse walker and parts.

Figure 18.5: Ratchet Mechanism.

Figure 18.6: Weight-Assist Walker

CHAPTER 19
UNIVERSITY OF NORTH CAROLINA AT CHAPEL HILL

Department of Biomedical Engineering
152 MacNider, CB #7455
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Principal Investigator:

Richard Goldberg (919) 966-5768

SOUND WALL FOR MUSCLE STRENGTHENING AND SENSORY STIMULATION

Designers: Xin He & Zhiyu Zhu
Client Coordinator: Nancy Curtis, Physical Therapist, North Carolina Easter Seals
Supervising Professor: Dr. Richard L. Goldberg
Department of Biomedical Engineering
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INTRODUCTION

A physical therapist requested a device that will strengthen the upper arms and trunk muscles of a girl with cerebral palsy. Currently, toys are available in the market aimed at training muscles of children with disabilities using sensory stimulation as an encouragement. The problems with these toys are that: 1) they provide limited sensory stimulation and fixed stimulation mapping, 2) most of them cannot be mounted vertically, thus the children do not have to reach up to trigger those switches, and 3) for most commercial devices, all the sounds are already built in by the manufacturer, thus the child cannot be creative to make her own sounds. The Sound Wall, shown in Fig. 19.1, is an attempt at a treatment device that addresses these shortcomings.

SUMMARY OF IMPACT

The major advantages of this device are that: 1) it is vertically mounted, 2) it is expandable, 3) the client can be creative while playing with it, and 4) it is appropriate for use with supervision by any child.

TECHNICAL DESCRIPTION

The device consists of three major parts: a frame, five function blocks and the power supply. Any combination of four out of the five blocks can be mounted in the frame at a given time. Bright colors and simple shapes are applied for aesthetics. The base consists of two parts, the frame and the supporting structure, which are easily detachable. Composed of aluminum, the base is light but rigid, and the triangular design of the support makes it stable. All the edges are rounded for added safety. A commercial wall transformer is used to provide a 12-volt power supply, which meets safety standards. A project box with four jacks is located on the back of the frame to provide 12 volts to each block. The power connector of each block is screwed into the jacket, making the connection robust and safe. The back panels containing circuit boards are all covered to prevent injury.

Five function blocks

Motorcycle driving block: This block can provide blowing air and flashing light stimulation. The client can stretch both her hands out to hold the motorcycle bar, which when turning can activate lights and fans on each side in response.

Recorder block: Two pulling switches are mounted on this block for recording and playback. By pulling the switch and holding it, the child will train and strengthen arm muscles. The child may also be creative by making up sounds to record and play back.

Telephone block: Installed in this block are nine push buttons, representing the nine digits on a telephone. When pushing a button, music or a message is emitted from the speaker. A three-way switch located just under the speaker is designed to be adjusted by the caregiver, allowing each digital button to play three distinct sounds. Another feature of this block is the phone bar. One set of magnetic stones with inverse magnetic polar are attached on the block and another set are attached on the phone bar. The phone bar can be hung on the block very easily in one direction, and impossibly in the other direction. To play with this block, the child is encouraged to push different buttons as well as feel the strength of repulsion and attraction of magnetic stones when hanging up the phone. All the materials of this block are from a commercial toy phone.

Rotating flower: On this block, two different melodies can be played by either simultaneously pulling two switches or pushing two buttons. A flower rotates, with controllable speed, when either set of switches is closed. This flower is specially composed of very soft fabric with plastic materials inside, so when the flower is touched a paper sound can be heard. The child must use both hands at the same time to receive music feedback. The design purpose of this block is to train muscles of both arms at the same time and stimulate cooperation of the two hands.

Velcro block: A music box is attached to this block by a screw, and several Velcro pads are attached with glue. Design purpose is to show the possibility to expand this project by the user, demonstrating an example of how to mount some simple toys on to the blocks.

Total cost for the sound wall is approximately $742.

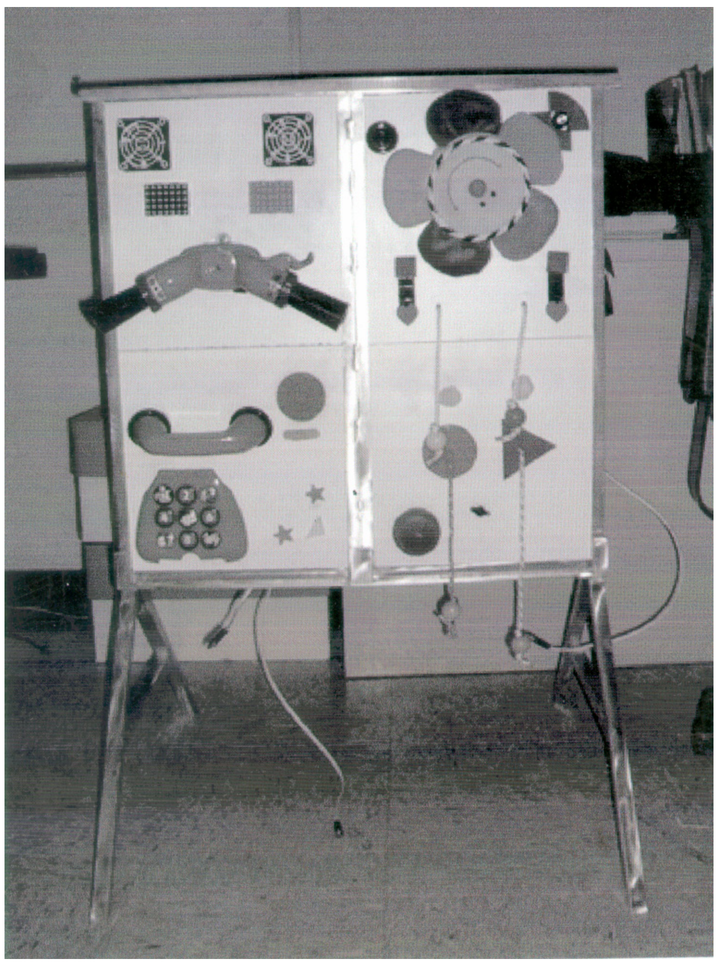

Figure 19.1. The Sound Wall.

TOY RETRIEVER FOR GRASPING OBJECTS FROM A WHEELCHAIR

Designers: Punita Christopher, Venkat Ramshesh & Vinay Tannan
Client Coordinator: Lilee Bonzani, Occupational Therapist, Durham Developmental Evaluation Center
Supervising Professor: Dr. Richard L. Goldberg
Department of Biomedical Engineering
University of North Carolina at Chapel Hill,
Chapel Hill, NC 27599-7575

INTRODUCTION

The client is a two-year-old boy with a spinal cord injury at C-7, resulting in paralysis below the chest. He has normal cognition and uses a wheelchair for mobility, and his need is for a device that helps him fetch toys off the floor from his wheelchair. People currently use commercial grabbers and reaches to fetch a range of objects, but these devices require significant strength in the arm and grip that our client lacks. Also, they are awkward for fetching flat objects. Our goal was to build a lightweight retrieving device that attaches to a manual wheelchair, operates on batteries, and is easy to use. A device was built that consists of a scooper that is lifted and lowered by a telescoping pole, powered by a rechargeable battery. It requires a minimum amount of physical effort to use.

SUMMARY OF IMPACT

The device will benefit the client by enabling him independently to pick up objects from the floor. It will also relieve family members of time and stress from having to help him. Because of the simple design, our client can learn to use the Toy Retriever quickly by operation of two switches. The parents can detach the device efficiently, thus storing it easily when not in use.

TECHNICAL DESCRIPTION

The device consists of a scooper and blocker that are used to scoop the toy. When the user wants to pick up an object from the floor, he or she simply moves the wheelchair adjacent to the object, positioning the scooper just behind the toy as shown in Fig. 19.3. The "lower" button is then pressed, which lowers the scooper and blocker to the floor and the motor automatically shuts off. The user wheels the chair forward, which pushes the scooper under the toy. The blocker moves independently from the scooper. It sticks to the floor and helps prevent the toy from sliding away as the scooper slides underneath the toy. To retrieve the object, the user simply presses the "raise" button, bringing the scooper/blocker unit within hand's reach. The user may then take the object from the unit as desired. The device is easy to use and accomplishes the task of toy retrieval in a fast and efficient manner.

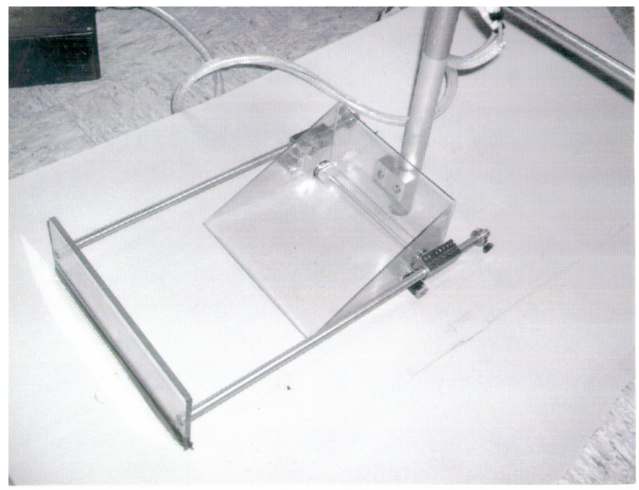

Figure 19.2. The Toy Retriever – Scooper and Blocker Design.

The device is designed keeping in mind the usual toys that the client would pick up. The material used for building the scooper and blocker is Lexan, which is strong and light. The scooper and blocker are connected with a sliding joint so that they can move independently. A rubber shelf liner covers the bottom of the blocker, so that it sticks to the floor when the client moves the wheelchair and scooper forward. The scooper and blocker unit is connected to a telescoping rod, which raises and lowers the unit. This is accomplished using a commercial power antenna and motor, purchased at an auto shop. The base of the antenna and motor is connected to one end of the telescoping rod. The tip of the antenna is pushed through the hollow rod and connected to the other end. As the antenna extends and retracts, it causes the rod to extend and retract. The aluminum rod provides good rigidity compared to the relatively flimsy antenna.

When the user presses either the "lower" or "raise" switch, it triggers the circuit to turn on the motor in the appropriate direction. When the scooper and blocker are lowered to the floor or rise all the way up, the motor starts drawing a higher current. This triggers current limiters (re-settable fuses) in the circuit, which turn off the antenna motor. The battery and circuit are enclosed in a project box, completely isolated for safety. The box contains ports for: 1) two switches, one for lowering the scooper/blocker unit, the other for raising it, 2) the battery recharging unit, 3) connections to the motor, and 4) a power switch. The primary source of power for the device is a rechargeable battery, which can be connected to a commercial charger through a port in the box. The battery has to recharge every few days. The antenna is connected to the wheelchair rod and the scooper and blocker unit in such a way that they can be easily attached and detached.

Total cost for the project is approximately $439.

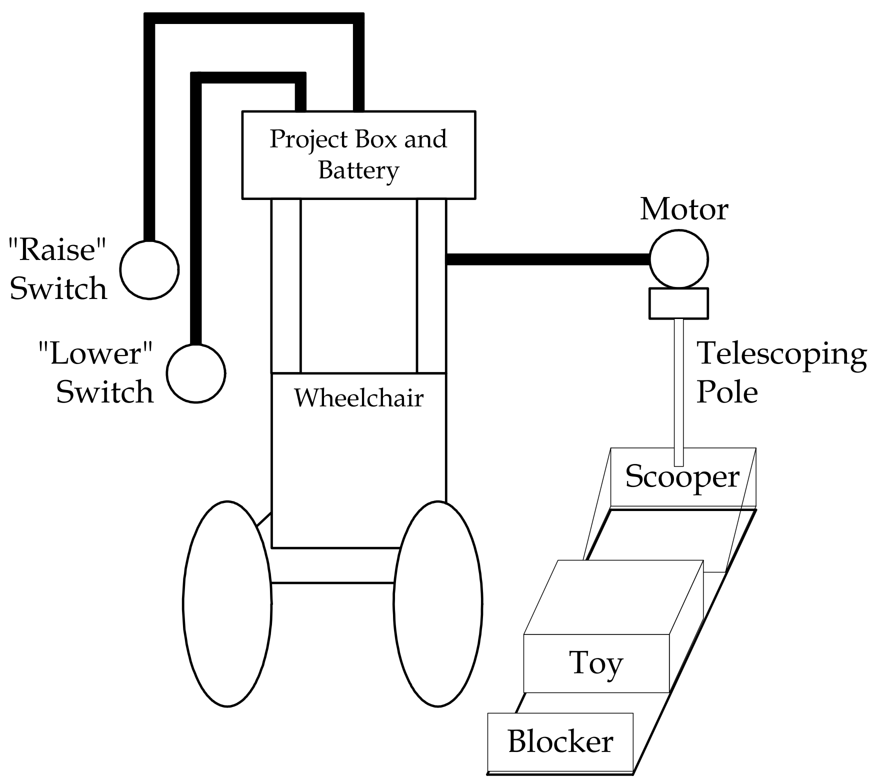

Figure 19.3. Block Diagram of the Toy Retriever. components.

PERSONAL ATTENDANT CALL

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Client Coordinator: Kevin Caves, Duke University Medical Center
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INTRODUCTION

Amyotrophic Lateral Sclerosis (ALS) occurs due to degeneration of motor neurons in the brain and spinal cord. People affected by ALS or similar conditions have a constant need for communication with a personal attendant. This may be accomplished using a simple device like a doorbell buzzer. The patient presses a switch next to the bed and a buzzer (carried by the attendant) alerts the attendant. In current devices, the attendant is unable to differentiate between an emergency case and a non-emergency case when buzzed. This can add additional tension on the attendant and, as a consequence, could affect the quality of patient care. This newly developed device improves communication by allowing the patient to send one of three different messages to convey needs. Possible messages shown in Fig. 19.4 are "Help", "Water", and "Restroom". In addition, the device features the option to emit different tones for a specific message.

SUMMARY OF IMPACT

The patient is able to communicate efficiently specific messages to the attendant. The attendant, aware of the patient's exact needs, is able to work in a more calm and relaxed manner. Since the number of non-emergency instances is more than emergency instances, this device would significantly reduce the tension on the attendant. Both the transmitter and receiver unit are easy to operate, taking little time to learn. Messages on both units can easily be changed depending on patient needs.

TECHNICAL DESCRIPTION

The patient and the attendant each have their respective unit. On the patient unit, there are three different messages, which can be written on a piece of paper and inserted into the message text slot. The unit cycles through each message, indicating the current message by turning on LEDs (light emitting diodes) located underneath each one. When the patient has a need, he simply presses the hand

Figure 19.4. The Personal Attendant Call – Attendant and Patient Unit.

switch while the desired message is illuminated. For example, if the patient needs water, the button is pressed when the "water" indicator is on. A radio signal is then sent to the attendant unit. The attendant unit has the same set of messages as on the patient unit. These are also written on pieces of paper and inserted into message text slots over a bank of LEDs. When the unit receives a message, it illuminates the corresponding message to indicate what the patient needs. Also it alerts the attendant that a message has arrived through audible (a distinct tone and a recordable audio message), visual (the LED indicator), and physical stimuli (a pager motor vibrator).

Any standard commercial switch plugs into the 1/8 inch jack on the patient unit, and it can be changed to suit the patient's abilities. The unit receives power from a commercial 9V transformer plugged into the wall. A Basic Stamp 2 (Parallax, Inc.) microprocessor is used to scan the input from the switch. Each message is coded with a numeric value. On selection of the message the numeric value is transmitted using a commercial 418 MHz RF (radio frequency) communication board (Parallax, Inc.). The default message on the unit is "Help" and it is always activated when the switch is pressed for an instant. Additionally, LEDs flash in sequence when no switch is detected on the unit. The programming for the microprocessor was done in the Basic Stamp PBasic language.

The attendant unit (powered by a rechargeable 9V battery) is light, durable and handheld. A Basic Stamp 2 microprocessor integrates the various operations of the unit. The unit has a commercial 418 MHz RF receiver board (Parallax, Inc.). The current signal from the microprocessor is amplified with an NPN transistor 2N2222A and is used to power the pager motor. Similar circuits are used to power the LED banks and the audio circuit. The pager motor is attached to the underside of the unit and vibrates when turned on. Depending on the numeric code received, the appropriate display lights up. The display on this unit consists of three banks of LEDs arranged in parallel rows of three each. As in the patient unit, the messages are placed over the LEDs and are highlighted when the LEDs flash. The microprocessor also sends out a tone to the speaker, with its intensity controlled by a potentiometer. There is a specific tone for each message. Pressing the switch on top of the unit can reset the entire unit. Additionally a SPST switch provides an option to turn off the vibrate alert. The programming for the microprocessor was done in Basic Stamp PBasic as well.

Approximate cost for the entire device was $325.

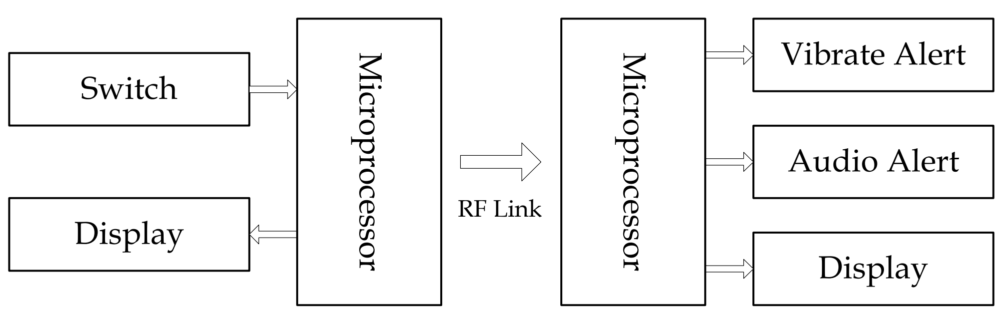

Figure 19.5. System Block Diagram: Transmitter (left) and Receiver (right).

CHAPTER 20
UNIVERSITY OF TOLEDO

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BACKWARD MOTION CLASS 2L MANUAL RACING WHEELCHAIR

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Group 2: (steering) Sam Studer, Anthony Kledzik, Patrick Mahoney, Michael Wozniak, Mechanical Engineering Students
Client Coordinator: Dr. Gregory Nemunaitis, Department of Rehabilitative Medicine,
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INTRODUCTION

The purpose of this project was to design and construct a backward motion class 2L manual racing wheelchair for a member of an athletic organization. This individual has a double hemiplegia, having partial use of his legs and little use of his arms and trunk. He competes in class 2L (L for lower) races, which is a unique style of racing that requires use of only leg motions to propel the wheelchair. This individual can propel better by using posterior facing - kicking forward leg motions, instead of the traditional 2L propelling technique, which uses anterior facing - pulling backward leg motions. Because of this physical condition, he cannot race as competitively as he could since traditional 2L racing wheelchairs are designed and built only to accommodate the anterior facing racing style. This individual wished to be able to race as competitive as possible, which requires use of a 2L racing wheelchair that allows for a posterior racing style. Design considerations included constructing a unit that is lightweight, aerodynamic, stable, durable, comfortable and ergonomically designed, and that allows easy transfer. These aspects of the design were analyzed using the I-DEAS Master Series™ Software (Integrated Design Engineering Analysis Software) and the 3D-SSPP™ (3D- Static Strength Prediction Program). Special considerations were also given to the steering mechanism and to the seating assembly because of the client posterior facing racing style. The wheelchair was made of lightweight one-inch aluminum tubing allowing for maximum speed and control on the track, as well as an extremely strong design for the client. As shown in Fig. 20.1, it uses three wheels, one front and two rears. The front wheel is used to steer the chair. The steering mechanism was designed to allow the client to adjust the amount of turn desired while also allowing him to easily return the wheelchair to head in a straight direction in both a reliable and repeatable manner. Fig. 20.2 shows the client with the engineering students who designed and built the unit.

Figure 20.1. Constructed Unit.

Figure 20.2. Client with Student Designers.

SUMMARY OF IMPACT

The Toledo Tornados is an athletic organization that is sanctioned by the United States Cerebral Palsy Athletic Association (USCPAA) to encourage persons with physical challenges to compete in track and field events that are tailored to their abilities. This racing wheelchair prototype provides one of the team members with an opportunity to participate and compete in class 2L 100, 200 and 400 meter racing events, where the only method of propulsion is the use of the legs. The chair fits the needs of the client while meeting the standards of the USCPAA. The prototype will permit him to use posterior facing – kicking forward leg motions to propel him, allowing him to effectively compete in future events.

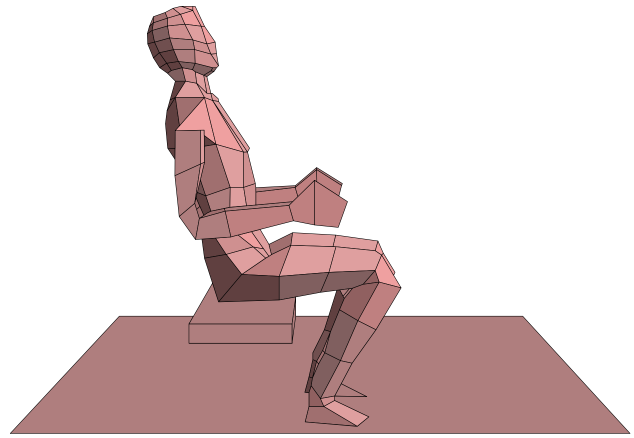

Figure 20.3. Anthropometric Model.

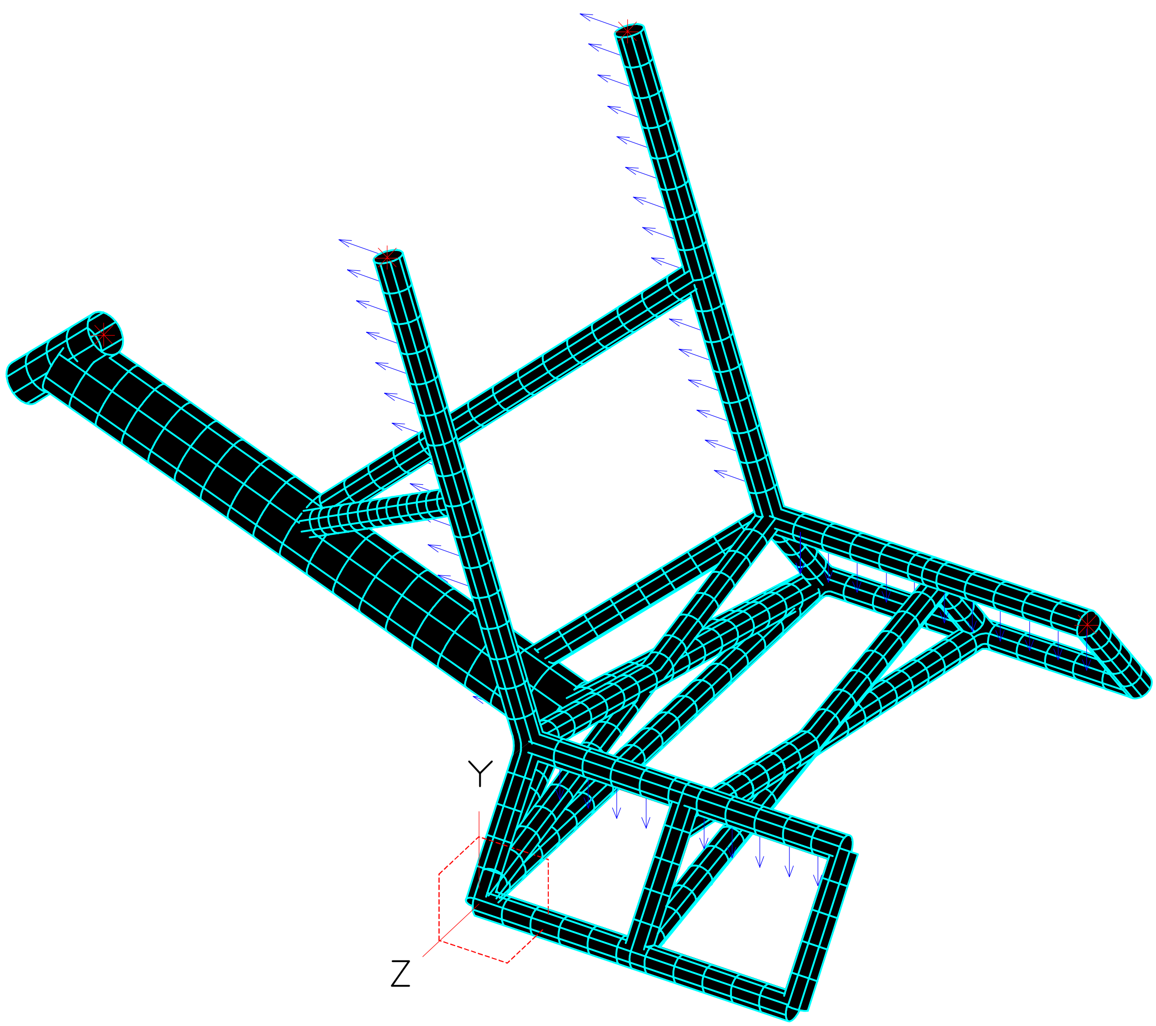

Figure 20.4. Finite Element Model showing Frame and Seating Sub-frame.

TECHNICAL DESCRIPTION

It is mandatory for all wheelchairs and athletes to pass inspection before entering into any competition. In order to conform to the regulations and rules of the USCPAA, the wheelchair must have at least two large wheels and a small one. Other rules and regulations include:

- The maximum diameter of the large wheel including the inflated tire shall not exceed 70cm (27.56 inches),
- The maximum diameter of the small wheel including the inflated tire shall not exceed 50cm (19.69 inches),
- No mechanical gears or levers shall be allowed that may be used to propel the chair,
- Any device of design element that exists for the purpose of reducing air resistance will be permitted provided that said device or designs is limited to the area between the rear wheels and must not extend beyond the lateral edges of the large wheels or extend in front or behind the edges of the tires, except that fenders may protrude two inches past the circumference of the inflated tire,
- Manufactures' labels or trade marks on equipment used within the competition area must be limited to one mark on each piece of equipment and the height of the characters mush not exceed 25mm (0.984 inches), and
- It is the responsibility of the competitor that the wheelchair conform to all the above rules and no event shall be delayed while the competitor makes adjustments to the chair.

The decision was made to use three wheels - one front, small wheel and two large rear wheels - to ensure stability. The front wheel will be used to steer the chair.

Methods and procedures for seating

The first step in the design process was to research and analyze current wheelchair designs and associated features. To complete this task, magazines, the Internet and other athletes with race experience were consulted. The team also reviewed the rules and regulations imposed by the USCPAA. After research had been completed, the design team met with the client to assess his personal needs and to collect his anthropometric measurements. These data were used to develop a customized biomechanical model of the client using the 3D-SSPP™ software. This model is shown in Fig. 20.3.

Several different design proposals were then formulated to evaluate and explore all possible options. The final design was selected using the following three key design criteria:

Posterior facing seat

A posterior facing seat was used in order to allow the client use of his legs for forward propulsion. The seat height was determined using the client's biomechanical model that described his physical profile to include length of legs, seated height, and range of motion. The seat was designed for comfort, functionality and easy transfer into and out of the

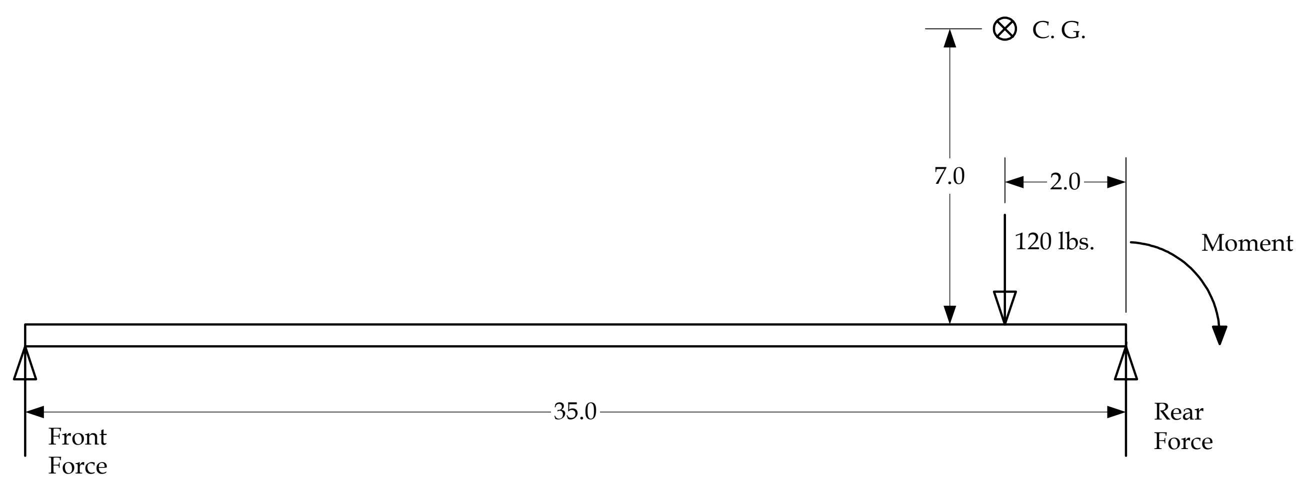

Figure 20.5. Location of the Center of Gravity of the Racer W.R.T. Front and Rear Axles.

racing wheelchair.

Upper body restraint system

The client wanted to be tightly restrained to the chair from the waist up allowing him the mobility of his lower half to adjust his weight in the chair for steering purposes. This also served as a safety feature.

Light weight aluminum frame

A lightweight aluminum frame that directly incorporated a seating sub-frame was used to improve structural integrity of the chair and keep total chair weight to a minimum. Fig. 20.4 shows the frame and the seating sub-frame. This separate seating sub-frame was incorporated into the design to allow a large range of motion of the client's legs. It was decide that the most effective solution to the client's desire to make complete strides beneath the seat was to cantilever mount the axles to the sub-frame.

Biomechanical Model of the Client

Anthropometric data included the seated height of the client, his weight, hip height, the length of his lower and upper legs, the length of his trunk/torso, the length of his upper and lower arms, his shoulder width, and his vertical grip reach in a seated position. These data were used to develop a customized biomechanical model that accurately predicted the client's reach. This model, shown in Fig. 20.3, was employed to simulate the different positions of the client during a race, allowing the wheelchair to be designed around these positions. The optimal seat position for the client was thus determined based on the location of his center of gravity. Anthropometric data indicated that to allow the client to be seated in a comfortable racing position, his upper body needed to be reclined at 108° with respect to the ground, and firmly restrained to the seat back. At the beginning of the stroke, his upper leg needed to be oriented at -15° and his lower leg at 30°. Also, and for comfortable steering, his right upper arm needed to be positioned at -90° and his lower arm at 10°. The anthropometric measurements also showed that the maximum range of motion in the client lower leg was from -135° to -55° with respect to the horizontal. These values were used to determine the clearance needed underneath the chair to permit the proper leg motion, and to design the chair accordingly.

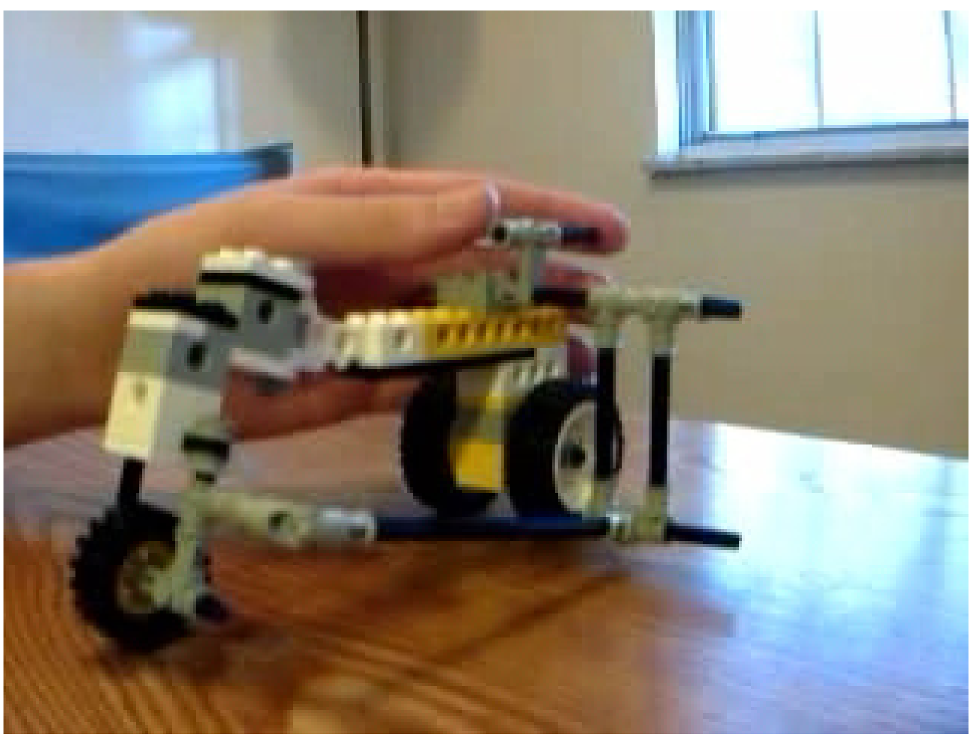

Figure 20.6. Lego Model Illustrating the Level Arm Steering Method.

Stability and Weight Distribution:

Three aspects were considered to allow the wheelchair maximum performance while remaining stable. The first of these aspects was the chair's wheelbase. It had to be long enough to provide stability but at the same time be able to turn effectively within the track dimensions. The chair had an overall length of 60 inches and a wheelbase from front wheel centerline to rear wheel centerline of 35 inches. The design was performed based on a client weight of 120 pounds, and a chair weight of approximately 25 pounds. The client desired to lean forward and apply a moment about the chairs rear axle, allowing him to lift the front wheel off the ground for additional maneuverability. To overcome the weight of the chair, the center of gravity of the seated racer was placed two inches from the rear axle, and seven inches above the rear axle as shown in Fig. 20.5. This allows the client to lean forward in order to assist in steering without the chair being tail heavy and unstable in racing conditions.

Based on the anthropometric measurements, the chair needed to be wide enough to for the client to sit comfortably and stably while staying within the standard lanes of a racing track. The width of the chairs with wheels cambered at five degrees was 29 inches at the ground. The wheelchair frame was made of one-inch T6-6061 aluminum tube, and was ordered from Invacare. The wheels were special ordered bicycle wheels that allow cantilever mounting. The two large wheels were 26 inches in diameter and the small wheel was 20 inches in diameter.

Using I-DEAS™ software, a structural analysis of the proposed wheelchair was conducted using the finite element method. A wire frame, shown in Fig. 20.4 was used to model the frame and the seating subframe using beam elements. Distributed loads were applied to the seat bottom and seat back to simulate those that would be applied during the operation of the chair. A safety factor of three was used to account for any extreme operating conditions, as well as use by a much heavier rider. It was found that the maximum deflection did not exceed 1/100 of an inch.

Seat design and material selection

A posterior facing seat was used in order to allow the client use of his legs for forward propulsion. The seat height and width was determined using the client's anthropometric data such as length of legs, seated height, and range of motion. Taking the safety of the client as a first priority, a single strap, approximately 12 inches long, wraps entirely around his upper body, securely restraining his torso in the chair and permitting desired movement in his lower half

A separate seating sub-frame was incorporated into the design due to large range motion of the client's legs. This allowed mounting the wheels using cantilevered axles, which was the most effective solution to the client's desire to make complete strides beneath the seat. The actual seat itself consists of two separate pieces of canvas for both the seat bottom and the back support. The canvas has the advantage of being more durable and lighter in weight than other materials, while providing a comfort to the racer. The width of the canvas seat was 15 inches. To secure the canvas seat to the chair, .25 inch brass grommets were incorporated into the design. The seat bottom and bask were then affixed to the chair with cord passing through the grommets and around the frame rails. This design was greatly accepted by the client due to its comfort and lightweight design.

Steering Mechanism:

Four different ideas were developed in the brainstorming sessions which involved steering the wheelchair: a swivel chair method, rack and pinion steering, hydraulic actuated steering, and the lever arm steering method. The swivel chair method had the client's seat geared to a third wheel in the back of the chair allowing the client to change direction by shifting his body. This method would allow the client a full range of turning ability but restrict his nature use of body weight to stabilize and adjust the wheelchair during the race. The client preferred mobility in the seat during the race, so any steering mechanism involving the seat would not be very effective. The rack and pinion steering method involved a lever that would be geared to a rack on a third wheel in the back of the wheelchair. This method would deliver a full range of steering ability but scaling from its current automobile use to wheelchair use would be difficult, and added weight to the chair is also a negative feature. The hydraulically actuated steering method would require the client to pull a lever which would compress a piston causing fluid to flow out of the piston and into another piston connected to a third wheel in the back of the chair. By moving the lever up and down the client could then turn left and right by compressing and decompressing these two pistons. While this method would provide full range of steering ability it is complicated by nature and carries a potential for fluid leaks and frequent maintenance. The lever arm steering method would again require the client to steer by pulling on a lever that would be connected in a three bar linkage pivoted by the seat and attached to the supporting fork of the front wheel. The lever would provide feedback to the client and allow the ability to adjust the heading of the wheelchair during the race environment. This design is lightweight and provides a simple and realistic approach to the problem yet lacks the full range of motion the client will be able to use in normal use. However, the normal use and nature of the racing event did not require a full range of motion in order for the client to safely maneuver the race. The client only needed to turn left and a few degrees to the right, which is significantly supplied by this design. Adaptations of this design may involve the ability to switch sides in order to provide for large right turns or clockwise racing events. This is the method chosen for the steering of the racing wheel chair. A simple model of this lever arm mechanism was constructed prior to fabrication using Lego as shown in Fig. 20.6.

The total cost of the material was $1500.00. Time for machining the different parts was donated.

ADAPTATION OF A WHEELCHAIR FOR HUNTING

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Rehabilitative Medicine, Medical College of Ohio and St. Vincent Mercy Medical Center
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INTRODUCTION

The goal of this project was to adapt a wheelchair to allow an individual with a disability to hunt using a shotgun. The adaptation consisted of attaching a turret to the chair on which the shotgun was secured. A Sip and Puff system (S&P) was used as triggering device. The client blew into the S&P system to activate a solenoid, which in its turn actuated a cable to pull the trigger as shown in Fig. 20.7. The client wears this Sip and Puff (S&P) system. The turret was mounted on the left leg post of the wheelchair, and was made to pivot to allow easy access to and from the wheelchair as shown in Fig. 20.8. During operation, the shotgun is clamped in a support block that pivots only in one plane on the turret. The solenoid is powered from the wheelchair's battery. A safety toggle switch was also integrated into the system to prevent misfiring of the shotgun by preventing current to be drawn from the battery.

SUMMARY OF IMPACT

A person with C6 tetraplegia had no use of his legs and minimal use of his upper body. He had poor tricep strength but good bicep strength. Before using a wheelchair, he was an avid hunter. His wheelchair was adapted to allow him to hunt. The final product delivered to the client was a shotgun turret and a firing system operated using an S&P device. The turret can be used to support different models of shotguns, which was convenient to the user. The turret allowed him to have a larger shooting range and more mobility. The unit was easy to disassemble which was also convenient. The client also had greater control over the firing of the weapon due to the S&P device. The safety toggle switch that was integrated into the system provided a higher safety level.

Figure 20.7. Cable Used to Pull Trigger.

TECHNICAL DESCRIPTION

Adapting the client's wheelchair to allow him to hunt successfully involves the design and construction of a stable shooting turret and a firing mechanism. The turret needs to withstand the significant dynamic forces that accompany the firing of a shotgun, and the firing device must be able to actuate the trigger successfully and repeatedly. The firing device is also required to operate as effortless as possible to allow the client to hunt successfully. A Sip and Puff system is used to activate a solenoid, which in its turn actuates a cable to pull the trigger. The turret is mounted on the left leg post of the wheelchair, and is made to pivot to allow easy access to and from the wheelchair. To resist corrosion, the turret is made of aluminum making it more suitable for hunting in the outdoors. It is also designed so that it can be easily removed and disassembled and can be fitted to different rifles and shotguns. The uprights of the turret, both top and bottom, and the support arm are fabricated from one-inch machined rounds.

During hunting, the shotgun is to be clamped within a support block that pivots only in one plane on the turret. The solenoid is mounted on the left side of the wheelchair, and draws its power from the wheelchair's battery. The client wears the Sip and Puff (S&P) system during hunting. This system includes a head set, a puffing tube, and a control box that attaches to the client's waist. This control box is wired with the wheelchair battery and with the solenoid. As this individual blows into the S&P system, an air pressure activated photo diode, housed in the control box, allows the current to pass from the battery to the solenoid, which pulls a cable to actuate the trigger. This cable connects the solenoid plunger to the trigger on the shotgun and allows the solenoid to pull the trigger. This cable was obtained from a bicycle hand brake cable and made up of two parts. One part is a Teflon coated stainless steel cable, and the other part is a flexible plastic conduit through which the cable runs. Using this particular cable has several advantages. The stainless steel Teflon coated cable allows the cable to survive the elements of the outdoors without corrosion, and Teflon coating reduces friction and allows the cable to easily slide in the housing.

A one-inch stroke solenoid rated at six pounds with an internal resistance of 100 ohms was used. It was purchased from McMaster-Carr. The solenoid is adequate enough as it delivers the required force to pull the trigger, and allows the necessary travel to fully actuate it. The shotgun has a trigger stroke of .225 inches, as measured with a set of calipers. A 5.25 pound load is required to pull the trigger as measured with a fish scale. This solenoid is also compact in size, which allows an easy mounting on the turret: it measures two inches long, 1.75 inches wide and 1.75 inches deep.

Due to the relatively high current, a relay is used to transfer the current from the battery to the solenoid, which protects the sip and puff device from any possibility of overload. The relay has a rating of 20 amps and is small enough to fit in an inconspicuous

Figure 20.8. Turret Mounted on Wheelchair.

place on the wheel chair. The interface between the cable and the solenoid is held in place with a cotter pin. This allows the cable to be pulled through the conduit with minimal resistance.

A safety toggle switch is also integrated into the system to prevent misfiring of the shotgun by preventing current to be drawn from the battery. The toggle switch is a simple single pole, single throw toggle switch, rated at 10 amps. The switch also lights up red when it is armed, thus providing a visual notification to the user that the system is armed and ready to fire. The switch also has a large toggle, making it easier for the client to use.

The interface between the shotgun trigger and the cable must be strong enough to hold the cable firmly in place, but free enough to allow the cable to slide with minimal friction in the conduit. To allow this, the cable is fastened to the gun using a picture-hanging clamp, and a hole is drilled thru the trigger to rout the cable. A cable crimp is used to tie the end.

The total cost of the material was $450.00.

AUTOMATIC FISHING ROD AND REEL

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Client Coordinator: Dr. Gregory Nemunaitis
Rehabilitative Medicine, Medical College of Ohio and St. Vincent Mercy Medical Center
Supervising Professor: Dr. Mohamed Samir Hefzy
Biomechanics and Assistive Technology Laboratory,
Department of Mechanical, Industrial, Manufacturing Engineering
The University of Toledo, Toledo, OH 43606

INTRODUCTION

The goal of this project was to design and construct a fishing rod and reel system that would allow an individual with a disability to fish for a long time with relative ease and comfort. This person has a C5 tetraplegia with good use of biceps and shoulders but no use of triceps and limited use of hands. He desired a fishing rod and reel system that would allow him to retrieve the line without any exertions on his hands. Adapting a system for casting was not necessary since this individual is able to cast seventy feet with an open-faced reel, which is not uncommon for the average fisherman. Also, for securing the rod to the body, the client preferred to use custom fitted plastic molded braces attached to his wrist. Therefore, design objectives were focused on line retrieval. The retrieval system used a small DC motor controlled by a linear rheostat to bring the line in; the motor was mounted to the reel. The rheostat could be retracted either automatically via a linear spring attached to it or by use of an on/off button. Two small clutch bearings were integrated within the system to allow the client either to retrieve the line manually using a hand crank as he presently does, or by activating the DC motor. A removable plastic guard was installed to cover the hand crank to protect his hands in case of malfunction. Fig. 20.9 shows the reel assembly unit that was constructed, and Fig. 20.10 shows a client demonstrating how the unit is used when attached to a fishing rod.

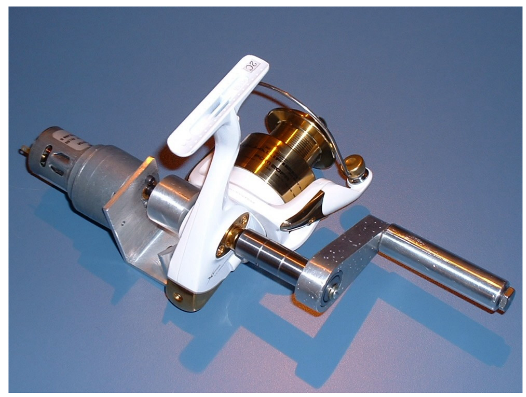

Figure 20.9. Completed Reel Assembly.

Figure 20.10. Reel Assembly Unit Attached to a Fishing Rod.

SUMMARY OF IMPACT

An individual with a C5 tetraplegia has been an avid fisherman for over forty years, but now he can not fish for a long periods of time. As he uses the fishing reel, he turns a hand crank to retrieve the line. His hands tire quickly from the repetitive rotational motion required to reel in the fishing line. A state of the art spinning reel was adapted with high quality mechanical products to allow this individual to fish with very little effort. He has tested the unit and found it efficient and convenient to use.

TECHNICAL DESCRIPTION

Design objectives were focused on line retrieval and securing the fishing rod. The design included using a small DC motor controlled by a rheostat to retrieve the line. The motor was mounted on the reel. The rheostat allowed the client to adjust the speed of the motor. In order to allow the client to retrieve the line either manually as he is accustomed to doing or automatically using the motor, two small clutch bearings were placed on the sides of the central drive shaft in order to disengage either the manual hand crank or the motor, depending on which retrieval method is being used. This eliminated rotation of hand crank as the motor is powered.

In order to estimate the torque required to turn the reel, an experimental approach was used. In this experiment, the crank torque and the bail torque radii were first determined by attaching a container to the bail and a second container to the crank and measuring the distances from the crank's and bail's axes of rotation to the respective masses. The second step of the experiment consisted of adding a known mass to the lever arm of the bail and then adding masses to the lever arm of the crank until equilibrium was attained. The ratio of the bail torque relative to the crank torque was thus calculated.

The minimum load was simulated using a worm made of rubber with one ounce weight, 0.25 inch diameter and a length of three inches. The maximum load was simulated using an eight-pound large mouth bass 24 inches long and with a head approximated as an oval with diameters of four inches and six inches. This fish was then modeled as a streamlined strut. It was estimated by an experienced fisherman that light lure should be reeled in at a rate of eight revolutions per 10 seconds (this would vary per reel but the client decided that this was a good rate for this particular reel). As the radius of the spool used in the constructed unit was 0.875 inches, the specified luring rate resulted to a line speed of 4.4 in/s, which represented the velocity of the worm or the fish. In order to calculate the minimum and maximum torques exerted on the bail, Reynolds numbers for the worm and the fish were calculated using 50o F fresh water. The corresponding drag coefficients were then found from the appropriate charts, which allowed calculation of the drag force on the worm and the fish. Using these drag forces, the weight of the fish and the worm, and the radius of the bail, the maximum and minimum torques exerted on the bail were calculated. Using the value obtained for the ratio of the bail torque to the crank torque, the maximum and minimum torques needed by the motor were estimated as 1192 oz*in and 9 oz*in.

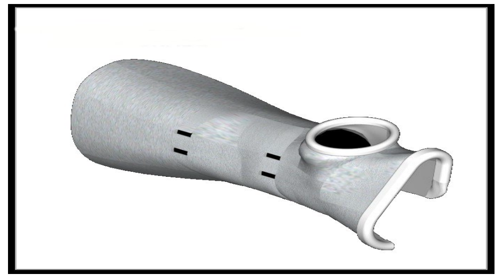

Figure 20.11 Custom Molded Arm Brace.

Due to size limitations, a smaller motor was purchased from Merkle-Korff Industries. It is a 12-volt DC gear-motor with a maximum torque of 6.6 in.lbs and rated at 105 rpm. This motor was not powerful enough to retrieve anything larger than a half-pound fish. The motor was secured to the reel itself using an aluminum bracket and two M2.5 machine screws as shown in Fig. 20.9. This design allowed for the new modified reel to be switched to another rod with no more effort than would be required in switching an unmodified reel. This is an important aspect because it is not unusual for a fisherman to switch rods when on a fishing trip either for fishing conditions or because of a broken rod. The motor's shaft was then assembled into a bearing adapter and then into a clutch bearing. The bearing was then attached to a hex shaft that ran into the reel from one side and then out the other to another clutch bearing. This clutch bearing was then pressed into a manual hand crank. The purpose of these clutch bearings was to allow one retrieval method to act independently of the other. This was an important part of the design because it was deemed unsafe by the design team to have the manual hand crank spinning while the motor ran and it was found to be impossible to turn the motor's shaft by hand.

The client has been using a custom plastic molded brace, shown in Fig. 20.11, to mount the rod. The mold partially encloses the forearm and upper hand with a hole for the thumb. It is secured to the arm using a two Velcro straps, one at the wrist and the other close to the elbow. The brace is mounted to the rod with two hose clamps. The client prefers this mounting due to its reliability and effectiveness.

The total cost of the material was $250.00.

BEACH WHEELCHAIR

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INTRODUCTION

Standard wheelchairs have narrow wheels that easily sink in the sand. This does not allow individuals in wheelchairs to access the waterfront and prevents them from enjoying the beach. A client who is active but cannot move her body from the waist down desired to use a custom made beach wheelchair that would allow her to access the waterfront. She cannot enjoy the beach while in her conventional chair.

The frame of the prototype was made of lightweight Polyvinyl Chloride (PVC) pipes to prevent corrosion as shown in Figures 20.12 and 20.13. Wide tires were used to prevent sinking in the sand. The design differs from conventional chairs in that the large wheels are the front wheels. These large wheels were 12 inches wide. Smaller six-inch wide wheels were used as the rear wheels. Having the large wide wheels in the front made pushing the wheelchair in the sand easier. Seat and chest straps were incorporated in the design to ensure safety. Ease of entry was enhanced by not including armrests on the seat, thus enabling the client to be set into the chair from the front or sides, or through use of a transfer board. A folding footrest was also incorporated into the design.

SUMMARY OF IMPACT

In the summer, the client with paraplegia likes to go with her family and friends to the beach. However, her conventional wheelchair does not allow her to access the waterfront because it sinks in the sand when pushed. The beach wheelchair meets her wishes by allowing her to access the waterfront and enjoy the beach. It is portable and equipped with large diameter wide tires, which prevents sinking into the sand, thus granting mobility when pushed. A sticker reading: “DO NOT USE IN WATER” was mounted on the back of the chair to ensure safe

Figure 20.12. The UT Beach Wheelchair.

operation and discourage misuse. The client is pleased with the safety feature of chest straps and a seat belt, preventing her from falling out.

TECHNICAL DESCRIPTION

Safety, portability, and ease of entry were three important design considerations. The final design utilized a combination of large and small diameter, wide tires. The tires selected were specifically designed for beach wheelchairs and beach applications. The large diameter wheels were placed just below the seat. The small diameter tires were located in the rear under the wheelchair handles. The frame of the wheelchair was made of lightweight Polyvinyl Chloride (PVC) pipes. The advantages of PVC are its availability, ease of machining, corrosion resistance, price, and low weight. The disadvantages are size, aesthetic appearance, and difficulty of integrating metal components (i.e. bearings, swivels). Since the material properties of PVC change with exposure to ultra violet rays from the sun, conventional PVC becomes more brittle and prone to fracture over time. To inhibit this deterioration, furniture grade PVC pipes and joints were used. Furniture grade

PVC contains a special UV inhibitor to prevent its deterioration due to from the sun. Steering and maneuverability were two issues that needed to be addressed. Conventional wheelchairs have two small narrow wheels in the front that swivel, thus increasing the ease of turning. Large wide tires require a large radius to swivel and if located in the front, may hinder entering and exiting the chair. Ease of entry was enhanced by not including armrests on the seat. The larger turning radius was not a major concern because the beach wheelchair would primarily be used on the open beach.

The rear swivels for the chair were purchased from Deming Design. The rear castors were press fit into a 90˚ schedule 80 L-shaped joint. These castors can easily be removed to enhance wheelchair portability. An added benefit of this design was the ability to remove the castors and change the bearings should a failure ever occur. A one-inch diameter hollow cylinder with a wall thickness of 0.065 inches and made of 4130 normalized steel was taken as the main axle supporting the two large tires. This axle was attached to the frame with plastic inserts. Custom inserts were designed and turned enabling the main shaft to be supported throughout its entire length. Custom castor inserts were also used to serve as spacers on the rear swiveling castors. These inserts prevented excessive play between the shaft and the castor bracket. The castor inserts also prevented the tire from traveling back and forth on the shaft thus rubbing against the bracket. The bar supporting the rear castors was reinforced to prevent failure. To achieve this, schedule 80 pipe and fittings were used in this location. Running a section of schedule 40 pipe through the piece from elbow to elbow reinforced this rear assembly. Adapters were made to attach the schedule 80 back section to the schedule 40 frame. Press fitting the schedule 40 into the schedule 80 members constructed the members in compression. Gluing and press fitting the schedule 80 into the schedule 40 constructed the section in tension.

Extended handlebars were incorporated into the design to keep the pusher further away from the swivel wheels to prevent possible injury. To support the additional length of the handle, a support piece running from the bottom of to the handle was installed. This feature greatly improved the rigidity of the handle.

A footrest was used to support the entire length of the foot. It folds up to allow greater ease when entering and exiting the beach wheelchair. Straps were installed from the front of the footrest to the base of the chair seat to ensure that the angle of the footrest remained at 90˚ to the chair frame. The front bar of the footrest has an embroidered piece of cloth attached stating that the footrest is not a step. This feature will help encourage proper usage of the beach wheelchair.

The design incorporated several safety features. Individuals with paraplegia often have little control of their upper torsos. Adjustable chest straps and seatbelts were installed to prevent an individual from falling out of the beach wheelchair. Using I-DEAS Master Series™ Software (Integrated Design Engineering Analysis Software), a structural analysis of the proposed beach wheelchair was conducted. The analysis showed that the design was safe.

The total cost of the material was $850.00.

Figure 20.13. Client Response.

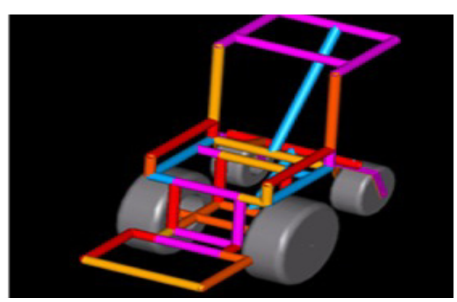

Figure 20.14. Beach Wheelchair Design.

AUTOMATIC WATER HYDRATION SYSTEM FOR MUSHROOM FARMING

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INTRODUCTION

A farmer with a C-4 incomplete tetraplegia grows shitake mushrooms. He has limited mobility and tires quickly. This individual is in need of a new hydration system to assist him in mushroom farming. The procedure for impregnating the mushroom spores includes drilling 5/16 inch diameter holes ¾ inch deep, into a four-foot long by six inch diameter oak log. After the holes are drilled, Shitake mushroom spores are inserted into the holes and the holes are covered with a cheese wax coating. Logs are placed in rows in a 1500 square foot open area to be mist hydrated. Three sprinklers are mounted on steel posts that are manually moved from one location to another to allow for irrigation of the different sections. Also, water is turned on and off manually using shut off valves.

During the irrigation process, this farmer, when moving a post from one location to another, manually removes it six inches from the ground, transports it to a new location, and then inserts it six inches underground. These tasks are physically demanding and require assistance from another individual since the limited mobility of this farmer prevents him from pulling out and digging these posts. This does not allow him to irrigate independently his mushroom farm. The objective of this project was to design, construct and install an automated mist hydration system for this farmer to allow him to irrigate his farm independently.

SUMMARY OF IMPACT

The system that offers adaptability for water supply to all or a group of specified sprinkler heads to cover a specified area with the option for future expansion if desired. It enables a mushroom farmer with a disability to irrigate independently his farm and reduce his fatigue. The new system ensures that the whole mushroom growing area will be hydrated sufficiently, in a timely manner, and according to the farmer's needs. The timer allows the farmer to program it according to the necessity to open and close specified valves to irrigate specific areas for specified times. With the touch of few buttons, the farmer will be able to irrigate his farm without any additional effort.

Figure 20.15. Mushroom Farm with Automatic Water Hydration System

TECHNICAL DESCRIPTION

The main components of the mist hydration system include automatic programmable timer and automatic shut off valves with additional posts, hoses and sprinkler heads. Hosing was run from the main water line to an intermediate valve assembly. From this assembly, hosing was run to six mounted sprinkler head assemblies. Hoses were used instead of PVC pipes since the farmer did not want to dig his farm to install the pipes. The automatic timer was installed in the farmer's barn for easy access. The automatic shut off valves were mounted on the outside of the barn and near the main water valve. Fig. 20.15 shows the mushroom farm with the newly installed automatic water hydration system.

The entire mushroom farm is 1620 square feet of open area that must be mist hydrated. An above ground water system that allows for future expansion was selected. An electronic programmable timer was the main component that needed to be evaluated. A 5006-1 Six Station Independent Program AC Controller from Drips Plumbing and Sprinkler Supplies was selected. This timer was able to open and close specified solenoid valves for specified periods of time. It works by sending an electrical signal to a valve, telling it to open or close. The watering period can range from one minute to twelve hours with an option for four different start times per day. A specified watering program can be cyclical from one day to thirty days. It was found that the timer was constrained to only open two valves at one time. This constraint was easily overcome to complete the project objective by using tee and elbow fixtures so that one valve will control three sprinkler assemblies, as shown in Fig. 20.16. This gave the farmer the ability to hydrate 810 square feet or all 1620 square feet at one time.

Compatible automated valves were used with the timer to control the flow to the sprinkler head assemblies. Five-volt signals from the timer to the lead wires for each valve open and close the valves. The controlled capacity of the automated timer was a total of six automated valves. These six solenoid valves were CP-075 Automatic Sprinkler Valves from Rain Bird. Additionally, these valves were rated for a pressure range from 15 to 150 psi and a flow rate range from 0.2 to 40 gpm, which was sufficient for this system. Currently only two of these valves are used as shown in Fig. 20.16. The other valves will be used to satisfy the client's plan for future expansion. The timer sufficiently works with the six valves and no changes to the timer will need to be made. Sprinkler heads were needed to provide a fine mist, which is required for mushroom farming. A sprinkler head assembly consisted of one ¾ inch male adapter, one ½ inch to ¾ inch reducing female adapter, one ½ inch male base and one Dramm Nifty Nozzle. The sprinkler heads formerly used by the mushroom farmer were chosen; they were rated for 100 psi and 2.2 gpm.

Mounting posts were needed to mount the sprinkler head assemblies at a specified height that allowed for optimum misting radii. The posts chosen were 5/8" cold rolled painted tubing that came in standard lengths of 22 feet. Three posts were cut in half, resulting in six 11 feet posts. One end of each

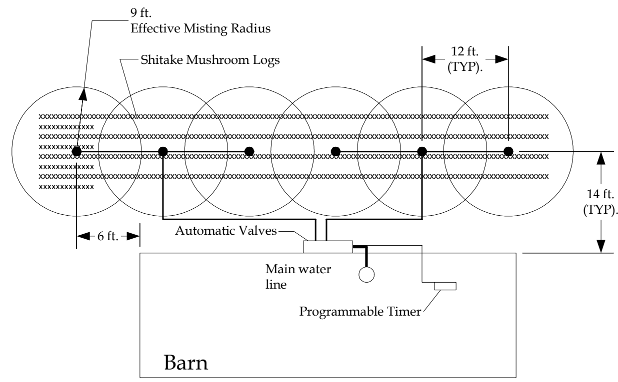

Figure 20.16. Water Hydration System Layout.

post was milled to a V-shape to allow for easy insertion into the ground. In order to design the lay out of the posts, the effective misting radius needed to be determined. A three-foot Plexiglas plate was used for this purpose by placing it near a sprinkler assembly. The transition from a fine mist to water droplets on the plate established the misting radius. It was assumed that all six valves would be open at a given time.

Sprinkler height was adjusted by moving the assemblies up and down the mounting posts. It was found that a misting radius of nine feet was measured for a sprinkler height of nine feet; all posts were thus inserted two feet into the ground. The posts were then inserted according to the specified locations shown in Fig. 20.16, where an overlap in the misting areas was necessary in order to ensure complete coverage of the farming area.

Miscellaneous components such as hosing, installation fixtures, clamps, and quick disconnects were needed to install and tie together the main components of the system. These components simply needed to be compatible and durable for completion of the system. The system was installed at the mushroom farmer's place of residence and found to work properly.

The total cost of the project was about $560.00.

DESIGN AND CONSTRUCTION OF A MANUAL RACING WHEELCHAIR

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INTRODUCTION

The purpose of this project was to design and construct a manual racing wheelchair for a 10-year-old individual with paraplegia who has spinal bifida, a congenital defect in the spinal column, and scoliosis, an abnormal lateral curvature of the spine. The unit that was designed and constructed is shown in Fig. 20.17. The prototype satisfied the design constraints of being lightweight, aerodynamic, stable, durable, comfortable, and ergonomic. Special considerations were given to the steering mechanism and to the seating assembly because of the client's small size and physical limitations in the inability to lean forward.

SUMMARY OF IMPACT

The client is a team member in an athletic organization formed to encourage persons with physical challenges to compete in track and field events. He has paraplegia, scoliosis and spina bifida, which limits his forward leaning motions. He is also very small. He is not able to purchase a manual racing wheelchair because none is commercially available in a size that will accommodate him. During competitions, he uses his own manual wheelchair, which is not practical for racing. The unit that was constructed was tested by the client who found it very efficient. Fig. 20.18 shows the design team and the client as he first tried the unit. The prototype will allow him to compete in future racing events because he found it more efficient for racing purposes than the wheelchair he had been using.

TECHNICAL DESCRIPTION

Three proposed designs were considered to include: modification of an existing Y-type frame, a customized A-type frame, and a customized T-type frame. The customized T-type frame was the method of choice since it was easier to tailor based on the client's dimensions, limitations of movement, and weight. Using AutoCAD, a stick figure diagram was used to estimate the location of the center of mass of each of the client's limbs with respect to the back of the seat of the wheelchair at three common positions: an upright position representing the client resting in the chair, the position at the beginning of the power stroke, and the position at the end of the power stroke. Using these data, the dimensions of

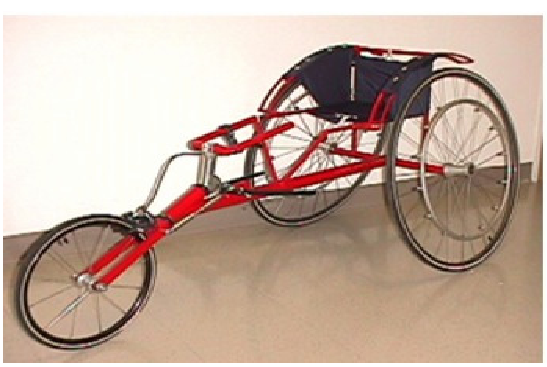

Figure 20.17. Racing Wheelchair.

Figure 20.18. Design Team with Prototype.

the frame were established. Stability of the chair was determined by verifying that the chair would not tip over while the client was using it. The speed at which the client could take a turn of a given radius was also calculated. Using I-DEAS™ software, a structural analysis of the proposed wheelchair was conducted using the finite element method. The frame was made of T6511-6061 aluminum. A factor of safety of 3.4 was estimated.

A 16 inch wheel was used as a front wheel; this was smaller than the typical 20 inch wheel found on most manual racing wheelchairs. A commercially available fork could not be obtained, and a custom-made one was used to fit the 16 inch wheel. The seat design was based on the dimensions of the wheelchair, the limited range of motion of the client, and a preference of the client of not sitting on his legs as many racers do. A seat that places the client in an upright seating position was chosen. The seat wrapped around the horizontal bars of the frame and the two adjacent vertical bars. String was fed through the holes much like shoelaces and was tied to secure the seat to the frame.

Side guards were placed in the open area of the frame between the racer and the wheels to prevent the racer's clothing or hands from getting caught in the spokes of the wheels. Typically these side guards are plastic. However because of the small size of the wheelchair, side guards could not be purchased. Therefore a fabric side guard was designed that would provide protection for both sides of the chair, as well as serve as fenders. The side guard goes underneath the seat, over the fender rails, and attaches to itself by means of button snaps. Fenders cover the wheels to prevent chafing of the racer's arms against the tires and are typically metal. Due to difficulty in having fenders fabricated, two fender rails, covered with the side guards, were used.

The steering system consisted of a stem, handlebars, and a compensator. The handlebars were held in place by the stem. Although the compensator device was not directly connected to the handlebars, it did control the angle at which the handlebars can be turned because both the compensator and the handlebars are connected to the fork. The compensator device allows the racer to take a turn, while not having to steer the wheelchair, so the racer can concentrate on propelling the wheels. It did this by applying a force to the front wheel that

Figure 20.19. Compensator System.

counteracted the wheel's tendency to turn to a straight path. The compensator device was made up of two components, a compensator bar and a compensator cylinder as shown in Fig. 20.19. The compensator bar was located on the top of the main tube to allow the racer to have easy access to it for adjustment while using the wheelchair. The compensator cylinder, which normally attaches to the compensator bar and the handlebars, was attached to the compensator bar and the fork because of complications of attaching it to the handlebars. To attach the compensator cylinder to the fork a threaded stud was welded to the left side of the fork.

To complete the design, it was required to determine whether or not the compensator bar allowed the front wheel to turn sharply enough to allow the racer to take any turn that he may encounter while racing. The effective turning angle for given radii can be calculated; the larger the angle, the smaller the turning radius. Since the compensator bar turned at an angle equal to the effective turning angle, the maximum angle that the compensator bar would turn was then measured as 30°, which corresponded to a turning radius of approximately 6.6 feet. This angle can be adjusted using two setscrews. A padded strap that wrapped around the client's torso was included as a protective restraint. This strap allowed the client to rest while in the racing position, which relieved stress from his back and permitted him to conserve his energy for racing. Also, this restraint reduced the possibility of the client sliding out under heavy breaking, making the wheelchair safer to operate.

The different components were painted and the wheelchair was tested by the client to find if further modifications were needed. It was determined that a foothold, instead of a leg strap, should be used to support the client's lower legs and feet.

The total cost of the material was $650.00.

MOBILE COMPUTER TOWER ELEVATING UNIT

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INTRODUCTION

A man with C6 tetraplegia cannot move his legs, hands, abdomen, or trunk and has only partial use of his upper arms. He owns a desktop computer with a tower. This tower sits on the floor. As this individual is working from his wheelchair, he cannot reach the different disk drives on his computer, and requires assistance in order to insert and eject disks from drives. This individual desires to be able to reach independently all disk drives while working from his wheelchair.

The purpose of this project was to design and construct a unit that will elevate and lower the computer tower to allow this individual to reach all disk drives independently while sitting in his wheelchair. This elevating unit was constructed as a mobile unit with wheels attached to the base to allow access for repairing the computer tower and access underneath and behind it for cleaning purposes. The elevating unit includes a base that supports the computer tower. This base is elevated and lowered using a linear actuator, the motion of which is generated using a motor mounted on a fixed base that is attached to the mobile frame of the unit. Wheel locks allow the mobile frame to remain stationary. Two control buttons are used to lower and raise the moving base.

SUMMARY OF IMPACT

While seated in his wheelchair, the client is now able to reach all drives and bays independently. Easy access was also made possible because the unit is mobile. Using push buttons to control the height of the disk drives allowed the unit to be easily and independently operated by the client

TECHNICAL DESCRIPTION

The client uses a table that serves as a desktop for the monitor of his computer. The computer tower, which was located to the right of the desk, sat on the floor. It was noted that the table supports were near each end of the table, but were not located at the edge of the table. The horizontal distance from the support legs to the edge of the tabletop was approximately a quarter of the overall length of the table. It was thus apparent that building a computer tower-elevating unit that would attach directly to the desk would be difficult. This type of unit would need to be located at the end of the table so that it could elevate to the proper height above the desk surface. However, at such a lengthy distance from any support leg of the desk, it would not be feasible to stabilize the unit. Additionally, the client did not want any attachments to the desk. For these reasons, the two best options to fulfill the client's needs were to build an entirely new desk, which would include the computer elevating mechanism, or to build a separate tower elevating unit that would sit between the current desk and the printer stand located to the right of the table. It would be very costly to design build a new desk. The client indicated that he prefers a mobile elevating unit since he is already satisfied with the current desk. This unit would only be big enough to hold the computer tower. The merits of this idea include; lower cost, increased mobility and access for client, decreased manufacturing time, and greater

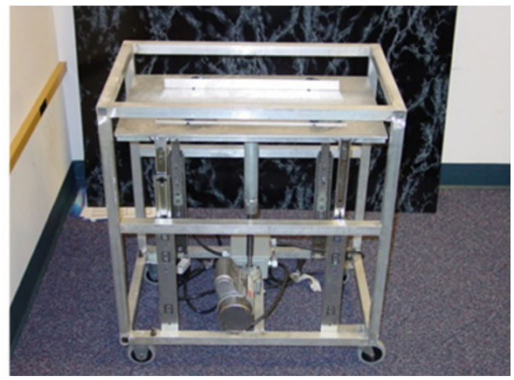

Figure 20.20. Tower assembly.

accessibility for computer tower servicing and repair. One demerit of this idea was that the unit would not be as stable as a single desk unit.

The dimensions of the computer tower were measured as 18 inches high, 7 ¾ inches wide, and 24 inches deep including two inches for connection wires located on the back. The overall dimensions of the elevating unit were specified to be 26 inches high, 16 inches wide, and 26 inches deep to allow for increased stability. The frame of the unit was made of one-inch square, AISI 6063 aluminum tubing.

The computer tower was secured to the moving base using two pieces of angle iron, one on each side of the computer tower. Adjustable cam-style clamps were used to attach the angle irons to the moving base of the elevating unit. An electrically powered linear actuator was used to raise and lower the moving base. The linear actuator moved vertically at a speed of 19.4 inches per minute. The overall travel of the linear actuator was modified to eight inches (from 12 inches) so that the moving base would not be raised more than 36 inches above ground, which will allow the client to access all drives while seated in his wheelchair. Limit switches were used to control the maximum and minimum heights of the moving base, which were established by measuring the distances between the bottom of the computer tower and each disk drive. A 3/8 inch diameter pin, made of mild carbon steel, was used to attach the linear actuator to the platform and to the frame. The frame of the unit also supported a lower fixed base where the motor used to drive the linear actuator was mounted. The moving base rode along vertical rails mounted on the side of the frame of the elevating unit.

Wheels were attached to the bottom of the unit to allow mobility. Wheel locks were used to allow the mobile frame to remain stationary when needed. Finally, two control buttons were used to lower and raise the moving base. The control buttons were connected to a six-foot flexible wire so the client could place the controls in an accessible location. A removable wood casing was constructed with a walnut colored veneer finish to match the client's desk.

Using I-DEAS™ software, a structural analysis of the proposed elevating unit was conducted using the finite element method. The frame was found to be safe. An analysis was also performed on the pins that attach the linear actuator to the frame and to the platform. The unit was tested and evaluated by the client. He found that the casing around each button represented a problem as they interfered with operation. This issue could be resolved by purchasing a different style of button. During testing, it was also found that the moving base appears to wobble slightly from side to side as it raised and lowered. This appeared to be due to a slight bend in the linear actuator shaft. This problem could be resolved by replacing the current rails with slotted rails. The moving plate would then have to be attached to these slotted rails by means of shoulder bolts and vinyl washers. However, even with the current wobble, there is no concern for safety. The clamps on the moving base will hold the computer tower securely so it will not fall off.

The total cost for all individual parts of the unit was $550.

WHEELCHAIR GARAGE ACCESS SYSTEM

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INTRODUCTION

The purpose of this project was to modify the entryway to the first floor from the garage of an individual's house and to design and construct a lift system that would safely lower this person twenty-three inches from the garage floor to the first floor level. This individual has paraplegia with full use of his arms. The house is a tri-level where the main door opens to the second floor, and the garage door opens to the first floor, which is below ground by approximately two feet as shown in Fig. 20.21. This person currently enters and exits the home from the main door using the long ramp in the front of the house. This is highly inconvenient for him and his family since he must enter the house from the second floor, which consists of only a living room, dining room and kitchen. No bathrooms are available on the second floor. Because of this, his family would like to move him to the first floor where he can have his living room and bathroom contained in one area. The only way the client can access the first floor independently is through the relatively elevated garage. In order to accomplish this goal, the entryway to the first floor from the garage needed to be modified. The first floor was accessible from the garage via two steps as shown in Fig. 20.21. Modification of the entryway required removal of these steps and additional concrete from the garage floor in order to enlarge the first floor stairwell area. A lift system was then designed, constructed and installed in the newly enlarged pit (it is called a pit since the two steps will no longer exist). The lift resembles a "forklift" design that consists of a steel platform powered by a single linear actuator, mounted on one side of the platform as shown in Fig. 20.22.

SUMMARY OF IMPACT

The client found the prototype to be convenient for his everyday use. This project allowed the client to live more independently and enter and exit the house through the use of a lift. This was not only important to improve the client's independence, but also a safety factor in case of emergency. The system efficiently raises and lowers the client to and from his garage to the first floor of his house.

Figure 20.21. Entryway to the First Floor from the Garage Before Modification.

TECHNICAL DESCRIPTION

Many factors and limitations had to be fully understood in order to identify the most appropriate lift system. The number one concern was the safety of the client, so all possible safety issues needed to be addressed when considering solutions. In addition, it was required that the lift system be easily used by the client and accommodate his needs as well as those of his family. A "forklift" design was adopted. Such a system uses very little material, is compact, allowing space saving, and would be very efficient in operation. A linear actuator was mounted on the side of the lift next to the wall of the garage. The actuator that was used is self-contained, where the oil reservoir, motor, microprocessor, bore, and stroke are all contained within the same unit. The actuator was powered by a twelve-volt car battery, which was housed away from the unit. The battery was to be connected to an automatic battery charger at all times, providing continuous power to the actuator. The battery will supply power to the lift in the case of a power outage. An automatic locking mechanism was contained within the actuator. When the lift stops, a series of check valves automatically close it to stop fluid flow. This kept the actuator locked in its current position and also allowed it to act as an emergency stop. As an added safety feature, two limit switches, placed at the top and bottom of the stroke of the lift, were added in order to ensure that the lift stopped at the correct location in the up and down positions. This ensured that the client would not stop the lift too high or low from the desired location, which would give him easy access on and off the lift.

This design also required some home modifications. The first floor was accessible from the garage via two steps. Modification of the entryway required removal of these steps. In addition, the final layout of the modified entryway must allow this individual to access the platform using a forward motion from either the garage level or the first floor level. Additional concrete from the garage floor was thus removed to enlarge the first floor stairwell area. Also, to allow access for his family, more concrete was removed to construct two steps to the side of the entry door as shown in Fig. 20.22.

The wheelchair lift system included a mast that acted as a support and was made up of two, one-inch diameter, six-foot long, 1060 hot rolled steel rods that were attached to a base plate. The linear actuator was located midway between these two steel rods and was also mounted to the base plate-the only portion of the lift in contact with the ground. The moving part, namely the platform, was powered by the linear actuator. The platform was made of 1.5 inch x 1.5 inch x 0.1875 inch 1020 steel tubing welded together to resist deflection as shown in Fig. 20.23. Aluminum diamond plating was attached to the frame of the platform to allow the client a non-slip surface in which to position himself for safe operation of the lift. The platform was welded to two vertical pieces of 2 inch x 2 inch x 0.1875 inch square tubing. Two oil-impregnated bronze flange sleeve bearings were mounted inside these vertical pieces using custom designed adapters. The bearings allowed the platform to move smoothly and quietly while guided by the vertical steel rods and also maintained a very low coefficient of friction. SolidWorks® software used

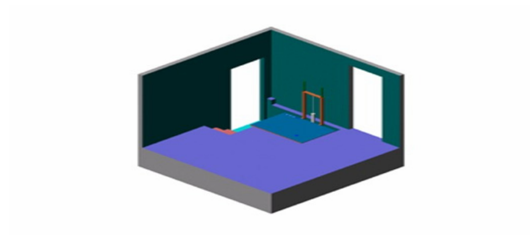

Figure 20.22. Modified Entryway Showing the Lift Raised to the Garage Level.

in the design process for visualization purposes as shown in Fig. 20.22.

The lift was designed to withstand at least 400 lb. Using the I-DEAS Master Series™ Software (Integrated Design Engineering Analysis Software), finite element analysis (FEA) was performed to determine the deflection of the platform and the stresses at critical welding points. The 400 pound load was placed on one corner of the platform to simulate a worst-case scenario. Joint stresses for this situation were found almost equal to the yield strength of the material, which corresponded to a factor of safety of two since the weight of the client was 160 pounds. Angle brackets were added to these joints for additional reinforcement. To simulate the most common scenario, two 200 pound loads were distributed over the two middle beams of the platform. Very small stresses were obtained at the joints in this situation; the corresponding maximum displacement of the platform was calculated as 2.13 millimeters.

The total cost of the project was about $3,200.00. The cost for concrete removal and work was $2,000; this was covered through donations secured from the local community.

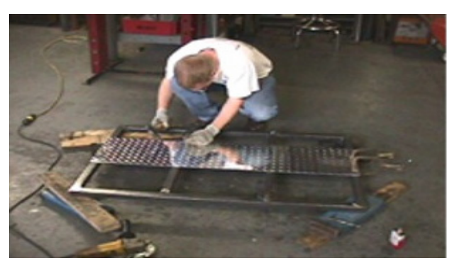

Figure 20.23. Assembling the Platform.

WHEELCHAIR WHEEL WASH SYSTEM

Designers: Jared Bright, Jay Lake, Jeff Raymond, Gregory Seth Turner,
Mechanical Engineering Students
Client Coordinator: Dr. Gregory Nemunaitis
Rehabilitative Medicine, Medical College of Ohio and St. Vincent Mercy Medical Center
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INTRODUCTION

An individual with T-3 paraplegia uses a wheelchair. He has good use of his upper body, but cannot move his lower extremities. He is active and seeks a high level of independence. As he moves in and out of his house, his floor gets dirty. This is because dirt such as sand and mud stick to the treads of the rear and large wheels of his wheelchair. This presents an additional burden to his family since they have to clean the carpets and the floor of the house each time he goes in and out from his yard.

The purpose of this project is to design and construct a manually activated wheelchair wheel wash system that allows this individual to clean the wheels of his wheelchair before going into his house. The system includes a fixed horizontal platform with a center-raised section as shown in Fig. 20.24. This construct allows each rear wheel of the wheelchair to back and roll into individually. Once a wheel is confined to the platform, it sits on two rollers and backs against a third one as shown in Fig. 20.25. This third roller acts as a stop to limit the backward motion of the wheel. Brushes are installed on the raised section of the platform. As the user manually rotates the wheel confined in the platform, the brushes will scrub the dirt and sand off the wheel. A garden hose water supply line and a water valve are attached to the platform. As the brushes scrub the dirt, water is sprayed down onto them, cleaning the wheel and brushes. To get out of the platform, the front roller is allowed to rotate only in one direction, namely a direction that allows the wheel to move backward. As the client is ready to move away from the platform, he pushes the wheel of his wheelchair forward causing the front roller to lock in place and his wheelchair to climb the front roller.

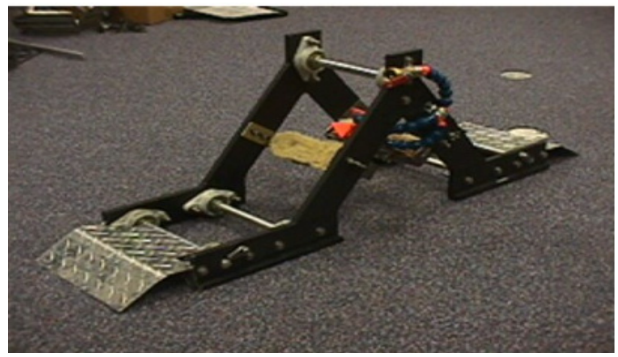


Figure 20.24. Wheelchair Wheel Wash Prototype.

SUMMARY OF IMPACT

Many individuals using wheelchairs use rags to wipe the wheels off before entering their houses so that the floors do not become dirty. This technique is inefficient because the users are unable to remove all of the debris. The unit that was designed and constructed allows an individual with paraplegia to clean the rear wheels of his wheelchair with little effort. The unit is compact in size, and when rigidly attached to the home entrance ramp, it is narrow enough to allow for a wide passing area by the wheelchair when the unit is not needed. The unit is also portable, which allows for seasonal use. No similar products are available in the market. The successful completion of this project allows for an increased level of independence and self-reliance for the client.

TECHNICAL DESCRIPTION

The main design consideration was that the unit had to be mounted on a flat surface. It also had to be narrow enough so that when it was not being used it would not intrude in either the walkway of non-users, or the path of a wheelchair. The other parameters considered were that the system had to be lightweight, corrosive resistant, used predominately during the warm seasons, low cost, easy to use, and low maintenance.

The unit consists of a frame with a raised center section. Fig. 20.24 shows a picture of this frame. Only one rear wheel of a wheelchair is cleaned at a time by rolling backwards into the unit as shown in Fig. 20.25. Once a wheel is confined to the unit, it sits on two rollers and backs against a third as shown in Figures 20.24 and 20.25. The third roller acts as a stop to limit the backward motion of the wheel. Two stationary brushes are installed, one on each side of the raised section, as well as a garden hose water supply line and a water valve. Before the system is used, the water supply may be turned on by a manual shutoff valve that is located on the frame. If the shutoff valve is put in the open position water flows through two adjustable hoses that spray water on the brushes. As the wheel rotates against the brush, dirt is scrubbed off the wheel and flushed away by the running water.

The rollers are made of 6061-T6 aluminum and are ¾ inch in diameter. This diameter is small enough so that the wheelchair would not be unstable while the rollers support the wheel. Once in the unit, the wheelchair wheel is elevated only 1-5/16 inch off the ground. The 6061-T6 aluminum is lightweight and offers good corrosion resistance. Rollers design was performed based on two loading conditions simulating the two most critical situations. The first situation is that the client will enter the unit directly in the center of the roller, creating maximum bending stress, which was calculated to be 5,690 psi. The second situation is where the client enters the unit with his rear wheel as close as possible to the bearing housing. This results in the maximum shear force, which was found to be 96.5 pounds.

The frame is also made of 6061-T6 aluminum due to its resistance to corrosion and its low density. Each side of the frame consists of five pieces, each three inches wide and ½ inch thick, that are welded together using double vee pass butt weld. In order to extend the life and intervals of maintenance of the wash system, the design utilizes two-bolt composite flange bearings developed for the food service industry. These sealed bearings are stainless steel, surrounded by a composite body. They are rated at a static radial load of 1,470 pounds, which is well above the maximum load of 96.5 pounds that the bearing was found to sustain. No dynamic loading was considered due to the slow speed at which the roller will be rotating.

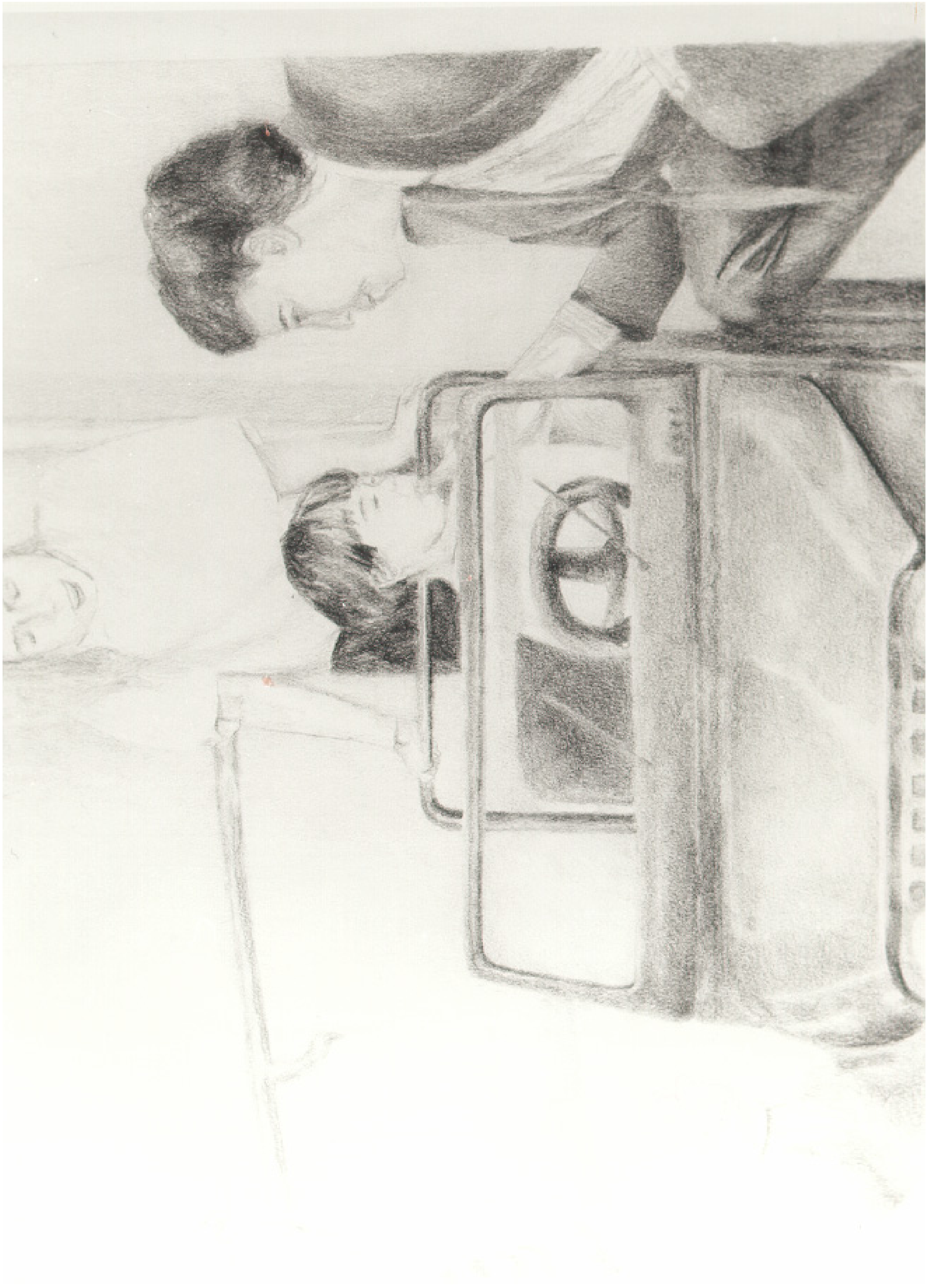
Figure 20.25. Unit in Use.

To get out of the unit, the front roller is allowed to rotate in only one direction, namely the direction that allows the wheel to move backward.

As the user is ready to move away from the unit, he will push the wheel of his wheelchair forward causing the front roller to lock in place and the wheelchair wheel to climb over the front roller and onto a diamond plate access ramp. This ramp is attached to the frame at 30 degrees with the floor, allowing a smooth entry and exit to and from the unit.

The unit was tested and appears to function appropriately. The system of rollers allows the rear wheel of a wheelchair to be pushed against the brushes and to rotate only in one direction – backwards as it is cleaned. Cleaning dirt from the rear wheel is accomplished by a combination of water being sprayed onto the brushes and the rear wheel being rotated. As a user exits the unit, the roller locking mechanism effectively locks the front roller, allowing the rear wheel to rotate forward. The unit access ramp is effective in allowing easy entry and exit to and from the wheel wash unit.

The total cost of the parts was about $800. This could be drastically reduced in mass production. The unit includes 10 bearings, each costing about $50.00. If this product is commercialized, the costs of the bearings will be drastically reduced, reducing the total costs to manufacture the unit.



CHAPTER 21
WRIGHT STATE UNIVERSITY

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MULTISENSORY ENVIRONMENT

Designers: Prachi Asher, Brandy Hill and Beth Wirick
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INTRODUCTION

The goal was to create a portable multisensory environment for students with severe disabilities. Schools use multisensory environments (MSE) to establish and improve perceptual and cognitive skills that students with various disabilities often have difficulty developing. Because of their disabilities, these children may not respond to traditional treatment and educational methods. This behavior may be partially due to a sensory imbalance. This MSE is designed to improve sensory imbalance. It is an interactive tool for both therapeutic and leisure activities. The children are sensitive to their surroundings and any changes to it. MSEs offer controlled experiences.

This MSE has one button that controls the stimulation whereas in a MSE room, all devices are controlled separately. The MSE allows choice, independence and the teaching of specific skills, and the same sensory experience as a multisensory room.

SUMMARY OF IMPACT

The MSE met the basic specifications of the client. The auditory and visual senses are stimulated through the use of lights, sounds, and actions generated from twelve different devices. The student uses a single push button to control these various generic devices. The teacher or therapist has several options to control how the MSE will function. The teacher first selects how the student buttons will function: hit and hold or timed. Other options include a selection of three scenes and the option of removing a device from the environment. Users found the environment absorbing and fun to use.

TECHNICAL DESCRIPTION

The approach to the solution was to use a tri-fold science fair board design with dimensions that fit a standard table. The tri-fold surrounds the student to give the effect of an environment. The casing of the MSE is made of plywood mounting panels and backboards. The frame is made of pine. Each panel is 2.5 feet high and three inches thick. The two side panels are two feet wide while the center panel is 2.5 feet wide.

Figure 21.1. User Interacting with the Multisensory Environment.

Figure 21.2. User Interacting with the Multisensory Environment.

There are a total of twelve devices included in the MSE. The first panel (purple) consists of an Ultra Violet Light, Beaded curtain, Bubble column, and a series of Christmas lights. The center panel (blue) consists of Christmas lights, a tap light, a mini fan, a fiber-optic spray, and a lightening storm. The last panel (green) consists of a bubble column, Christmas lights, and rope lights. All of the devices operate on 12 V AC/DC or less. Two of the devices have mirrors mounted behind them to give the illusion of depth to the device. Most of the small devices are mounted on a ¼ inch thick panel of wood that is permanently fixed within the casing.

All of the button functions are set and controlled by the teacher. The internal circuitry for the teacher options is read and executed by the microprocessor. The student-controlled button is plugged into the project box, which contains the main circuit, located behind the MSE. These switches control each device, one at a time, when pressed. The circuitry for the MSE is fitted into two project boxes that are externally connected to the backboard of the center panel. There are two devices that use motors: the fan and the beaded curtain. These motors are small three-volt project motors that can be purchased at any hobby shop

The MSE operates using a microprocessor and various analog and digital circuitry. The MSE is powered by 120 VAC that is readily available. The main portion of the circuitry utilizes logic gates, monostable mulitvibrators, and a flip-flop to transmit signals from the teacher options to the six input pins (P0-P5) of the microprocessor. Approximately thirty different integrated circuit chips (ICs) are used, half of which are complementary metal oxide semiconductor field-effect transistors (CMOS). The remaining ICs are transistor-transistor logic (TTL) components. The chips were placed onto sockets and wire wrapped together on a standard project board. An effort was made to minimize the power dissipation and thereby minimize the operating temperatures. Since the operating conditions do not require many rapid switches from one logic state to the other, CMOS components are preferred.

Ten pins of the microprocessor are designated as the output pins. Four go to the light portion of the devices and six go to the sound chip. There are a total of twelve light devices but only four output

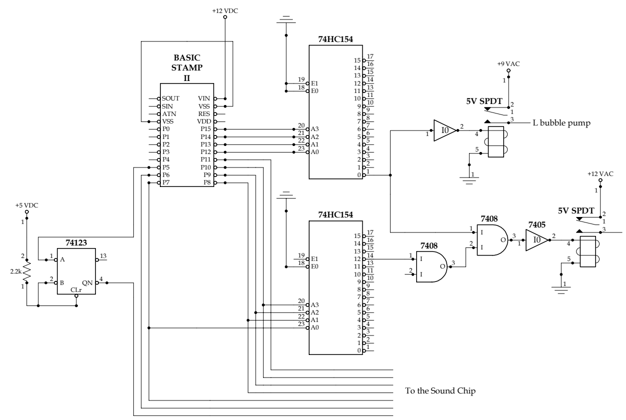

Figure 21.3. Output Electrical Circuit.

pins. To remedy this problem, a four to sixteen decoder was used. A decoder uses a four-bit binary input and gives sixteen different outputs. Each device is connected to one output of the decoder. Following the decoder, a buffer was used to get a clean five-volt output and also increases the current. Following the buffer, a relay was used to connect the device. A relay is an electromechanical switch that uses a small voltage, which in this case is five volts, and is capable of switching to high voltages. This is necessary because some of the devices use voltages greater than five volts to operate.

The wiring of the devices are shielded by ¼ of an inch thick piece of wood, approximately the same height and width of a panel, that screws into the back of each panel thus making it hard for children to access. Also, this design allows the owner to be able to replace damaged parts (i.e. bulbs or motors) for some of the devices. All the external wires have been encased in plastic tubing so that they are not pulled or snagged.

The total cost of parts and labor was $1000.

MOVABLE VIBRATING CHAIR

Designers: Jacob Abraham, Teena Manimalethu and David Walker
Client Coordinator: Marlys Loyer, United Rehabilitation Services, Dayton, OH
Supervising Professor: Dr. Chandler Phillips
Biomedical, Industrial and Human Factors Engineering Department
Wright State University
Dayton, OH 45435-0001

INTRODUCTION

The movable vibrating chair is a system that provides multiple sources of stimulation to individuals with various mental and physical disabilities. This chair is designed to enhance the reactions of clients for different motions and sensory perceptions. Most of the patients at the facility have cerebral palsy (CP), but there are also individuals who have had head trauma or strokes as well. This system aids in the rehabilitation process of the patients. The multiple modes of stimulation include vibrational, vestibular, and auditory stimulation.

The vibrational stimulation involves a change in the patient's daily routine and even a change in blood circulation. Some of the clients are extremely uncomfortable at changing positions. This is known as gravitational insecurity. The vestibular mode of stimulation (a tilting mechanism) allows the clients to become accustomed to changes in positions. The auditory stimulation feature helps in keeping the clients calm while experiencing the vibrational and vestibular stimuli.

SUMMARY OF IMPACT

The system provides vestibular, vibrational, and auditory stimulation. Upon delivery to the client coordinator, two clients were able to test the product. The therapist was able to use every feature in the chair and both therapist and client reactions were positive.

TECHNICAL DESCRIPTION

The chair used for the base design is a minivan captain's chair. This chair features two arm rests, firm cushioning, a standard reclining feature, a chair mounted seat belt, a detachable headrest, and a pocket located in the back. It has a steel framework that provides a reliable and sturdy base. Most of the components and structures on the chair are detachable which allowed for easy alterations. Since the chair is manufactured by the automotive industry, data were obtained and analyzed for forces on the chair, center of gravity and moments of inertia to aid in the design process. The chair is reupholstered with vinyl upholstery for ease of cleaning and protection of internal components. Footrests from a wheelchair are attached for the comfort and convenience of the user.

Figure 21.4. Movable Vibrating Chair.

Vibrational stimulation is achieved with an existing product. It is a chair pad with various motors that produce different vibration intensities at different speeds. The chair pad has 10 motors, various intensities, various speeds, and can be controlled by using a handheld control panel attached to the pad.

Vestibular stimulation is achieved with a three-level tilt table attached to the base of the frame of the chair. This system is comprised of three independent four-sided steel frames. Each frame is 20 inches on each side and is made of angle iron. This gives a good strength to weight ratio and lends itself to easy construction.

There are walls along each frame, which are connected by axels of 3/8-inch diameter. The bottom frame is static while the middle frame tilts side-to-side, and the top frame tilts forward and backward. Actuators from a power-seat cause the tilting action. The actuators consist of a 1.5 Amp DC motor turning a cable, which runs a worm gear that drives a screw. The pivot point is 10 inches away from our actuator. Through trigonometry, it is known that a 1.76-inch displacement will create a 10-degree tilt. The actuator provides two-inch displacement in each direction; this is more than adequate for the required ten degrees of tilt.

To control this tilting motion, control of the direction of rotation of the motor is required. This is accomplished by controlling the polarity with a double-pole double-throw switch. A 12-Volt battery powers the twin 1.5 Amp motors. The charge on the energy cell is maintained by an automatic charger, which charges at 1.5 Amps. If the tilt system is run continuously for one third of the day, it can charge for the remaining two thirds of the day. This will allow it to be fully charged at the beginning of each day.

Figure 21.5. Three-level Tilt Table.

An auditory stimulation system is implemented by mounting a CD player and computer speakers onto the chair. The CD player is shock resistant and waterproof, making it rugged enough to withstand the abuse it may take in the rehabilitation center. The speakers are mounted near the headrest, so they will not interfere with patient transfer. This is a cost effective solution that allows the client to choose from a wide selection of music and sounds.

The total cost of parts and labor was $1250.

COIN RECOGNIZER

Designers: Matthew Beach, Brian Kandell and Matthew Roberts
Client Coordinator: Ms. Marcia Thomas, Green County Educational Services (Xenia, OH)
Supervising Professors: Dr. Blair Rowley
Biomedical, Industrial and Human Factors Engineering Department
Wright State University
Dayton, OH 45435-0001

INTRODUCTION

The Coin Recognizer was designed to teach users how to associate coins with their corresponding monetary value. With many of the interactive children's toys on the market involving money, the user does not handle real money and instead touches buttons that look like coins. It may not be easy to associate a button with a real coin. Another problem is that some children know the value of the coin they have, but they don't know how many it takes to arrive at a specific total. The solution was to make a device that identifies a real coin that is put through a slot (similar to a pop machine), and then audibly returns the coin's name and value along with a total of the value of all the coins entered up to that point.

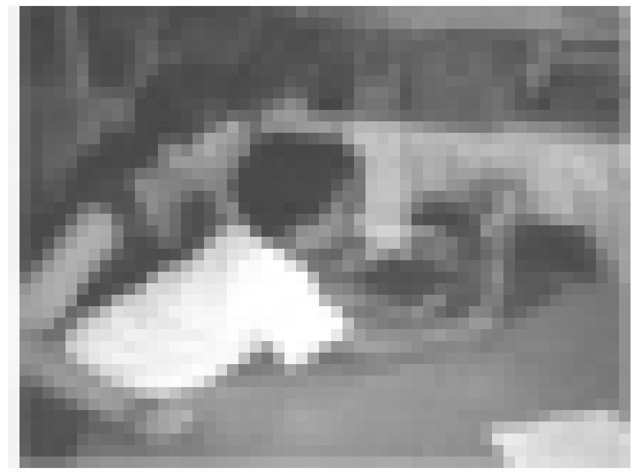

Figure 21.6. Coin Recognizer.

SUMMARY OF IMPACT

A device was produced that allows the user to input a coin and recognize the monetary value of the coin in two distinct ways. The user is able to see the value of the coin on a digital display. The design allows for multiple coins to be accumulated and the total amount of money to be displayed simultaneously with the previous single coin value. The user is also notified audibly of the value of the coin. The product includes a voice chip that tells the user the value of the current coin inserted and the total value of all coins inserted. This design feature, coupled with the digital display, will be able to assist a vast number of users with either visual or auditory impairment.

All design requirements were achieved in the final product. All desired goals except that of battery power were also achieved. Feedback obtained upon final delivery of the product to the client indicated that the children find the device simple and motivating to use.

TECHNICAL DESCRIPTION

The final product used a coin sorter for a base unit that sorted coins by their respective diameters. Optical sensors were used to detect coins as they were inserted into the unit. The advantages of the sensors were that they did not miss any coins and did not have a "bouncing" problem associating with mechanical switches. Fig. 21.6 shows a circuit diagram of the infrared LED and phototransistor matched pair that was used for coin detection. The beam intensity of the sensors was proportional to the inverse square of the beam length. The resting voltage was proportional to the inverse of intensity. Therefore, the voltage was proportional to the distance squared. This information was used to determine the required voltage to operate the sensor accurately at the specified distance.

The BASIC Stamp II microprocessor was selected as a microcontroller because of its ease of programming and its ability to meet all of the computational and control requirements. The BASIC Stamp II interfaced with all of the components of the system (i.e. LCD and voice module) and its cost was also minimal (donated).

After much evaluation of different LCD displays that work with the BASIC Stamp II it was decided that the 120x32 graphic LCD was the best choice for the project. The most influential factor for this decision was that the children have limited reading ability and any display must be as easy to read as possible. The graphic LCD provided for smooth fonts with two different sizes (large or small). The graphic LCD also provided the option of displaying bitmap graphics. A use for this feature could be the display of a graphic representative of the coin entered or removed. Although this LCD was the most expensive, its unique and impressive features offset the high cost.

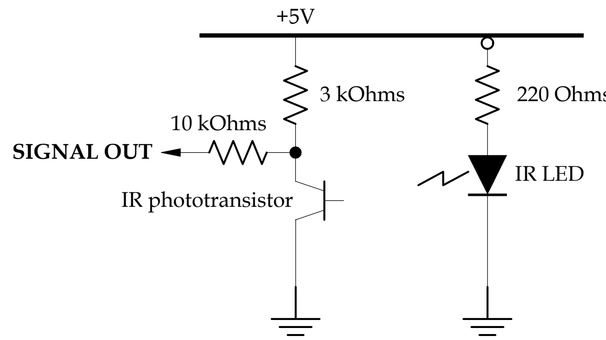

Figure 21.7. Circuit Diagram of Infrared LED and Phototransistor.

Audio feedback to the user was achieved with a Quadravox QV306m4-P preprogrammed playback module, a Board of Education (from the makers of the BASIC Stamp II), an inverter, and 22-gauge wire. The Quadravox module was selected because it comes preprogrammed with 240 commonly used words and phrases (i.e. numbers, math, money etc.) with excellent speech quality. It also has a variable volume option that was useful for the client coordinator when the device was used in a classroom setting.

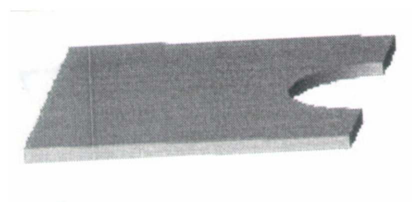

Figure 21.8. Coin Subtraction Plate.

The device also allows for subtraction of coins from the final total. This is achieved by mechanical removal of the coins from the tubes where the sorted coins are placed. The user presses a button that causes a plate to push a coin from the tube.

The plate has a round notch with the same diameter as the specific coins in the tube. When a coin has been removed by pressing the button, the microprocessor calculates the new total and informs the user visually and audibly.

The total cost of parts and labor was $675.

VOICE ACTIVATED VOICE REPEATING TELEPHONE SYSTEM

Designers: Richard McKinley and Jenna Warman
Client Coordinator: Ms. Elaine Fouts, Gorman Elementary School (Dayton, OH)
Supervising Professor: Dr. Chandler Phillips
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Wright State University
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INTRODUCTION

The project has been designed for pr-school children in the age range of three to five years with cognitive and developmental delays. Children with these disabilities often play in parallel mode rather than an interactive mode. This means that they play with similar toys in analogous ways, but they do not directly interact. These children often have problems with verbalization, pronunciation, phone etiquette, and communication with others. A voice activated voice repeating telephone was designed in an attempt to address these problems.

The voice activated voice repeating telephone system consists of three phones. One phone automatically records the child's voice until he or she stops talking. Once talking is terminated, the system automatically plays back the message. The repeating telephone gives feedback to the children and encourages communication and vocalization. The other two phones provide a direct communication link between two different children. Essentially, they operate as an open phone line between two individual phones. The telephone system allows children to communicate in an indirect route, which alleviates much of the apprehension associated with direct communication. The response characteristic promotes the pattern of talk-listen and reinforces correct pronunciation and grammar.

SUMMARY OF IMPACT

The design of the voice activated voice repeating telephone system satisfies a majority of the required and desired specifications detailed by the client. The mechanical design of the stand allows it to be easily folded and transported. The ergonomic design permits two subjects simultaneously to sit or stand on the same side of the stand. The product can be easily cleaned and is water resistant with the exception of the handset. It is expected that the children will benefit from its use in that they will increase vocalization and socialization skills.

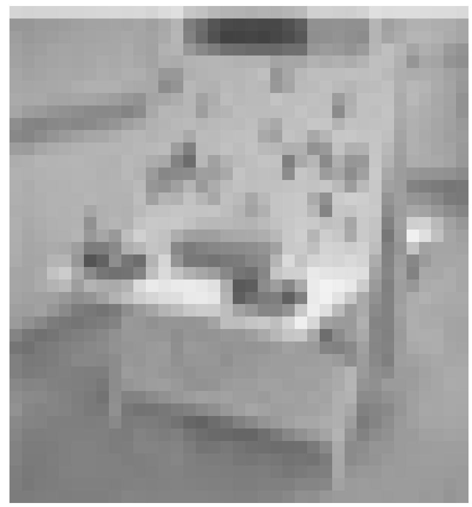

Figure 21.9. Voice Activated Voice Repeating Telephone System.

TECHNICAL DESCRIPTION

In order to meet the specifications given by the client, it was decided to use three separate subsystems; a single person set-up, a two person direct talk set-up, and a structure to house the phones and circuitry. The first subsystem is a voice activated, voice repeating telephone that automatically records and plays back the subject's voice. This single person set-up utilizes one toy phone so that there is no direct interaction with another person. A voice-activated switch (VOX) from Ramsey Electronics and a record/playback chip from Radio Shack were selected to complete this objective. When the subject talks into the microphone in the handset, the VOX enables the chip and begins recording a message up to 20 seconds in length. After the child stops talking for two seconds, or when the end-of-memory is reached, playback is initiated. The child then hears the recorded message through the speaker in the handset. The chip cannot record a new message while a previous message is being played back to teach the talk-listen pattern of communication. The speaker and the microphone wires travel through tubing from the handset to the phone. These wires then continue to the record/playback circuitry. Due to the size of the overall circuit, it was placed in a foam-insulated chassis box. This subsystem makes the children more comfortable with their own voices and provides feedback to teach proper phone etiquette and increase vocalization.

The second subsystem consists of two toy phones that work together to provide direct open line communication between two subjects. This is accomplished through the use of hands-free two-way communication walkie-talkie circuitry. This circuitry is transferred from the walkie-talkies to a set of toy phones. The same power supply from the single person set-up is used to power this configuration. A voltage divider provides the three volts required for operation. Tubing that connects the handset and phone base insulates the wiring for the speaker and microphone. The system provides endless open communication. The two phones are placed on opposite sides of the stand. The two-person set-up allows subject-to-subject interaction, but prevents face-to-face confrontation.

The final subsystem is the stand that houses the toy phones and the voice record/playback circuitry. Due to the client specification of easy mobility and storage, it was decided to construct an assembly similar to a folding easel. The folding easel design has a triangular frame that can be collapsed using a hinge. The construction of this structure consists of white painted wood and ¼ inch plastic PVC board. Handles were placed on both ends of the frame so the stand can be lifted and carried. In addition, an eyehook latch is attached on both ends to secure the frame in the closed position during relocation and storage. The phones are mounted on a horizontal platform that is supported by a stainless steel hinged diagonal beam. The single person set-up circuitry is placed in a chassis box mounted in the middle of one of the horizontal platforms. For added visual stimulation, scenes are painted with acrylic paint on both sides of the stand.

The total cost of purchased parts and labor was $775.

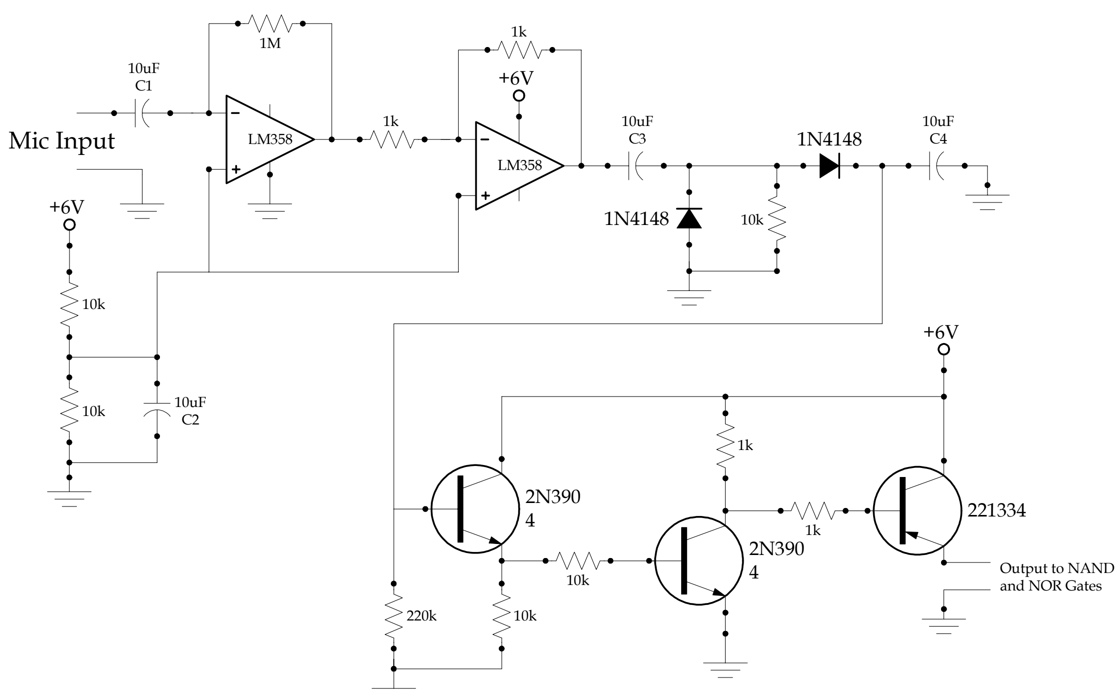

Figure 21.10: VOX Circuit Schematic.

TRANSDUCER FOR MEASURING NORMAL AND SHEAR STRESS

Designers: Adam Fournier and Andrew Lewis
Client Coordinator: Ms Alena Hagendorn, Ohio Transportation Research Center (East Liberty, OH)
Supervising Professors: Dr. Ping He and Dr. David Reynolds
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INTRODUCTION

This project involved designing a device that measures both the normal and shear forces exerted on a sensor via the capacitive method. The capacitive method involves the relationship connecting the change in capacitance between two plates to an applied shear and/or normal force on those plates. As the space and area of overlap between the plates change, so does the value of the capacitance measured. No such model existed that could measure contact normal and shear forces between two surfaces.

The specifications of the design are modeled from the existing capacitance method that measures force in the normal axis. Since the design had to have the ability to measure force in three dimensions, five capacitors were used. One capacitor measures normal forces while the other four peripheral capacitors measure shear forces. The capacitors on opposite sides of the main capacitor are wired together such that the direction of force application can be seen by the change in phase of the voltage output. The circuit balances and remains balanced until a shear force is applied. Once the forces are removed, the original capacitance is achieved by way of springs placed at opposing corners of the floating top plate that re-center the device after forces are withdrawn.

SUMMARY OF IMPACT

The designed product met all of the requirements. Some areas for further expansion and improvement include further centering the device such that the output is initially a flat baseline, placing known loads on the device and measuring the magnitude of output signal produced, and finally a the micro-machining of the design into a much smaller model. Possible implementations exist in prosthetics design relating forces between the soft tissue of an amputated limb's skin and contact surface of the socket, bed sore applications, robotics and other commercial applications.

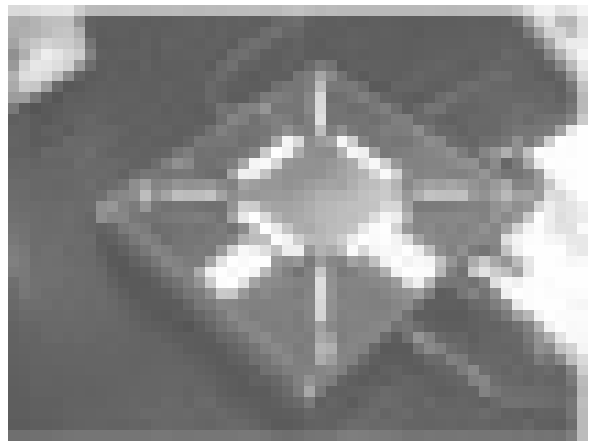

Figure 21.11. Transducer for Measuring Normal and Sheer Stress.

TECHNICAL DESCRIPTION

The final product has the implementation of a five-capacitor system. The capacitor transducer system is primarily made of plastic and a copper alloy. The transducer system is mounted atop a product box that holds the circuitry and the plugs for all the necessary connections. The central capacitor measures applied forces normal to the top plate while four peripheral capacitors measure the applied shear forces. The two-peripheral capacitors opposite each other are coupled together and wired in to the following circuit, shown in Fig. 21.11. In this way, the changes in the output voltage would be measured in three groups. First, the voltage between the top plate and the central base plate and then two output voltage pairs between opposing peripheral capacitors and the top plate. To make sure measurable signals were obtained the voltage signals were amplified by a series of instrumental amplifiers.

The size of the capacitor transducer was determined by scaling up Ko's idea (US patent # 5,528,452) by a scale of 100. This gave the dimensions and range of capacitance for our design. Ko's capacitive pressure sensor operated at 5.5 *p*F. The desired 5.5 *p*F required that the base electrode and the top electrode be separated by four mm (three mm of air and one mm of dielectric). To achieve 5.5 *p*F the side capacitors needed an overlap of 7.5mm with the top electrode along with a separation of one mm. A series of springs was used to resolve the issues of re-balancing the system after the forces are removed. The idea for using springs came from the patent of Xu et al. (US patent #6,341,532), which used "zig-zag" springs to keep the top capacitor electrode balanced and centered. To reduce friction between moving surfaces four pieces of Teflon were cut and placed over the peripheral capacitors. Teflon was chosen not only because of its low coefficients for static and kinetic friction, both 0.04, but also because it was inexpensive, malleable, and readily available.

To prevent the various components of the design from coming into contact with each other and causing a short, a series of buffers and spacers were used. A thin plastic sheet was placed on the central base capacitor to prevent a short between the top plate and the lower base plate when a sufficient normal force is applied. The Teflon covers on each of the peripheral capacitors prevented the top plate from causing a short, and the Plexiglas spacers prevented the base plate from causing a short with the peripheral capacitors as well. During construction the peripheral plates were carefully placed such that there was no contact between them, thus ensuring there were no shorts in the circuitry at any time.

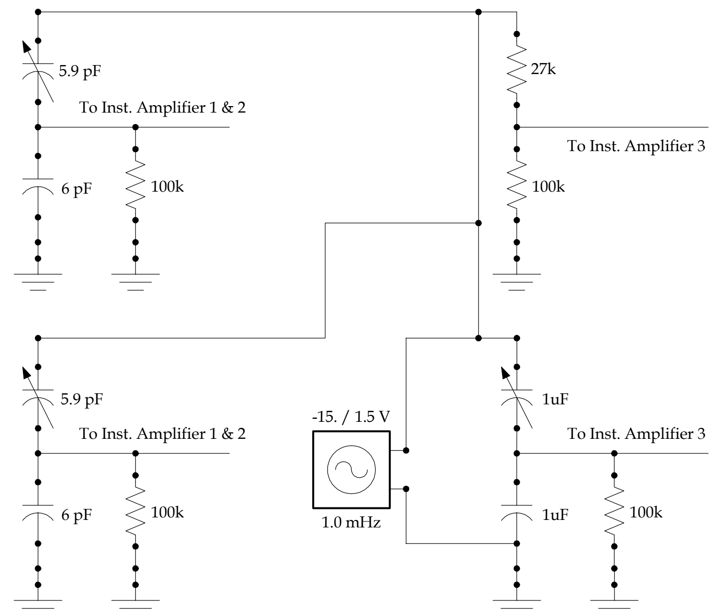

Figure 21.12. Circuit Design Implemented in Testing with the Capacitor Sensor.

The operation range is designed to be easily changed. By varying the spring constants, different magnitudes of shear forces can be measured. By varying the thickness of the top plate, different magnitudes of normal forces can be measured. The transducer was designed to displace three mm in both the + & - X and Y dimensions. Using the range of forces desired for prosthetic applications, shear forces of 15 kPa and normal forces of 100 kPa, the ideal spring constants were 30.26 lbs/in.

The total cost of parts and labor was $550.

THE SWITCH OPERATED SENSORY TABLE

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INTRODUCTION

The switch operated sensory table is designed to encourage users to make use of upper extremity movements through various types of stimulation. The users include individuals that have had strokes, cerebral palsy, mental retardation, developmental delays, brain injuries, or autistic tendencies. Some of the patients have limited movements due to degrees of paralysis. The age range of users that was given by the client coordinator is between three and fifty years. The switch operated sensory table is a device for presenting various stimuli to the user through four physical senses: touch, smell, sight, and sound.

Most current designs for stimuli presentation involve just one component for interaction. The problem with such designs is that users like variety and wish to interact with many kinds of stimuli. If the user does not like the single component given, he or she will tend not to interact with that component. Most designs also do not incorporate multiple senses, but instead focus on one or two senses in their stimuli. The switch operated sensory table combines multiple forms of stimuli that are recognized through four of the senses.

SUMMARY OF IMPACT

The final product was a table that will improve the upper extremity movement and provide stimulation of users with physical and cognitive disabilities. The feedback received from the client coordinator indicates that users were drawn to all of the stimuli in the table and readily attempted to use their upper extremities to manipulate the various stimuli.

TECHNICAL DESCRIPTION

The tabletop is 36 inches in diameter with an overall thickness of three inches. It has a 1.5 inch hollow compartment, with a volume of 0.72 cubic feet. This compartment houses the internal electrical components. Four sheets of square plywood arranged in a crossing pattern separate the tabletop into four sections, each one focusing on a specific sense. The tabletop is made of ¾ inch oak plywood, with the top half of the tabletop capable of rotating independently of the bottom half. Two 36 inch circular pieces of plywood, along with two 36 inch OD/ 33 inch ID plywood rings, were utilized to construct the tabletop. The middle of the table also has two six-inch diameter circles placed inside the hollow. The circles are centered and fastened to the top and bottom inner surfaces of the hollow compartment. These circles help to carry the weight of the table and control the centering of the table during rotation. A pin is seated in the middle of these circles. The pin is a 1 ¾ inch solid copper cylinder with a ½ inch diameter. This pin acts as a central axis during rotation to keep the tabletop from shifting.

The top half of the tabletop has press fit ball plungers inserted into drilled holes, which aid with the rotation of the tabletop. Calculating the weight of the upper half of the table and comparing this to ball plungers that have a starting force of five pounds and ending force of fourteen pounds determined the number of these plungers needed. In order to lift the weight of the table, five ball plungers were needed. The plungers are spaced evenly along the outer edge of the upper half of the tabletop where it touches the lower half. A sheet of plastic is placed on the bottom ring to reduce friction between the ball plungers and the surface of the wood. The tabletop has four clasping locks that allow the therapist to lock the tabletop into place, preventing unsupervised rotation. The stand portion of the unit places the bottom edge of the tabletop at a height of 28 inches above the ground. This height was selected for wheelchair accessibility. The base of the stand is from an office chair, attached to one inch iron piping. The piping was covered with two inch PVC piping for cosmetic purposes. The base has locking castor wheels that allow the table to roll efficiently, but prevent movement when the wheels have been locked.

The table is divided into four sections, one for each sense. The boundaries between each section are clearly defined by two dividers pieced together. The dividers have been held in place through the use of shelf pins, which were glued into the table to keep the dividers stable. Olfactory stimuli occupy the blue colored section of the table. When a switch is pushed, a fan propels scented air through a vent on the top of the table. The user can select two different scents, which can be changed by the therapist.

The visual stimuli section features a plastic wind dome and buttons illuminate different colors when pressed. When the wind dome switch is pushed, a motor at the bottom of the dome starts to run and causes colorful puffballs to fly about in the dome.

The touch stimuli section has textiles of varying textures such as smooth, soft, rough, hard, etc. Another stimulus in this section is a mechanism that vibrates when the patient pushes a button. The last form of stimuli in the touch section of the table involves a Koosh ball. This allows the user to compare the rubbery spindles to the textures of the fabrics.

The auditory stimuli section has a musical keyboard that can play a single note or more than one note, depending on the number of keys pressed. A demo button in this device allows for the patient to hear assorted tunes. There are also buttons that feature pictures of different animals. When pushed, these buttons will make the noise the corresponding animals make. Also included in the auditory stimulus portion of the table are various noise-making objects. The objects are connected to a turntable so they are all easily accessible.

The battery is placed under one of the components on the tabletop so that it is easy to access. This permits the client to plug it in to recharge overnight. The battery puts out 13.1 volts and is rated at 9.5 amps per hour. The components require 3.3 amps if every one of them is activated at the same time. This allows the table to run for almost three hours with every component being utilized continuously in this time period.

The total cost of parts and labor was $850.

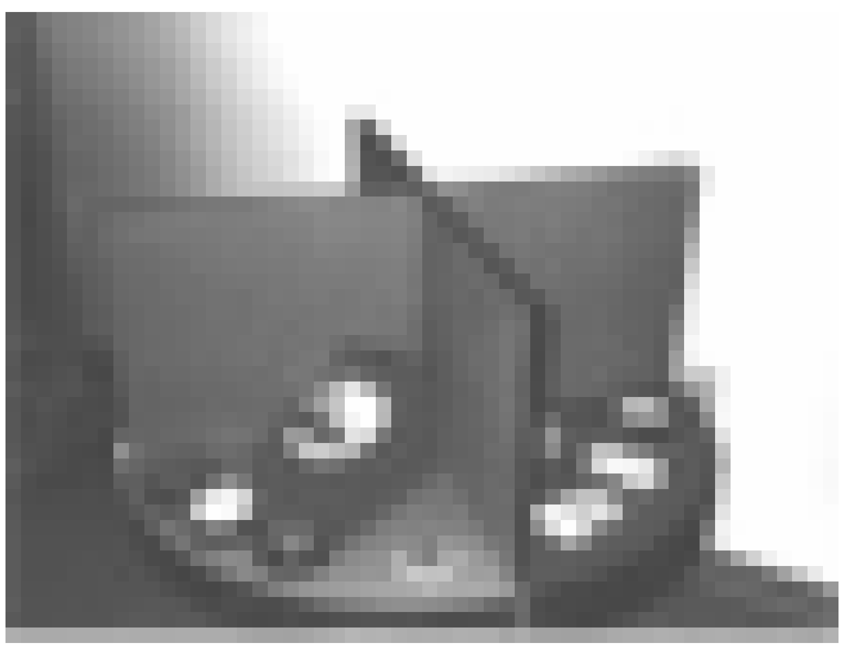

Figure 21.13. Switch Operated Sensory Table.

MANIKIN CERVICAL INTERFACE PLATE FOR TWISTING SIMULATION

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INTRODUCTION

Manikins are used in industry today to assess the possible injuries imposed on humans. They are commonly employed in the automotive industry and in the design of ejection seats for the Air Force. In research and design facilities, it is essential to model the human neck's response to impact. An important aspect of the manikins used to model the response of humans is biofidelity, or the ability to accurately behave in the same manner as a human. The effects of side impacts have been of recent interest; however, a manikin capable of modeling the human neck response to a lateral impact did not exist. When a human is impacted laterally, the inertial properties of the head cause it to rotate about its vertical axis.

The purpose of this project was to design a cervical interface plate for the Hybrid III manikin's 3-Segment Neck to allow for rotation about the vertical axis. This will allow the head and neck of a manikin to accurately model the human response to a lateral impact. The manikin being used in the Air Force Research Laboratory (AFRL) was called the Hybrid III and did not have this capability. The neck being used was the Hybrid III 4-Segment neck. The Hybrid III has only lateral, forward, and backward movement. The client recently expressed the need for the development of a manikin/cervical interface plate to simulate rotation about the vertical axis.

SUMMARY OF IMPACT

Torque testing of the springs using two separate methods led the design team to the same conclusion—the springs were not created with the proper spring coefficients. This manufacturing error prevented verification of the cervical interface plate's properties. However, the testing procedure generated data that show that the cervical interface plate does provide the quadratic response that the team designed it to simulate. With new springs that have the correct spring coefficients, the design will work as intended.

Figure 21.14. Exploded Solid Works Drawing of Cervical Interface Plate Mounted Between the Hybrid III 3-segment Neck and the Mounting Plate for the Hybrid III Head.

TECHNICAL DESCRIPTION

The final product consists of several parts working together with the Hybrid III head and neck to produce the rotation response. The product consists of torsional springs, a bearing, a top plate, a bottom plate, and a damper.

The torsional springs provide the resistive force to the rotation of the top plate that simulates the human response. Two torsional springs were used to model the quadratic response data produced by the Articulated Total Body (ATB) simulation software package. A smaller spring was used to model the ATB simulator data from 37.5° to 55° of neck rotation from the eyes-forward position. From the data, a linear best-fit line with a slope of ~221 [in*lbs/˚] was analyzed by the group for this angular range. The diameter of 1.3125 inches is smaller than the inner diameter of the larger spring; therefore the smaller spring could be placed inside the inner diameter (1.375 inches) of the larger spring, thus maximizing the inner cavity space of the bottom plate. The larger spring was used to model the ATB simulator data from 55˚ to 70˚. From the data, a linear best-fit line with a slope of ~390 [in*lbs/˚] was analyzed by the group for this angular range. Because the springs both have a straight offset design, the same activation mechanism was used for both springs. As the top plate rotates, it is free to rotate until 37.5˚. At 37.5˚, an aluminum catch compresses the smaller spring through 55˚. At 55˚, the same aluminum catch compresses the larger spring, and both springs are compressed through 70˚.

A bearing was placed in the apparatus to make the rotation as smooth and effortless as possible. In the interest of simplicity a single row, deep-groove ball bearing was selected for the product. Selection of the bearing was dependent on the dimensions of the cervical plate and the outer diameter of the large spring. The load capacity requirement for the bearing was minimal, and not a factor in the selection process.

The features of the top plate were designed to activate the other parts of the design to simulate the desired response. The top plate serves the purpose of connecting the entire design to the Hybrid III 50% head. The entire top plate itself was machined from one piece of ALUM-6061 (minus the ball bearings and titanium screw). The components of the top plate include the catch for the springs, the bearing wall, the titanium screw and the ball bearing, and the four screw holes.

Over the duration of the design process, the bottom plate design was the most changed part of the entire product. The reason for this fact is the bottom plate interacts either directly or indirectly with every other portion of the final product, and it interacts directly with the Hybrid III neck. The entire bottom plate was machined from one block of ALUM-2024.

The damper consists of the damper backing and the damper foam. The backing is made of ALUM-2024.

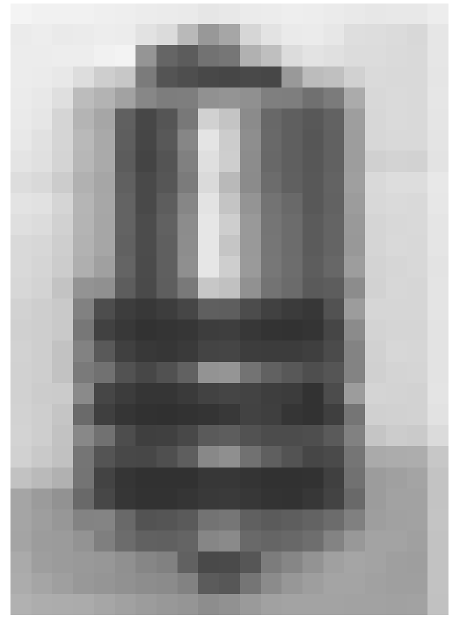

Figure 21.15: The Interface Plate Mounted Between the Hybrid III 3-segement Neck and the Mounting Plate for the Hybrid III Head.

It was designed under considerations for both strength and size. The ringed portion of the backing slips over the beveled portion of the rod, and a 2-56 screw is used to secure the backing to the rod in the proper position. This construction provides the damper system with enough strength to endure the rotational energy exerted on it during dynamic testing of the interface plate. The arm of the damper is designed such that a piece of Confor foam can be fastened to it. The Confor foam damper designed for the interface plate has one main objective: energy dissipation. Under the rigors of dynamic testing, the system has an inert tendency to return to the 0˚ position with a large amount of velocity. The damper foam, therefore, is designed to meet the aluminum catch on the top plate and allow for the transfer of energy from the top plate into the foam. As the foam, which will deform, absorbs the blow from the catch, the velocity of the top plate will be reduced, and the top plate will return to the position determined by the specifications. Industrial strength Velcro will be placed on the damper foam to help slow down the top plate’s rotation and ensure the top plate will come to rest within the specifications.

The total cost of parts and labor was $950.

CHAPTER 22
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