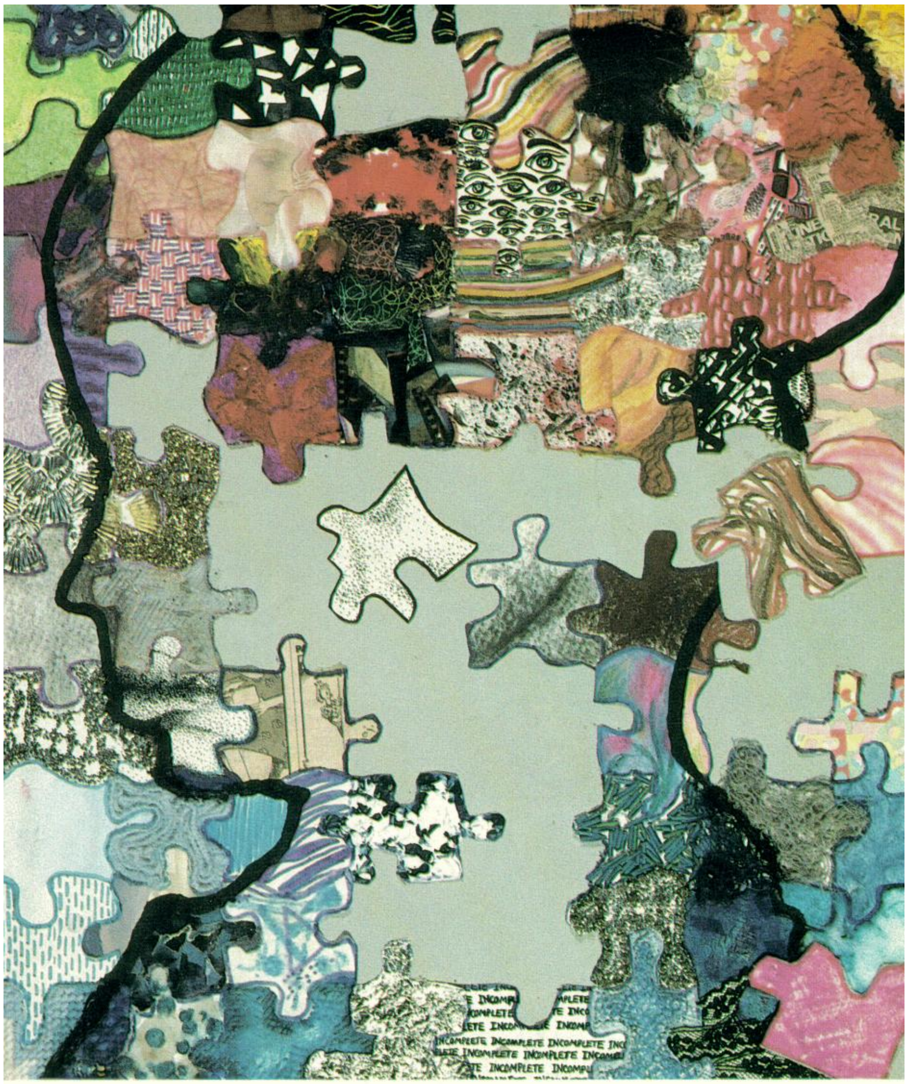
NATIONAL SCIENCE FOUNDATION 2007 ENGINEERING SENIOR DESIGN PROJECTS TO AID PERSONS WITH DISABILITIES



Edited By
John D. Enderle
Brooke Hallowell

NATIONAL SCIENCE FOUNDATION

2007

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CONTENTS

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FOREWORD

Welcome to the nineteenth 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 was published describing these projects, entitled NSF 1990 Engineering Senior Design Projects to Aid the Disabled.

North Dakota State University (NDSU) Press published the following three issues. In the NSF 1991 Engineering Senior Design Projects to Aid the Disabled almost 150 projects by students at 20 universities across the United States were described. The 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. The 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. The 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. The 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. NSF 2002 Engineering Senior Design Projects to Aid Persons with Disabilities, published in 2004, presented 115 projects carried out by students at 16 universities during the 2001-2002 academic year. In 2005, NSF 2003 Engineering Senior Design Projects to Aid Persons with Disabilities was published, presenting 134 projects carried out by students at 19 universities during the 2002-2003 academic year. NSF 2004 Engineering Senior Design Projects to Aid Persons with Disabilities, published in 2005, presented 173 projects carried out by students at 17 universities during the 2003-2004 academic year. In 2006, NSF 2005 Engineering Senior Design Projects to Aid Persons with Disabilities was published, presenting 154 projects carried out by students at 16 universities

[1] This program is now in the Division of Chemical, Bioengineering, Environmental, and Transport Systems (CBET).

during the 2004-2005 academic year. NSF 2006 Engineering Senior Design Projects to Aid Persons with Disabilities, published in 2007, presented 152 projects carried out by students at 15 universities during the 2005-2006 academic year.

This book, funded by the NSF, describes and documents the NSF-supported senior design projects during the nineteenth year of this effort, 2006-2007. After the 5th chapter, each chapter describes the projects carried out at a single university, and was written by the principal investigator(s) at that university and revised by the editors of this publication. Individuals desiring 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, and writing about and working with individuals who have disabilities are also included in this book.

Hopefully this book will enhance the overall quality of future senior design projects, directed toward persons with disabilities, by providing examples of previous projects, and also motivate 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 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 has been 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, Semahat Demir, Robert Jaeger, Gil Devey and Ted Conway, 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 Kelsey Bird, Clint Wilson, Emily Boyer, JoLynn Vargas, Lindsey Carlson, Rachel Poling, Frederick Napier, Dayna Tran, and Alexandra Enderle for editorial assistance. We also appreciate the technical illustration efforts of Michael Chen, Matthew Curreri, Samuel Enderle, and Justin Morse. Additionally, we 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 and 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 Director of 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. They are sometimes prohibitively expensive or even nonexistent. Many persons with disabilities have limited access to current technology and custom modification of available devices. Even when available, personnel costs for engineering and support make the cost of custom modifications beyond the reach of many 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 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 while 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 emphasis of the program is 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. Examples of projects completed in past years include laser-pointing devices for people who cannot use their hands, speech aids, behavior modification devices, hands-free automatic telephone answering and hang-up systems, and infrared systems to help individuals who are blind navigate through indoor spaces. The students participating in this program are richly rewarded through their activity with persons with disabilities, and justly experience 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 2006-2007. 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 address effectively the needs of persons with disabilities.

Thirdly, through its initial 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 modification is usually included. Next, a technical description of the device or modification is given, with parts specified in cases where it may be difficult to fabricate them otherwise. An approximate cost of the project, excluding personnel costs, is provided.

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 specific individuals.

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.[2,3,4] 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 (2006). Accreditation Policy and Procedure Manual Effective for Evaluations for the 2006-2007 Accreditation Cycle. ABET: Baltimore, MD.

[3] Accrediting Board for Engineering and Technology (2006). Criteria for Accrediting Engineering Programs. ABET: Baltimore, MD.

[4] Enderle, J.D., Gassert, J., Blanchard, S.M., King, P., Beasley, D., Hale Jr., P. and Aldridge, D., The ABCs of Preparing for ABET, IEEE *EMB Magazine*, Vol. 22, No. 4, 122-132, 2003

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 relationships.

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 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 where 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. Manufacturers' 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 detail. Specific components of the device, such as microprocessors, LEDs, and electronic parts, are 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 (including interfaces, voltages, impedances, gains, power output, power input, ranges, current capabilities, harmonic distortion, stability, accuracy, precision, and power consumption)
- Mechanical parameters (including size, weight, durability, accuracy, precision, and vibration)
- Environmental parameters (including location, temperature range, moisture, and 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 an 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 often require a multidisciplinary system or holistic approach to create a successful and useful product. This stage of the design process is typically the most challenging because of the creative aspect to generating 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 often 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 are analyzed and constructed with safety as one of the highest priorities. Clearly, the design project that fails should fail in a safe manner, 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;

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 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 the project is given to the client. Ideally, the project in use by the client should be evaluated periodically for performance and usefulness after the project is complete. Evaluation typically occurs, however, when the device no longer performs adequately for the client, and it is returned to the university for repair or modification. If the repair or modification is simple, a university technician may handle the problem. If the repair or modification is more extensive, another design student may be 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 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; they 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. Photographs of the device may be included in the final report but mechanical and electrical diagrams are often more useful in documenting 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 web-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 grants from the National Science Foundation, and is offered each fall. The course 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 ensure 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 are 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 featuring 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.

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 oriented 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 participate in interviews.

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

- Determine a product,
- Name the company,
- Determine the process for company name registration,
- Generate a market analysis,
- 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,
- Meet with patent attorneys, real estate agents, members of the business community, bankers, and a venture capitalist,
- Demonstrate understanding of the cost of insurance and meet with insurance agents to discuss health and life insurance for employees and liability insurance costs for the company, and
- Explore OSHA requirements relative to setting up development laboratories.

Students carry out these tasks using direct person-to-person contact and the vast amount of information on the Internet.

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 assessing the problem, defining the needs, and making a decision as to whether or not they are interested in 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 design. Once a project has been chosen, the student must begin the process of generating a written technical proposal. This document must clearly indicate answers to the following questions:

- What are the project and its technical specifications?
- Why is the project necessary?
- What technical approach is to 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

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. 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 members 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, and pursue his or her own project. Each student is required to participate in the project definition session, which enriches the overall design experience. The meetings take place at the beginning of each semester, and periodically thereafter as projects are completed and new ones are identified.

The needs expressed by the collaborating agencies often result in projects that vary in complexity and 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.

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 project reports.

Throughout each phase of the project, a faculty member supervises the work, as do the university supported teaching assistants assigned to the rehabilitation engineering laboratory. 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. The design team 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 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 projects be revised and reworked until they meet faculty approval.

At the end of each academic year, the faculty member 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 questionnaire 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

All senior electrical engineering students at North Dakota State University (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 individual with a disability in 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 includes an introduction, 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 printed circuit boards using OrCAD, and then finish the construction of the projects 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 shows. 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 or 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, a waveform generator, an oscilloscope, a breadboard, and a collection of hand tools.

The second laboratory contains 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 the 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 of 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 are occasionally projects constructed at NDSU (and at other universities) that prove 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. An additional five-year grant was awarded in 2005. These NSF projects are a pronounced change from previous design experiences at UConn, which involved industry sponsored projects carried out by a team of student engineers. The new Biomedical Engineering Program at UConn has now replaced the ESE Department in this effort.

To provide effective communication between the sponsor and the student teams, a web-based approach was implemented.[5] Under the new 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

[5] Enderle, J.D., Browne, A.F., and Hallowell, B. (1998). A WEB Based Approach in Biomedical Engineering Design Education. Biomedical Sciences Instrumentation, 34, pp. 281-286.

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 Internet, telephone, e-mail, postal mailings, and video recordings.

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 in teams, design process, planning and scheduling (timelines), 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 an individual after interviewing a people 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 each student with a person who has a disability. The A.J. Pappanikou Center provides an MS Access database with almost 60 contacts and a short description of disabilities associated with the clients in each. 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 speech-language pathologists and 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, each student selects two clients to interview. The student and a UConn staff member meet with the client and 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 require 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 web-based approach is used for reporting the progress on projects. Students are responsible for creating their own Internet 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.

Teamwork

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[6,7]. 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.[8,9,10]

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,
- 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,[11,12] the two most essential determiners for success in teamwork are positive interdependence and individual accountability.

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

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

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

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

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

[11] Cottell, P.G. & Millis, B.J. (1994). 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.

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

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 an 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 vital to success, eliminates most management issues, and allows the instructor to monitor the activities by student team members. Activities for each week must be documented for each team member, with an optimal target of five to ten 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, and 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 timelines 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 too difficult, scheduling of team meetings was too challenging, their backgrounds were insufficient, 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.

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, and completing a project according to specifications and on time, this approach lacked the important and enriching multidisciplinary team experience that is desired in industry.

NSF Projects Year 2

During the second year of the NSF senior design program, seven students worked on 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 had three students working on individual projects. These projects required integration in the same way a music system requires integration of speakers, a receiver, an amplifier, a CD player, etc. In general, when teams were formed, the instructor would facilitate the teams' 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 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 an improved focus on the project itself during the senior design experience.

Timelines

At the beginning of the second semester, the students are required to update their timelines 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. This allows the professor or instructor to gauge progress and to determine whether the student is falling behind at a rate that will delay completion of the project.

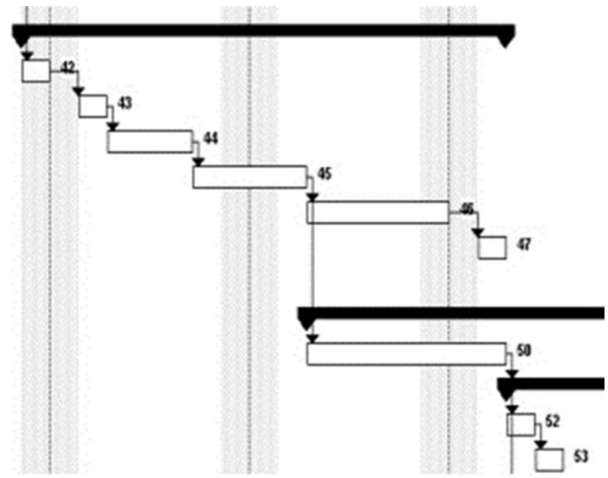

Fig. 2.1. Shown above is a section of a typical timeline. The rectangular boxes represent certain tasks to be completed. These singular tasks are grouped into larger tasks, represented by thick black lines. The tasks are numbered to correspond to a task list that is not shown. The thin lines that descend 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.

Also during the second semester, the student is required to report project progress via the web on a weekly basis. Included in this report are sections of their timeline that focus on the week just past and on the week ahead. The instructor may meet with students to discuss progress or the lack thereof.

Theory

The Senior Design Lab utilizes what is perhaps the most easily understood project-planning tool: the timeline. The timeline, or Gantt chart (see Fig. 2.1), 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. Concurrent tasks should be clearly delineated in the timeline for each project.

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. The timeline facilitates time loading (resource management) by helping the project manager schedule people and resources most efficiently. For example, optimum time loading keeps a machining center from being overloaded one day and 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 if a task requires more time than expected or if a design method turns out to be unsatisfactory, requiring that new tasks be 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 from 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, 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 to enable the project manager to follow the plan with 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 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 manufacturing 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 publish his or her timeline and proceed to follow the 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 and 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 as well as on the web site. Weekly report structure for the web page 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 coordinator use the web reports to keep up with the 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 Internet 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 has been issued for a “Four-Limb Exercising Attachment for Wheelchairs” and another patent has been allowed for a “Cervical Orthosis.”

CHAPTER 3
MEANINGFUL ASSESSMENT OF DESIGN EXPERIENCES

Brooke Hallowell

The Accrediting Board for Engineering and Technology (ABET)[13] has worked to develop increasingly outcomes-focused standards for engineering education. This chapter is offered as an introduction to the ways in which improved foci on educational outcomes may lead to: (1) improvements in the learning of engineering students, especially those engaged in design projects to aid persons with disabilities, and (2) 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, as well as evidence that assessment results have led to improved teaching and learning and, ultimately, better preparation for beginning professional careers. 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.[14]

"Meaningful" Assessment Practices

Because much of the demand for outcomes assessment effort is perceived by instructors as time consuming bureaucratic chore, 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".

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

[13] Accrediting Board for Engineering and Technology (2006). Criteria for Accrediting Engineering Programs. ABET: Baltimore, MD.

[14] 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.

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.[15]

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. However, 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.[16] 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, 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 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 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

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[15] 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.

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

educational/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 we can better ensure a sense of personal identification with assessment goals on the part of the faculty. Also, by agreeing to develop outcomes assessment practices from the bottom up, rather than in response to top-down demands from administrators and accrediting agencies, faculty member skeptics 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
- Demonstration of the means by which certain assessments, such as student exit or employer surveys, may be used to make strategic program changes.

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).[14]

With the recent enhanced focus on educational outcomes in accreditation standards of ABET, and with all regional accrediting agencies in the United 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[17] provide 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

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[17] Accrediting Board for Engineering and Technology (2006). Criteria for Accrediting Engineering Programs. ABET: Baltimore, MD.

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 are 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- and post-tests to assess "value added",
- Design portfolios,
- Rubrics for 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,
- 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.

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APPENDIX: Desired Educational Outcomes as Articulated in ABET's "Engineering Criteria for the 2006-2007 Academic Year" (Criterion 3, Program Outcomes and Assessment)[18]

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 applied science 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 professional practice

[18] 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[19]. 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 as well.

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[19] Accrediting Board for Engineering and Technology (2006). Criteria for Accrediting Engineering Programs. (Criterion 3, Program Outcomes and Assessment). ABET: Baltimore, MD.

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 varies 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: 1) form and formatting, 2) accompanying images, 3) grammar, spelling, punctuation, and style, 4) overall content, and 5) 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.

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, 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[20]. 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 to such flaws as grammatical errors, misspellings, misuse of punctuation, and 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

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. Consequently, it is impractical or impossible for many instructors to provide 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.

[20] Ohio University Center for Writing Excellence Teaching Handouts [on-line] (2007). Available at: http://www.ohio.edu/writing/tr1.cfm

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 type size 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 world-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. An early classification scheme proposed by the WHO, the International Classification of Impairments, Disabilities and Handicaps (ICIDH) employs the general terms "impairment", "disability", and "handicap"; a more recent scheme, the ICIDH-2, employs the terms "impairment", "activity", and "participation"; the most recent version, the International Classification of Functioning, Disability and Health (ICF), suggests that body functions and structures, activities and participation should refer to the various contextual aspects of disabling conditions one might experience.[21] Healthcare 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 it is essential to keep current regarding changes in accepted terminology.

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.[22] 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 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

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21 World Health Organization (2007). International Classification of Functioning, Disability and Health (ICF) [on-line]. Available: http://www.who.int/classifications/icf/en/

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

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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[23] 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 disabilities 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 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 ensuring that 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 and determines the ways to 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 or family carries 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 that “with the grace of God” the disability can be overcome.

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. A variety of factors are assessed in terms of barriers and 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 one's 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 powerful and that 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 he or she is, not for what he or she does or does 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 guidelines on person-first language, a keyword internet search will reveal many resources. For detailed guidelines on writing, see Chapter 4.

Assistive Technology and Universal Design

Assistive Technology (AT) 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. It can include off-the-shelf items as well as special designs. 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).

AT 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 replacing 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 (UD) are available for review at www.design.ncsu.edu, The Center for Universal Design, North Carolina State University. These basic principles provide the philosophical interface between functional limitations/disability and best practices in design. In fact, universal design principles can often 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, memory, and cognition. 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 is 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.

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) (including their Sports and Outdoor Assistive Recreation (SOAR) project) and the university's special education program.

With this assembled team of professionals, specific duties were assigned 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 or her family members, caregivers, or 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 project 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 Fig. 5.1. Overall, an individual with a disability was linked with a student engineering team, which was to provide a prototype custom designed assistive device specific to his or 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 his or her legal guardian signed a "Hold Harmless" agreement. This agreement was reviewed and approved by the university's legal office.

At the individual project level, students must:

- Be educated on assistive technology awareness,

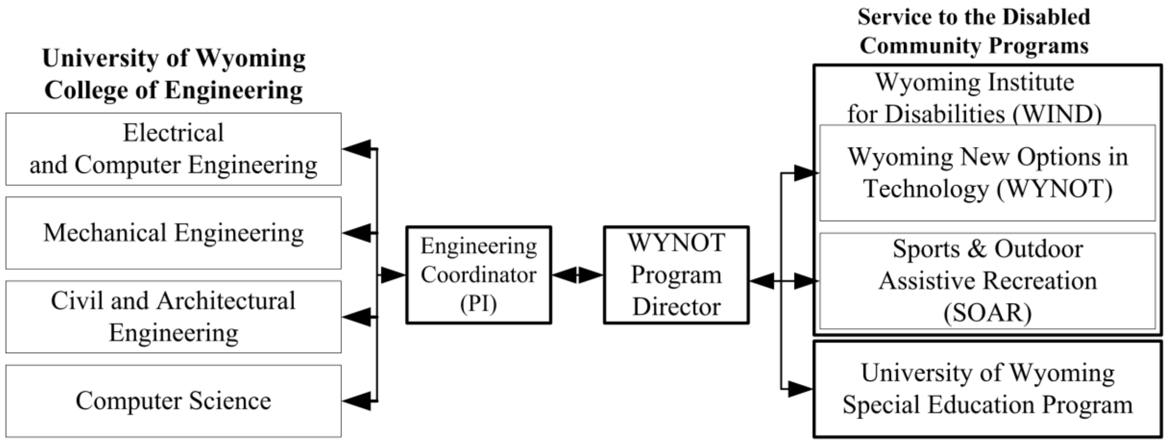

Figure 5.1. Program Flow for Undergraduate Design Projects to Aid Wyoming Persons with Disabilities (Barrett, 2003).

- 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 locate all of the state assistive technology projects and obtain contact information for his or her 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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HANDCYCLE

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INTRODUCTION

A device to enhance mobility was requested for 66-year-old woman. As a child, she had fallen into a cooking fire and burned off much of her left foot; only the heel remains. She had been walking in this condition ever since. She lives without paved roads or electricity in rural Milawi, Africa. She was walking one mile uphill in rough terrain daily to get to the market. Walking without proper structural support caused her severe back problems. A handcycle was deemed the most effective solution given the timeframe. All components used to create the device were to be readily available in Malawi. The design was to be easily reproducible and take into account the environmental conditions of the client's residential area: rough terrain, a severe monsoon season, high temperatures during the summer, and steep hills.

SUMMARY OF IMPACT

The design (Figures 6.1, 6.2 and 6.3) takes into consideration not only the client's mobility, but also her physical capabilities and environmental factors. The handcycle has crank handles set for maximum efficiency. The client can easily move the handles forward, moving the cycle forward, stop them to stop the device, or move the handles backwards to reverse. The client's lower back problems should diminish as her mobility increases. Her travel to and from the local market is likely to be far less painful.

Fig. 6.1. Handcycle.

TECHNICAL DESCRIPTION

The final prototype is adjustable so that it can accommodate users of different sizes. For example, the length of the crank, distance from crank to seat, seat position, and handle positions are all adjustable. In addition, the wheels can be removed by the touch of a button in the center. This serves two purposes: avoiding the problem of theft and making the handcycle easier to transport or ship.

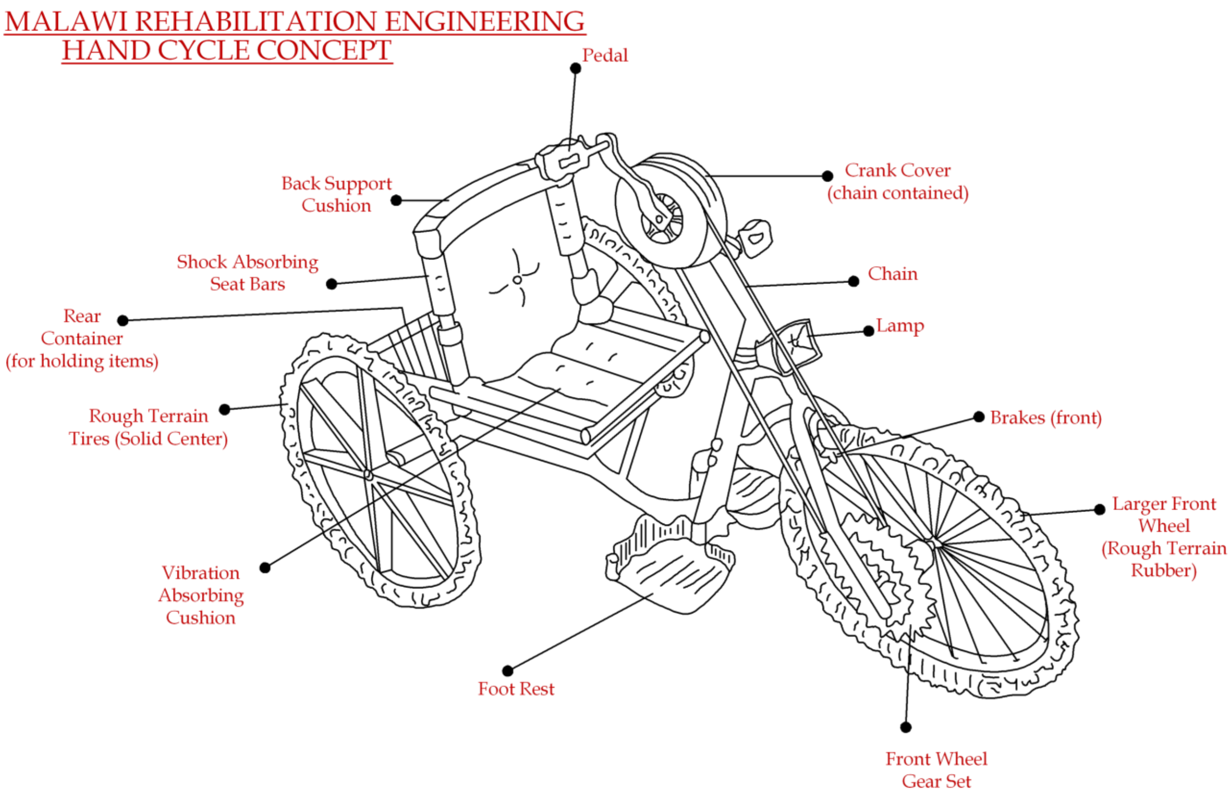

Fig. 6.2. Handcycle Schematic.

Fig. 6.3. Finished Product.

EEG-ACTIVATED ALARM FOR AN ALS PATIENT

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INTRODUCTION

A device was designed to enhance an ALS patient's ability to communicate a need. The patient's existing communication system relied upon detectable eye movements, requiring clear vision to purposefully control cursor navigation on a computer monitor. Also, the eye-tracking system required that his head be stabilized, causing him discomfort and sore spots along the face when used for long periods of time. An alternative to his eye-tracking system was requested. The new design uses biofeedback to detect the patient's need for help. The motivation to choose this approach instead of creating an electrical stimulator for the patient's eyelids were twofold: the client needed a solution that would allow his eyeglasses to be worn or removed, and he needed a simple alternative to his current system. The existing eye-tracking system involves an on-screen keyboard with which he can type.

SUMMARY OF IMPACT

The system (Fig. 6.4) enhanced the client's comfort and provided an alternative means to communicate a need. By extension, this project could be made useful for people with ALS who have lost the ability to communicate. The system design is compact, easy to handle, and portable.

TECHNICAL DESCRIPTION

The system (Fig. 6.5 and 6.6) works through the combination of biofeedback and computing systems, the latter of which runs a help detection method. Once electrodes are applied, the user may sit or lie down. The system works with a PC. Comfort and efficiency were top priorities. A mobile USB-powered system functions with 64-bit PC tablets and laptops and includes a driver CD. The stand-alone software is a mental distress alert algorithm that triggers an audible alarm at a predetermined value related to the alpha and beta bands. The system DAQ is lightweight and portable, weighing only 5.40 oz with dimensions of 4" (L) x 3" (W) x 1.6" (H).

Fig. 6.4. Patient Wearing the EEG-Activated Alarm System.

Attached to the DAQ are five EEG gold cup electrodes with 48" long wires. As the amygdala is the center for panic and fear, four EEG gold-cup electrodes were situated along the mid-brain line to capture distress. Functionality was demonstrated through test results. The mental distress alert program is an EEG processor, specified to measure amplitudes and sum them in specific alpha and beta bands.

The budget for this project was $700, of which $300 was used for supplies.

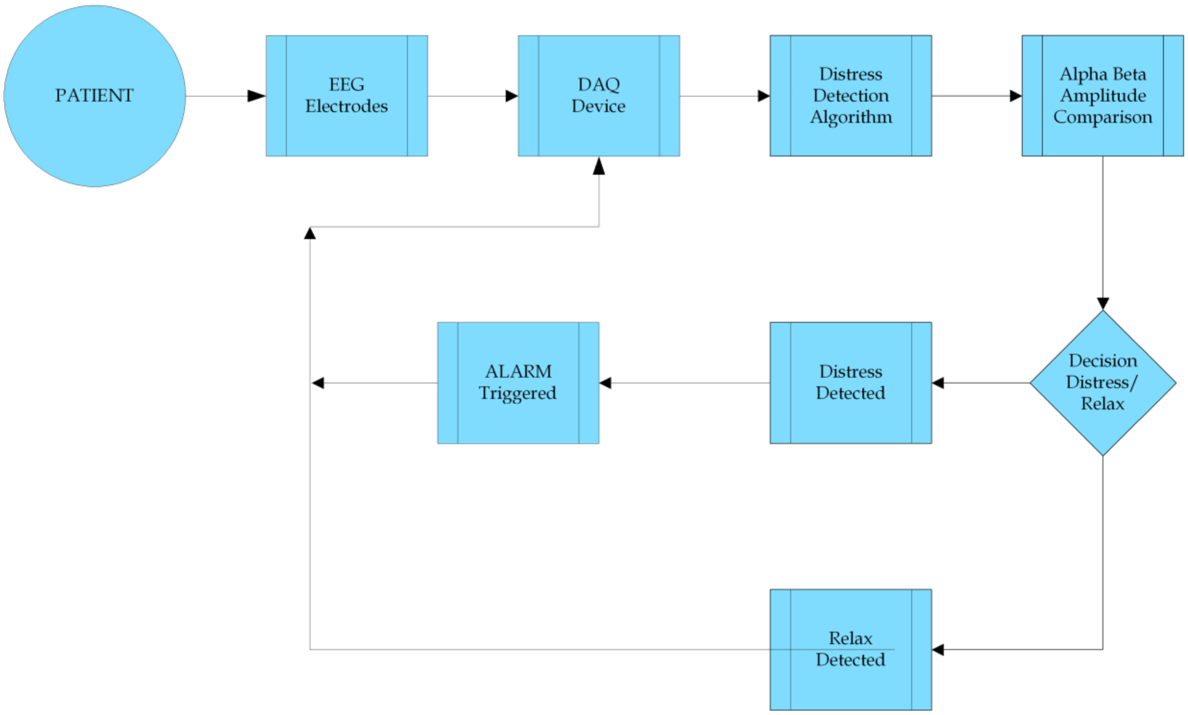

Fig. 6.5. Block Diagram of EEG-Activated Alarm System.

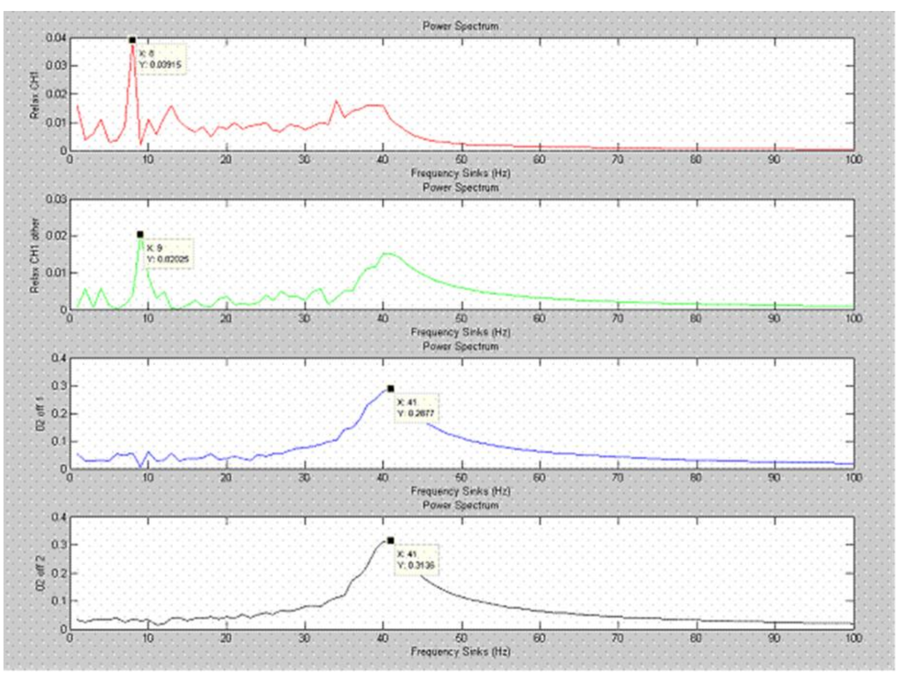

Fig. 6.6. Power Spectrum for Filtered Rest State Biofeedback (Top Two Frames) and Power Spectra for Filtered Distress State Biofeedback (Bottom Two Frames).

FOUR-TIP CRUTCH

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INTRODUCTION

A specialized crutch was designed to assist a 79-year-old man born with legs of unequal length. The client's left leg is about half the length of his right. He lives in a small mountain village far from modern technology and medical care and has recently experienced cardiac problems and declining health. The client's job requires a great amount of mobility. Also, he walks four miles from his house to a nearby market daily. As most of the roads in his village are pitted with holes and covered with rocks, a wheelchair is not of practical use.

Fig. 6.7. Photo of the Device.

SUMMARY OF IMPACT

The prototype (Fig. 6.7) was tested by two adults aged 54 and 59. After some additional modifications, the final form of the product was completed and shipped to the client in Vietnam.

The device will improve the client's daily mobility.

TECHNICAL DESCRIPTION

The goals of the design were to enhance stability, increase walking speed, and provide better support at the wrists and elbows. The crutch has four tips at the base for extra stability, with springs added for comfort. The crutch can be folded in half, along its length, for easy storage (Fig. 6.8). The arm rest is designed to have an upward curve of about 2 inches from the back to the front.

Fig. 6.8. Photo of the Device When Folded Into Half.

MULTI-USE NECK AND HEAD DEVICE

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INTRODUCTION

A device was designed to combine pressure techniques with modern technology, helping alleviate migraine pain. The device (Fig. 6.9) applies gentle pressure to specific points on the head and neck, thereby diminishing pain with no drugs or side effects.

SUMMARY OF IMPACT

The device has the potential to diminish migraine pain without drugs or side effects.

TECHNICAL DESCRIPTION

A Gantt chart is shown in Fig. 6.10. Even though much of the appropriate hardware and materials have been identified, the device is still a work in progress. In an experimental test the device functioned successfully, but there is still progress to be made. If the fully functional device becomes a success, the product can be marketed to hospitals, doctors, and eventually directly to users who suffer from minor neck injuries, stress, and other factors associated with muscle tension. Reliability and affordability are important requirements for this design.

Fig. 6.9. Multi-Use Neck and Head Device.

The cost was approximately $135.

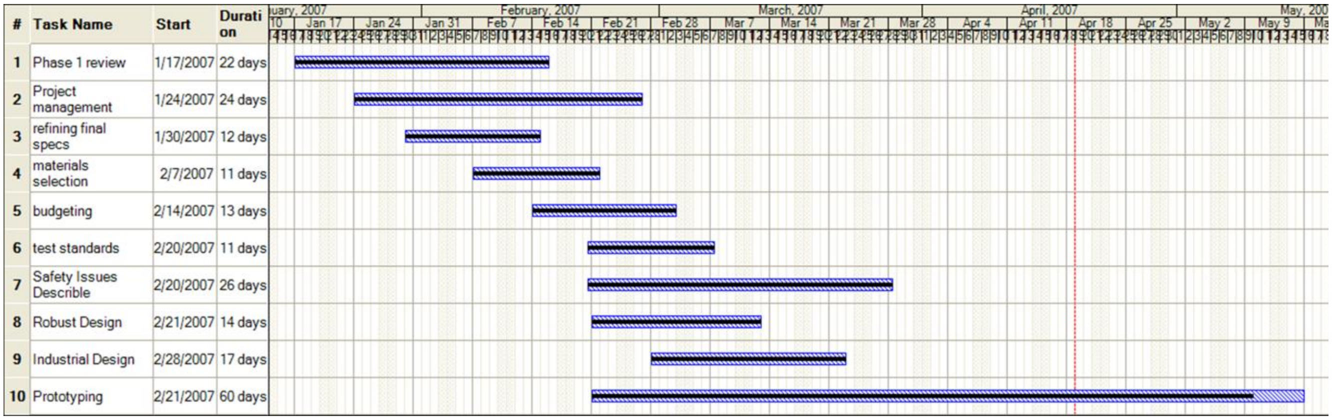

Fig. 6.10. Gantt Chart of Project Progress.

CHAPTER 7
DUKE UNIVERSITY

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AUTOMATIC ROCKING CHAIR

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INTRODUCTION

Children enjoy and can benefit from rhythmic motion, such as rocking, but many children with disabilities cannot rock themselves. The Automatic Rocking Chair incorporates a glider-style rocking chair powered by an electric gear motor. It has features such as: 1) a timer; 2) child-operable switch; 3) speed control.

SUMMARY OF IMPACT

The Automatic Rocking Chair benefits children with disabilities and their caregivers. A supervisor from a local children's home states, "This is a tremendous help for staff, by freeing up caregivers who previously had to stay right beside a rocking chair to manually keep it moving… The flexibility provided by the motor's speed control and by the positioning straps will permit us to use the chair with almost every child in our facility. And we are so impressed with… the tray top with hand-painted designs!"

TECHNICAL DESCRIPTION

The Automatic Rocking Chair (see Fig. 7.1) design is based upon a previous student project, but is tailored to the special needs of children living in a group home setting. The design translates the rotational motion of a gear motor into the translational motion of a Classic Glider Rocker by Storkcraft (model #002646350).

Components of the design are shown in Fig. 7.2. A fixed arm is attached to a 90-volt DC gear motor (Dayton #2H577) with two setscrews to create an offset shaft. This fixed arm is attached to a moveable arm by a bearing pin. The other end of the moveable arm attaches with a bearing onto the moveable dowel, which is made of ¾" aluminum rod. When the motor is turned on, the fixed arm rotates, driving the moveable arm back and forth laterally, thereby gliding the chair back and forth.

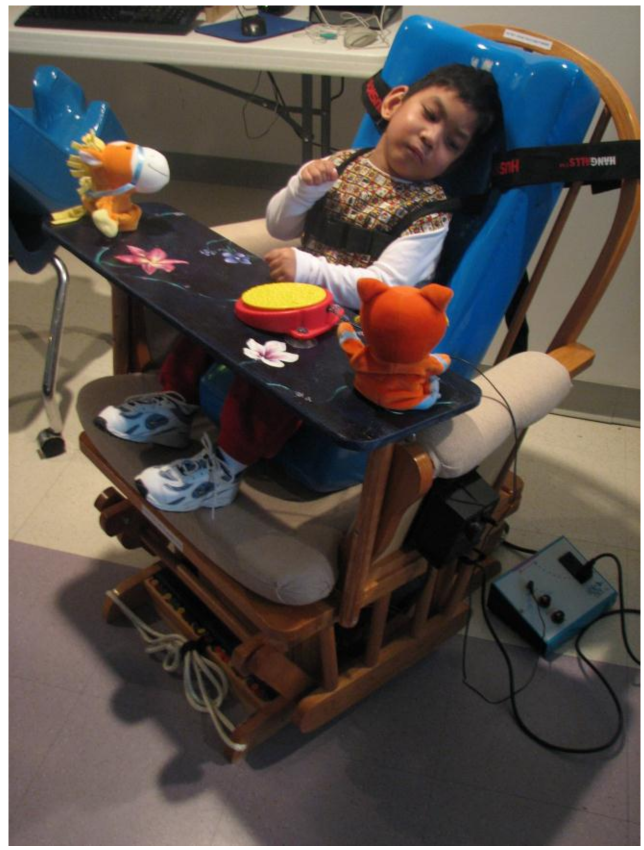

Fig. 7.1. Automatic Rocking Chair.

The motor provides 235 in-lbs of torque and operates at a maximum speed of 62-rpm. A Dart (model #5JJ58) speed control allows users to adjust the speed of the motor within a 0 to 30-rpm range. One rotation of the motor translates into one full swing of the chair, so the maximum rocking frequency of the chair is one swing every two seconds. The speed control is conveniently mounted on the side of the chair and plugs into a wall outlet.

A Powerlink2 device (Ablenet, Inc.) allows children to initiate the rocking motion via a switch selected by an aide. Because not all the children have the physical or cognitive ability to use this feature, the

PowerLink2 also has a setting that allows the teacher to turn on the device.

A custom adjustable-height desk provides a sturdy surface for the child-operable switch. Two wooden dowels, connected to the chair, slide through holes in the desk. Two pins fit through holes in the dowels to support the desk at four different heights.

A TumbleForms child seat attaches to the chair with two Velcro straps that fit through slits on the child seat and wrap around the back of the chair. To accommodate different children, the seat incline is adjustable. Wheels (attached to the back legs of the chair) and a lifting strap (attached to the front legs) make the chair transportable. Lifting the strap upwards tilts the chair back onto the wheels so it can be rolled into an adjacent room.

Cost of parts was approximately $850.

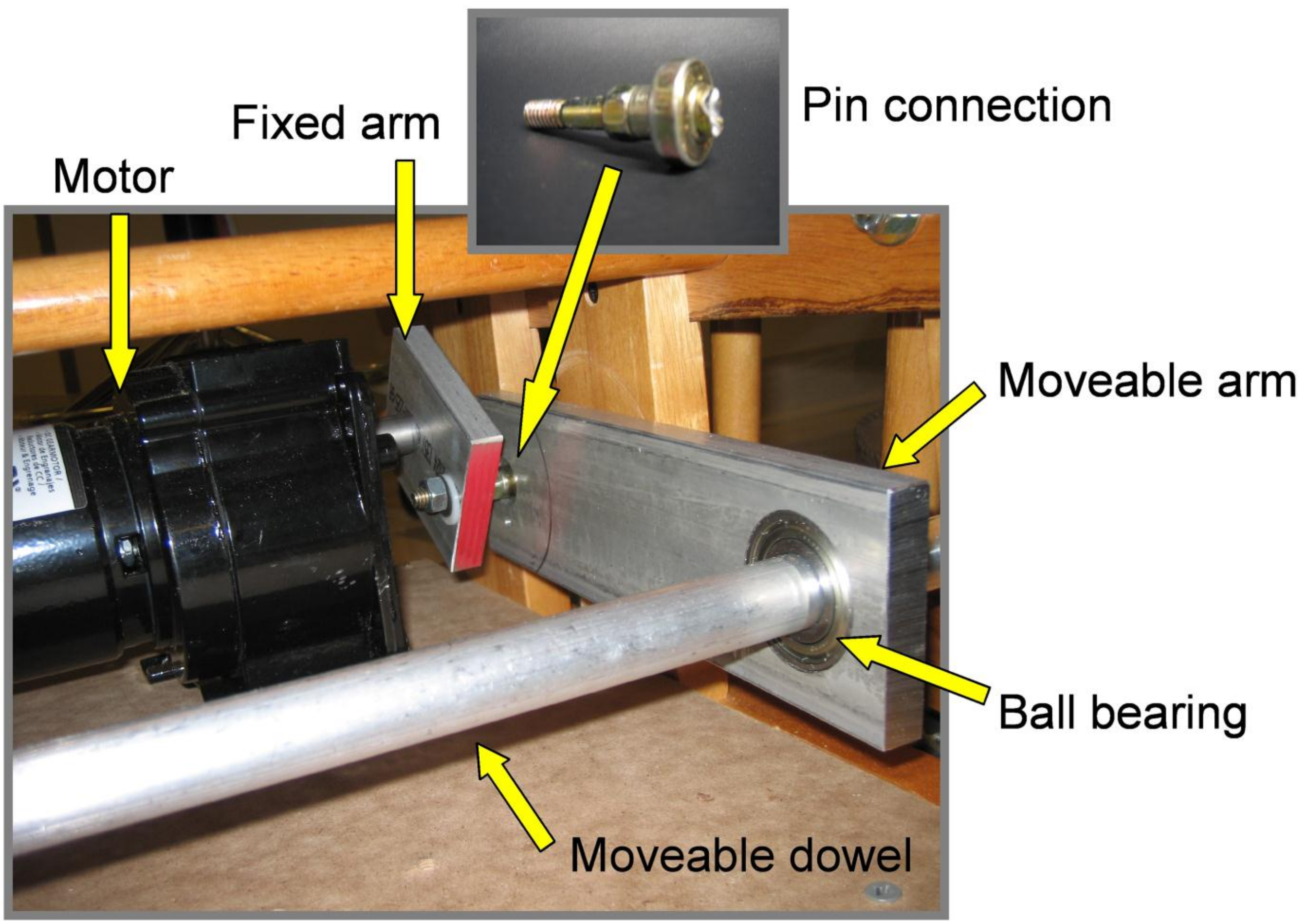

Fig. 7.2. Automatic Rocking Chair Components.

BATH CHAIR

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INTRODUCTION

The Bath Chair was designed for an eight-year-old boy with Thrombocytopenia Absent Radius (TAR) Syndrome, who could not bathe independently because his arms are weak and very short. The Bath Chair has a PVC frame and mesh bath sponges as washing surfaces. A shower caddy is mounted to a safety railing on the right side of the chair, and showerheads attach to the top of the chair and to a safety railing on the left side. The client controls water flow for each showerhead using two push-button valves on a diverter.

SUMMARY OF IMPACT

The client previously needed help from his parents to bathe, but he can now bathe himself. His mother commented, “This is a huge step for (him) in terms of personal care... I can't put into words the joy it makes me feel to see him excited about gaining his independence.”

TECHNICAL DESCRIPTION

The frame of the Bath Chair (Fig. 7.3) is made from 1 ½” furniture-grade PVC pipe. The base is rectangular and has two layers. The bottom layer is for structural support, and the top layer, which contains an extra horizontal crossbar, supports the seat. Safety rails on each side of the seat are made from one inch PVC.

Two showerheads are mounted to the frame of the chair: one at the top of the seat back and one on the left safety railing. A flexible hose attaches to the tub faucet via a threaded fitting. This hose is connected to a diverter valve, which connects to hoses for two showerheads. Each showerhead attaches to the frame on a rotating showerhead mount. A handle made from ¾” PVC pipe with a PVC tee attaches to each rotating mount, allowing the client to control the direction of water flow. The diverter has an on/off switch for each branch, which allows him to control the water supply to each showerhead.

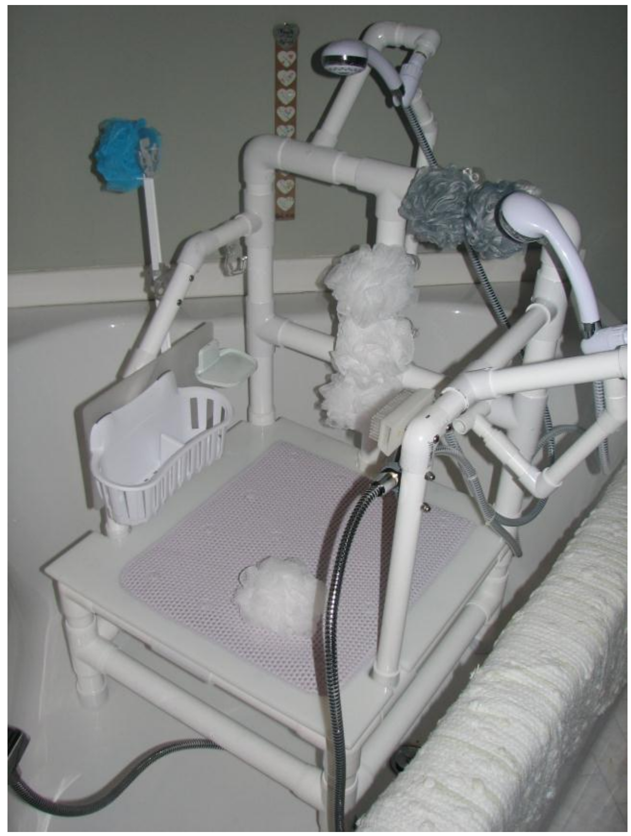

Fig. 7.3. Bath Chair.

The seat is made from ½” thick high density polyethylene with smooth routed edges. It is secured to the base with countersunk flat-head stainless steel machine screws. The top of the seat is covered with a ComfortArt™ Plus Non-Slip Bath Mat (Griptex), which gives the seat a comfortable non-slippery surface. Small holes drilled through the seat prevent pooling of water.

An acrylic sheet attached to the right safety railing provides a convenient location for bathing accessories. A soap/shower caddy, which holds soap, shampoo, and a cup that the client uses for rinsing, is mounted to the acrylic sheet. Bath sponges attached to the frame of the chair allow him to wash different parts of his body by rubbing against them: two sponges on the top bar for his head, three on the middle vertical bar on the back for his back, and one on the seat for his groin area and backside. Each bath sponge attaches to the frame using a custom attachment system, which consists of an ovular acrylic sheet with two acrylic disks secured to one side using rivets. The result is similar to the clasp of a manila envelope and holds the bath sponge tightly when the strings of the sponge are wound around the disks. This system makes the sponges secure and also easy to replace. Fig. 7.4 shows the client using the Bath Chair.

Cost of parts for the device was approximately $500.

Fig. 7.4. Client Using Bath Chair.

WHEELCHAIR RAMP POWER ASSIST

Designers: Daron Gunn, Audrey Burke, and Sophie Strike
Supervising Professor: Larry Bohs
Department of Biomedical Engineering
Duke University
Durham, NC 27708

INTRODUCTION

The client currently uses a manual wheelchair and wanted to preserve her independent lifestyle in the event of an upper body injury. The goal of this project was to develop a device to help her ascend the ramp into her home more easily. The Wheelchair Ramp Power Assist pulls her up the ramp using a winch motor and a steel cable attached temporarily to her wheelchair. A remote control, held by the client, actuates the winch. A pull-cord safety switch mounted to the ramp rail stops the system in an emergency. This system provides powered assistance for the client and still allows her to ascend the ramp manually.

SUMMARY OF IMPACT

The client uses the device regularly and more often in cold and inclement weather. She commented, "The Ramp Assist has become a useful tool in my routine. It saves energy and stress on my shoulders. I used it daily during the winter and use it a few times a week in the spring. The Ramp Assist has given me an added and unexpected factor of safety and independence, especially in winter weather. The surface of the ramp ices over so on occasions when there was ice or snow, the Ramp Assist enabled me to get up without help. I could barely get up without it because my wheelchair tires would not grip on the ice or snow."

TECHNICAL DESCRIPTION

The Wheelchair Ramp Power Assist (see Fig. 7.5) uses a 12-volt DC winch (Superwinch T1500) with a 40′ steel cable that ends with a large spring hook. A second piece of steel cable with spring hooks attached to each end loops through this hook. The client attaches her chair to the system by attaching these two hooks to each armrest on her wheelchair (see Fig. 7.6).

The client controls the winch using a wireless remote system (Superwinch). The remote has two buttons, one for winding and one for unwinding the

Fig. 7.5. Wheelchair Ramp Power Assist Components.

cable. The client must continually press the buttons on the remote to operate the winch. This feature provides a safety mechanism, because if the client drops the remote, the winch will automatically stop. The wireless receiver is housed in a weatherproof box and mounted at the top of the client's ramp near the winch.

The winch is powered by a 12-volt deep-cycle lead-acid battery, which is necessary because no outside power outlets exist at the client's condominium. The battery must be charged approximately every four weeks. A battery charger (Schumaker, Monroe, NC), battery tester (Motormite), and extension cord are provided. The battery and charger are stored out of sight under the ramp. The battery tester is mounted at eye level at the top of the ramp, alerting the client with an LED light when the battery needs charging. To charge the battery, the client attaches the extension cord from an outlet just inside her front door to the male AC plug securely mounted near the winch, and leaves it overnight. A double throw toggle switch with two positions, "winch" and "charge", guarantees that the winch cannot be used while the battery is charging, and vice versa.

An industrial single pull stop switch (Allied Electric, Southfield, MI) provides an additional safety mechanism. The pull stop connects to a cable that runs down the length of the ramp. Should the winch continue winding when the client releases the remote button, the client can pull the cable, cutting power to the winch and stopping all movement. The client can then unhook herself and ascend the ramp manually.

The winch cable is taken to the bottom of the ramp by reversing the winch direction while the client descends. Descending in this manner takes longer than descending freely, but she has improved her speed and comfort with practice.

Cost of parts was $840.

Fig. 7.6. Client Using Wheelchair Ramp Assist.

ICE SKATING CHAIR

Designers: Keigo Kawaji, Eric Blatt, and Kalpana Sampale
Client Coordinators: David Burns and Sue Cheng
Supervising Professor: Larry Bohs
Department of Biomedical Engineering
Duke University
Durham, NC 27708

INTRODUCTION

An ice skating chair was developed to allow individuals who use wheelchairs to participate safely in skate-in events organized by a hockey league franchise. The device is a modified manual wheelchair on hockey skate blades. It enables participants to skate with assistance. The device includes a safety brake that automatically stops the chair when the assistant releases a lever. It is easy to operate by any experienced skater pushing from behind and accommodates transfer between chairs when off the ice.

SUMMARY OF IMPACT

The Ice Skating Chair provides an opportunity for hockey fans in wheelchairs to participate in skate-in events.

TECHNICAL DESCRIPTION

The Ice Skating Chair (see Fig. 7.7) was constructed by modifying a standard manual wheelchair. The rear wheels were replaced with skating blades, mounted parallel and 20″ apart. These were bolted to a 1/4″ aluminum plate, which is bolted to the wheelchair frame. The blades were tilted on a 13-degree angle, using aluminum wedges, to recline the chair backwards for user safety and comfort. Handlebars, made from bent conduit and padded with foam insulation and fabric, were attached to the rear of the wheelchair.

A braking mechanism provides safety in the event that the pusher loses control of the chair. This mechanism consists of a rectangular bar of one inch square steel tubing hinged on the front end and forced downward by a 70-lb compression spring at the rear. The brake is made of a five-inch-long metal plate that attaches to the bar three and a half inches from the point of rotation so that it contacts the ice when at rest. A bicycle cable attaches to the bar and to a brake lever on the handlebars. When the pusher releases the lever, the brake plate engages with the ice. The braking mechanism is calibrated by adjusting the cable length so that the brake rests on ice when the brake lever is released and is lifted a half inch above the ice when the brake lever is depressed.

Pads protect the user and other skaters in the event of a collision. The front protector consists of youth-size goalie pads (23″ x 11″) mounted to wooden panels that are attached to tubing inserted in the wheelchair leg supports. The tubing is custom bent to support the front padding system, which allows it to swing open while a skater loads or unloads from the chair. The tubing for each side joins in the center with a compression fitting, allowing for easy locking or unlocking. The right cover uses Velcro to allow users to access the bolt to adjust the foot rest height. Custom side protectors attach to the wheelchair armrests and provide protection as well as extra support for the user's arms. Finally, safety harnesses and supports for the neck, back, torso, pelvis, knee, and ankle were installed.

On-ice tests revealed that the chair glides smoothly as long as the pusher does not exceed a maximum safe speed of about eight-mph. Users can be transported off-ice by lifting on the rear handlebars and rolling the chair on the front wheels.

Cost of parts was approximately $520.

Fig. 7.7. Ice Skating Chair.

WHEELCHAIR GARDEN CART

Designers: Eric M. Spitz, Jordan M. Sadowsky, & John M. Schoenleber
Supervising Professor: Larry Bohs
Department of Biomedical Engineering
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Durham, NC 27708

INTRODUCTION

The Lawn Care Assisting Device (LCAD) helps a woman who uses a manual wheelchair to garden independently. The device's shape maximizes usable space and increases tool accessibility. The LCAD is composed primarily of Lexan and uses swivel caster wheels for optimal maneuverability. A sturdy removable shelf and a rear flap maximize the device's functionality. The LCAD easily attaches to and detaches from the wheelchair and transports items such as a watering pail, gardening tools, and yard waste. The client uses the device to water her garden and transport piles of leaves, among other tasks.

SUMMARY OF IMPACT

The LCAD enables the client to better enjoy one of her favorite pastimes. She commented, "This cart has made it so much easier for me to garden... I really appreciate it. It is great!"

TECHNICAL DESCRIPTION

The LCAD (see Fig. 7.8) easily attaches to the client's manual wheelchair, which allows her to transport yard waste (such as leaves), carry tools (a rake, clippers, etc.), and carry a full water pail.

Fig. 7.8. Lawn Care Assisting Device.

The device consists of a narrow chamber that fits between the rear wheels of the wheelchair and a larger primary chamber with a hinged rear flap. An elevated shelf within the primary chamber provides a convenient location for small tools and a watering can, within reach of the client while seated in her chair. An attachment hook holds the shelf on the side of the cart when it is removed to increase storage capacity of the main chamber. The chambers are constructed using 0.375" Lexan walls and a 0.22" polycarbonate base, attached rigidly using stainless steel, countersunk screws. Large rubber caster wheels are bolted onto the bottom of the cart, and the shelf, made from 0.375" Lexan, rests on Lexan blocks. The rear flap, a 0.093" sheet of Lexan, attaches to the base with a brass piano hinge. A lawnmower pull cord raises the flap. Magnets inlayed into an upper crossbar, connect with metallic sheets. The sheets are inlayed into the flap to hold the flap in the upright position. The user can easily detach the flap by pushing so it will lie like a ramp to allow the chambers to be filled with garden debris.

The front attachment mechanism uses two tubes, which connect to the safety wheel attachment supports on the client's wheelchair. They provide support in vertical and horizontal directions. A large hinged hook prevents the cart from pulling away from the wheelchair. Drainage holes allow water to drain from the chambers. A circular sander was used to smooth all corners and give the Lexan a scratch-resistant, foggy look.

Cost of parts for the LCAD was approximately $480.

Fig. 7.9. Client Using LCAD.

SOOTHING ROCKING CHAIR

Designers: Phil Nicholson, Justin Hilliard, and Josh Lundberg
Supervising Professor: Larry Bohs
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INTRODUCTION

The client is a 13-year-old boy with cerebral palsy. The purpose of this project was to develop a soothing environment for him to find comfort when anxiety levels are high. The Soothing Rocking Chair includes vibration and audio output with easy-to-use controls to accommodate his degree of motor capability. In addition, the device includes a removable desk workspace to provide a place to read and a digital photo album for viewing his own photos.

SUMMARY OF IMPACT

The client's mother commented, "The innovative combination of music, rocking and vibration has been of therapeutic value to our son. When he is feeling upset and anxious he chooses to retreat to his chair and "chill out." [He] will be having orthopedic surgery this summer, and the wide seat and reclining angle of this rocking chair will really help facilitate his recovery. I know he will be spending a lot of time in his chair this summer."

TECHNICAL DESCRIPTION

The Soothing Rocking Chair (see Fig. 7.10) consists of a gliding rocking chair that incorporates audible, tactile, and visual stimulation elements to engage the client's personal interest while providing a comfortable and soothing environment. A Boom Chair 2.0 (Lumisource, Inc.), which includes vibration and audio elements, forms the foundation for the device. The chair is mounted in a supportive wooden frame, modified from a SafeRocker Deluxe Adult Glider Rocker (Foundations, Inc.).

The Boom Chair includes vibration motors throughout and has large knobs on the side that allow the client to adjust the intensity of the vibration and sound. RCA jacks on the chair are used to play music through the speakers. A modified CD player connects to RCA jacks, which allow the client to select his own music. The CD player's remote is hard-wired to large pushbuttons

Fig. 7.10. Client Using Soothing Rocking Chair.

mounted to the chair, giving the client easy control of play, pause, skip, and stop functions.

A custom work desk allows the client to read books, draw pictures, or do homework while sitting (see Fig 7.11). The desk features a two-inch recessed work area that is large enough to fit a standard 8.5" by 11" piece of paper. The desk features a locking mechanism with ¼" spring pins inserted into dowels that connect the desk to the chair, which prevents the desk from tipping. An assistant is required to move the desk while the user is in the chair.

Because the client enjoys taking pictures and viewing them on the computer, a digital photo album (CRDMP4, Ziga USA, Inc) is mounted onto the structure supporting the chair. The album is mounted to a dowel rod, which slides into a custom slot on the chair so that the album can easily be attached or removed.

To provide additional stability to the Soothing Rocking Chair, eight inch long anti-tilt extensions attach to the rear legs, making it impossible for the client to tip the chair backwards. To help him enter and exit the chair safely, external wooden armrests are attached to each side of the chair. Extending approximately four inches above the original armrests, the external armrests help stabilize his body as he enters and exits the chair. A rear wooden connecting arm attaches between both external armrests to ensure that the client cannot fall out of the chair.

Cost of parts was about $800.

Fig. 7.11. Client Using Chair with Desk.

CONVERTIBLE TRI-CANE

Designers: Amanda Fuller, Yubo Gong, and Toby Kraus
Client Coordinator: Allison Darwin, OT
Supervising Professors: Kevin Caves and Richard Goldberg
Department of Biomedical Engineering
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Durham, NC 27708

INTRODUCTION

The client is a 95-year-old male with a fused left knee and mild dementia. He enjoys walking outside but tires easily and sometimes needs additional support, especially when walking on unfamiliar terrain. The Convertible Tri-Cane was designed for the client. It is a single-point cane that can be converted to a tri-point cane for additional support. The design uses a twist-and-push mechanism, which allows the client to easily convert between modes. The Convertible Tri-Cane allows for either left- or right-hand usage, and is also height adjustable.

SUMMARY OF IMPACT

The client did not initially feel he needed the additional support. However, as the project progressed he appeared much more interested in the stability the tri-point mode provided. His occupational therapist stated, "Since we started this project, he has realized that he needs more stability." It is now easier and safer for the client to walk outdoors. He can walk faster, more comfortably, and more independently.

TECHNICAL DESCRIPTION

The Convertible Tri-Cane (see Fig. 7.12) includes tripod legs and a sliding mechanism that provides easy conversion between single and tri-point modes. The tripod legs are made from ½", furniture-grade, black PVC, bonded with heavy-duty cement. PVC was chosen instead of aluminum to minimize weight. The PVC legs connect to a pivot, made by mounting a four-way joint onto the cane. PVC extensions insert into the horizontal extensions of the joint and are milled precisely to create a snug fit that still permits rotation.

An aluminum cross-brace connects the two legs together and is through-bolted to each leg with two screws and nylon lock washers. To connect the tripod mechanism to the sliding mechanism on the shaft of the cane, two hinge-arms attach between the cross-brace and a shaft collar on the base of the sliding mechanism. The hinge-arms are attached to the cross-brace via a custom U-shaped steel bracket. The sliding mechanism uses an aluminum tube, slightly larger in diameter than the client's cane. A slot milled vertically in this tube allows a pin on the cane shaft to keep the mechanism positioned properly. Two shaft collars at the top of the sliding tube allow the mechanism to lock in place. The lower aluminum collar provides a secure attachment to the sliding tube. The upper Delrin collar attaches to the lower collar and provides a snug fit around the cane shaft. A handled-screw in the Delrin collar allows the sliding mechanism to lock in place. When

Fig. 7.12. Convertible Tri-Cane.

the screw is tight, the slider and thus the tripod legs are immobilized in either the up or down position; when it is loosened with about one-half to one-third of a turn of the handle, the sliding mechanism easily moves up and down. Fig. 7.13 shows the client using the cane.

Cost of parts was about $400.

Fig. 7.13. Client Using Cane.

CUSTOM EASEL

Designers: Tommye Fitzpatrick, Jessica Son, Christine McMahon
Client Coordinator: Karen Hammers
Supervising Professors: Richard Goldberg, Kevin Caves
Department of Biomedical Engineering
Duke University
Durham, NC 27708

INTRODUCTION

The client is a five-year-old male with cerebral palsy. He has an unstable trunk and stiff arms that move best vertically at the elbow. He only has use of his left hand, which cannot comfortably grasp anything less than one inch in diameter, and he is suspected to have Cortical Vision Impairment. The Custom Easel has adjustable angles and a magnetic whiteboard. The angle of the easel work surface may be adjusted to the best angle for the client, depending on the activity. A modified paper cutter, modified glue bottle, book ledge, clothespin book clips, page-turning wand, and magnet clips help him independently glue, cut, hold books, and turn pages. The Custom Easel also accommodates his suspected visual impairment with a detachable magnifying device.

SUMMARY OF IMPACT

The client's teaching assistant stated, "This project is a huge step in achieving independence for him at school. Now he will be able to work on many more tasks by himself. As he gets older, the easel will be able to adapt as his needs change."

TECHNICAL DESCRIPTION

The Custom Easel (see Fig. 7.14) features a 13" x 18.5" magnetic white board work surface with a ¾" varnished oak frame. The 16" x 23" varnished oak easel base adjusts to four positions, from flat to almost 90 degrees, with a reinforced stainless steel brace that folds flat for carrying. A black non-skid mat keeps it from moving while the easel is in use.

A sliding magnifier was developed from a commercially available 22" x two inch varnished wooden drawer slide. The magnifier slides over the top of the easel work surface and is held in place on top by two metal brackets. The male part of the drawer slide is raised two and a half inches above the work surface, thereby magnifying the book or paper underneath without distorting the letters.

Fig. 7.14. Custom Easel.

Pegs on the male and female pieces of the slide allow the client to slide the magnifying sheet all the way to the left edge of the easel work surface so the client can turn book pages but simultaneously keep the male piece from falling out of the female piece. A cutting device was modified from a FISKARS® Ultrashape Xpress by shaving a rubber anti-skid pad down to fit around the blade, allowing the cutter blade to retract inside and not be exposed when the device is not in use. Two strips of magnetic tape attached to the bottom of the cutting device stabilize it against the magnetic white board. To hold paper in place while cutting, six sheet metal strips with magnetic tape attached to the back are supplied (two two inch, 7.5", 10.25", two 13"), to be placed around the edge of the paper.

A gluing device was modified from an Aleene's® Brush-On Tacky Glue bottle. The tacky glue is replaced with Elmer's® Washable School Glue. A rare earth magnet glued to the bottom of the glue bottle helps it stick to the magnetic white board work surface. A modified plastic salsa bowl fits like a skirt around the glue bottle, stabilizing it while in use. A one and a ½" tall foam roller, attached to an oak disk, is screwed into the top of the glue bottle so that the client can hold the glue brush more easily and comfortably.

To facilitate page-turning, a wand was created by gluing a ¾″ diameter round magnet and metal ring onto the end of a 4.5″ long, one inch diameter wooden dowel. Three-quarter-inch diameter magnets were also glued on plastic AccoTM Hot Clips, one magnet per clip were are placed on the edge of each page of a book for the client to turn. The clip magnets are not strong enough to stick to each other, but are strong enough to stick to the magnetic wand. Plastic magnet clips are used rather than metal paperclips because they give an added weight to the page, ensuring that once the client turns the page, the page will not flip back, frustrating the client.

Two rare earth magnets are placed on the back of a wooden ledge for a book to sit on, and five magnets are placed on the backs of two 6″ clothespins that hold either side of the book open. To make transporting the easel and all of its accessories around during the school day easy, a 23″ x 27″ durable nylon ArtBin® Tote Folio is provided. The main pocket of the folio is lined with cotton batting to prevent damage in the case of accidental drops or falls to the folio. Since the client's aide needs both hands free to push his wheelchair from classroom to classroom, the folio can either be worn slung over the shoulder using its shoulder strap, or it can hang on the back of the client's electric wheelchair. Fig. 7.15 shows the client using the easel.

Cost of parts was approximately $260.

Fig. 7.15. Client with Easel.

DIGITAL CAMERA ASSIST

Designers: Greg Larkin, Alissa Van Arnam, and Greg Darland
Supervising Professors: Kevin Caves, Richard Goldberg
Department of Biomedical Engineering
Duke University
Durham, NC 27708

INTRODUCTION

The client is a 14-year-old boy with cerebral palsy who enjoys photography. He cannot consistently use a camera because it is difficult for him to hold it and the buttons are too small to access reliably. The Digital Camera Assist is a custom machined enclosure for a compact digital camera. It has a comfortable handle and large buttons that actuate standard camera functions. With it, the client can enjoy one of his favorite hobbies.

SUMMARY OF IMPACT

The client's mother commented, "This is the most amazing device. The design and materials used is just outstanding. [He] loves this camera more than any other toy or tool he owns. He always wants to take pictures wherever he goes… Having these adaptations has allowed [him] to pursue a hobby that he didn't have total access to before. It has facilitated his creativity, literacy, and computer skills. After he uses the camera to take the pictures, he wants to download them to his computer and has been writing sentences and building stories using these pictures. This is huge for [him]."

TECHNICAL DESCRIPTION

The Digital Camera Assist (see Fig. 7.16) consists of a custom housing that was fabricated using black Delrin® plastic. It is designed to accommodate the client's camera, a Casio Exim Z750. The housing has two parts, the base and top. The base secures the camera from three sides: 1) bottom; 2) left; 3) right. An extension off the left side allows for attachment of the handle. The base also houses the mechanisms of two buttons, the left and right review buttons, on the back side of the camera. A right hand grip attaches to the right side of the base.

Fig. 7.16. Digital Camera Assist (Rear View).

The top secures the camera inside the base piece. It attaches to the base by a hinge on the right side and a draw latch on the left side. The draw latch operates similar to the draw latch on the front of a toolbox. The top also houses the mechanisms for three buttons: 1) power; 2) shutter; 3) zoom.

The handle is fabricated using a black diameter Delrin® acetal plastic rod. This rod extends below the base piece on the left side of the camera. A bike grip attached to this rod provides a comfortable grip. The right hand grip was custom made to fit our client's hand from a piece of black Delrin® acetal plastic. It attaches by four screws to the right side of the base piece below the hinge.

The buttons are made from: 1) screws; 2) nuts; 3) screw caps; 4) springs. They attach to the housing through predrilled holes and are secured by the nuts. The springs retain the buttons in the "off" position when not being pressed.

A zoom control button was created using: 1) an additional piece of black Delrin®; 2) two small screws; 3) two small springs. It magnifies the existing zoom control on the camera and makes it easy for the client to zoom in and out with a horizontal shift of the button. A small eye hook on the left side of the base provides an attachment point for a camera strap. Fig. 7.17 shows the client using the device.

Cost of parts was about $350.

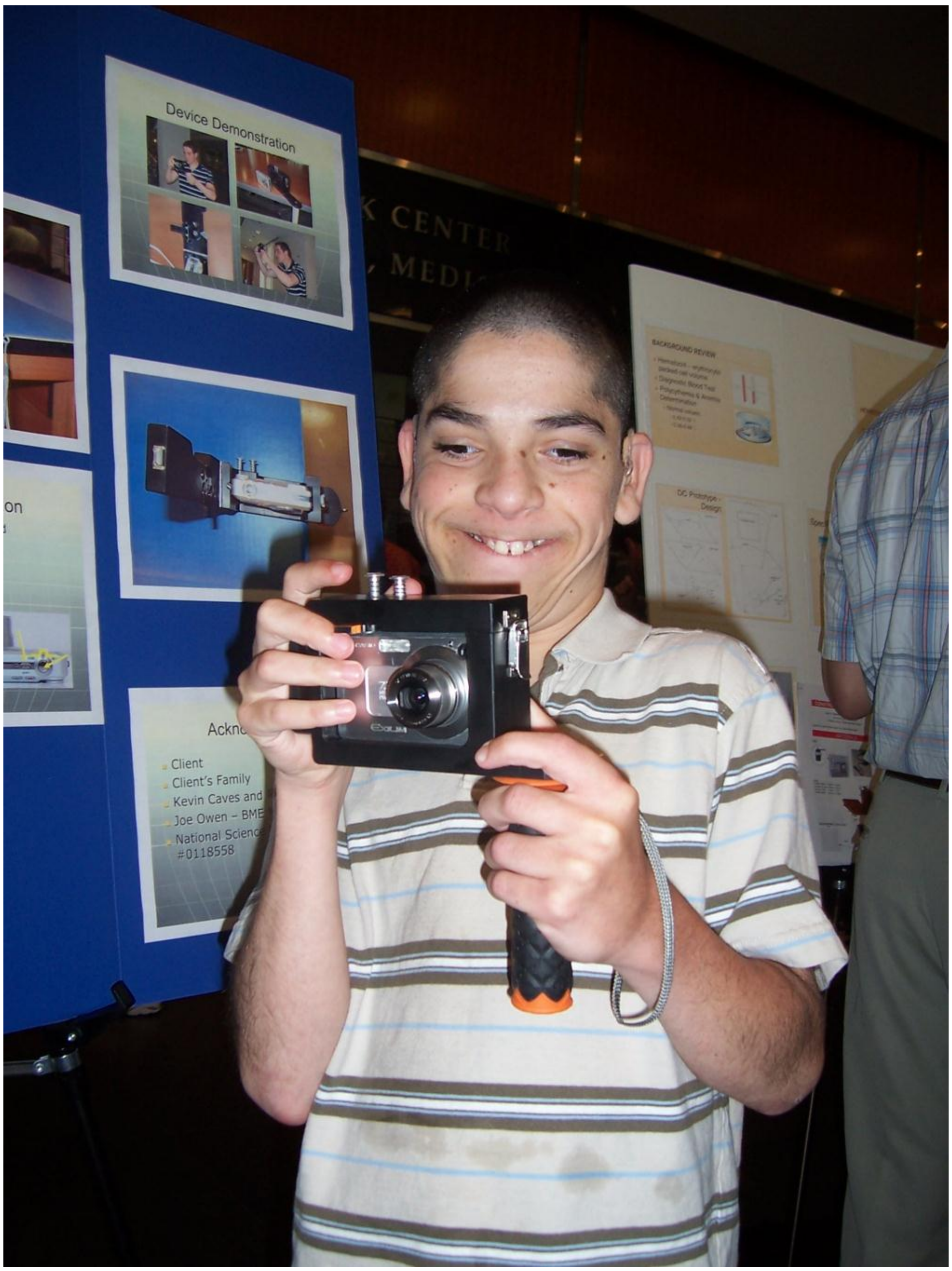

Fig. 7.17. Client Using Camera Assist.

EXERCISE MOTIVATOR

Designers: Turan Kayagil, Matan Setton, and Jenny Yuan
Client Coordinator: Catherine Alguire, OTR/L
Supervising Professors: Richard Goldberg and Kevin Caves
Department of Biomedical Engineering
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INTRODUCTION

The client is a 14-year-old male with autism, attention deficit hyperactivity disorder, and mental retardation. He benefits from regular aerobic exercise on a stationary bicycle, but loses interest after less than eight minutes and relies on food and verbal reinforcements from his supervisors while pedaling. The Exercise Motivator links a commercial stationary bicycle to any assistive technology device accepting a standard switch input, such as a battery interrupter, PowerLink unit, or keyboard emulator. In addition, a universal remote has been adapted so the exercise motivator can trigger the remote to send play or pause commands to a CD or DVD player. When the user pedals above a threshold speed, the associated device is turned on. The exercise motivator also provides verbal prompts in response to sustained above or below-threshold activity.

SUMMARY OF IMPACT

The client coordinator commented, "This project does an outstanding job of meeting the highly specific activity support needs of this developmentally complex teen … I am especially excited that the output can be graded to adjust for learning and skill acquisition, as well as be flexible enough to easily use with a wide variety of other items. This unique device has the potential for meeting life-long activity support needs for this individual."

TECHNICAL DESCRIPTION

The Exercise Motivator (see Fig. 7.18 and Fig. 7.19) accepts the standard reed switch output, built into most stationary bikes, as an input to determine pedaling speed. For bikes without the reed switch output, an aftermarket switch can be installed. The device creates a switch closure output signal compatible with commercial assistive technology devices and connects to them with a 1/8" plug. When the pedaling cadence reaches a threshold value, the Exercise Motivator turns on the external device.

The device is housed in a 5.3" x 5.3" x 2.0" case. Primary control functions are accomplished by a BASIC Stamp 2 microcontroller (Parallax, Inc.). Voice prompt playback is accomplished using an MP3 playback module (Rogue Robotics Corp.). The device inputs include: 1) a 1/8" (3.5 mm) mono jack for the bicycle; 2) a 1/8" (3.5 mm) mono jack for an auxiliary switch (described below); 3) an SD flash memory card slot for the MP3 player; 4) a size N coaxial DC power jack. The outputs include: 1) two RCA phono jacks for external device control; 2) a 1/8" (3.5 mm) stereo headphone jack for playing verbal prompts; 3) a piezo buzzer. Device controls include: 1) an illuminated power switch; 2) a mode select switch; 3) a threshold knob; 4) a recalibrate button to adjust the dynamic range of the threshold knob. The device is powered by a nine-volt DC, 300-mA power supply. Appropriate cables are provided for making connections.

The device compares pedaling speed to a threshold set by the position of a threshold control knob. The dynamic range of the threshold knob can be calibrated to a particular bicycle using the reset button on the front of the device.

The device has two separate outputs, which are switched by relays. It can be set in one of two modes using a mode switch. In "continuous" mode, output switch one is open below the threshold and closed above, and output switch two is closed below threshold and open above. In "momentary" mode, both outputs are open, but output one pulses closed on upwards threshold crossings, and output two on downwards crossings. Sustained activity above threshold elicits praise prompts played over the headphone jack, and below-threshold activity elicits encouragement. Voice prompts are selected randomly from a list and may be custom recorded on the memory card, which plugs into an accessible slot in the rear of the device. The device also has an auxiliary switch input, which allows an external button to be connected in series with the first output. In continuous mode, the button is active, but below threshold it does nothing. Removing the button automatically returns output one to its normal operations.

Cost of parts was approximately $550.

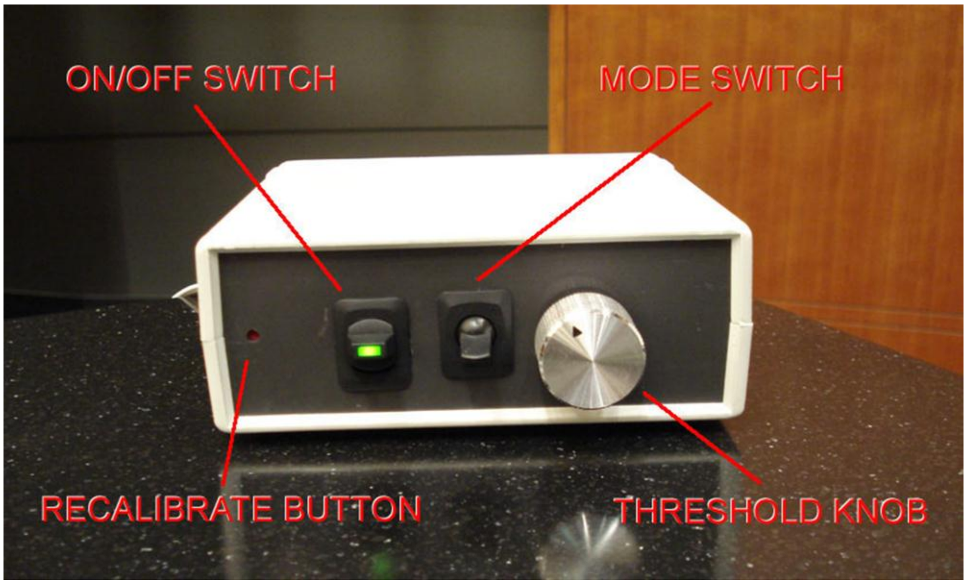

Fig. 7.18. Exercise Motivator, Front Panel.

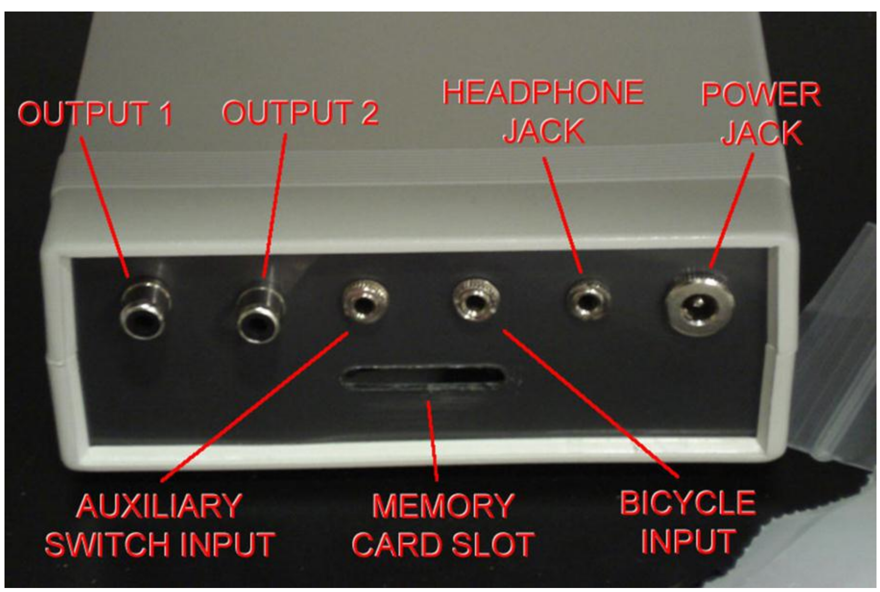

Fig. 7.19. Exercise Motivator, Rear Panel.

RAIN SHIELD

Designers: Kelsey Boitnott, Dennis Cattel, and Shawn J. Mendonca
Supervising Professors: Kevin Caves and Richard Goldberg
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INTRODUCTION

A woman uses a manual wheelchair that she transports with her car. She gets wet on rainy days when getting in and out of the car and when traveling outside in the wheelchair. The Rain Shield uses a large commercial umbrella and custom attachments for the car and wheelchair to allow the client to remain relatively dry in these situations. An additional plastic shield attaches to the car and the umbrella to further improve protection when it is also windy.

SUMMARY OF IMPACT

The client commented, "As a new wheelchair user,

Fig. 7.20. Client Inside Rain Shield Attached to Car.

the rain has made it really difficult for me to get in and out using this chair. The rain shield is going to make it so much easier for me to get out and go to work and do my daily activities without getting wet."

TECHNICAL DESCRIPTION

The Rain Shield (see Fig. 7.20) includes four components: 1) the umbrella holder; 2) the wheelchair attachment; 3) the side panel; and 4) the umbrella closing system. The umbrella holder uses a 10.5" section of one and a half inch black diameter PVC pipe as a sheath to hold the umbrella upright. A semicircular notch, milled in the pipe near the top end, allows the umbrella to be secured to the pipe with a hose clamp. An eye screw attaches near the bottom of the pipe, and a carabiner clips through the eye screw. To mount the umbrella to the car, the user rests the umbrella between the opened door and the car roof, which is attached to the carabiner to the U-shaped door locking hook on the side of the car. A stainless steel L-bracket also attaches to the bottom of the black pipe, which is used to connect the umbrella to the wheelchair as described below.

The wheelchair attachment (see Fig. 7.21) mounts under the client's seat. The base of the wheelchair attachment consists of three 1/8" thick aluminum layers stacked on top of each other, with cuts and screws placed on specific areas depending on the functional use of the layer. A gap between the outer layers accepts the horizontal end of the L-shaped bracket on the umbrella holder. Once the bracket is slid into the base, it is secured by a pin. Two pairs of circular clamps secure the base to the wheelchair.

The clear vinyl side panel only needs to be used during extremely windy and rainy days. It attaches to the umbrella via six button snaps.

A closing system was devised to help the client close the umbrella after use, while seated in the driver's seat of the car. At the top end of the umbrella, nylon fishing wire is braided into the spokes. Below the spokes, this fishing wire is interwoven into a powder-coated black jack chain, which provides the main support of the closing system. A hanging hook attaches to the fishing wire/chain approximately 19" from the spokes. While the client is sitting in the driver's seat, the small carabiner is still attached to the door lock hook. The client then

Fig. 7.21. Client Using Wheelchair Umbrella Attachment.

pulls the hanging hook attached to the fishing wire/chain and attaches it to the outer hole of the L-shaped bracket. This closes the umbrella to a level where she can reach the umbrella slider and then fully close it.

Other features ensure stability, safety, and aesthetic appeal of the device. For connecting the umbrella to the car, a second attachment point was added to improve device stability. A large caribiner was attached to the grab bar in the front passenger side of the car. A nylon loop in the fishing wire/black chain approximately 20" from the umbrella spokes was attached to this caribiner on the grab bar. Also, a removable black nylon fabric cover was created for the umbrella holder to improve its appearance.

Cost of parts was about $440.

PORTABLE WHITE BOARD FOR HOSPITAL TEACHING

Designers: Brian Lee, Maher Salahi, and Vitaly Chibisov
Client Coordinator: Amanda Headley
Supervising Professors: Richard Goldberg, Kevin Caves
Department of Biomedical Engineering
Duke University
Durham, NC 27708

INTRODUCTION

The Portable White Board was designed to enable mobile school teachers in hospitals to move a white board between hospital rooms. The Portable White Board includes three components: 1) a large whiteboard for the teacher to write on; 2) a smaller easel whiteboard for the student or patient; and 3) a support structure for both of them. The large white board can be adjusted vertically and radially. The support structure is made of the: 1) base; 2) suction cup; and 3) basket. The easel is simply a whiteboard that can stand by itself and is portable.

SUMMARY OF IMPACT

The client coordinator, a local teacher, commented: "I have been wanting something that would improve my delivery to my bedridden students for many years. The board will enable me to introduce algebra problems more easily by being able to use the board for many practice problems as well as notes that the student can immediately refer back to. The board is more effective than leaning over their bed."

TECHNICAL DESCRIPTION

The Portable White Board (see Fig. 7.22) includes: 1) a teacher's portable whiteboard; 2) a student's easel; and 3) a support structure. The teacher's whiteboard was manufactured from a large piece of raw white board material (Everwhiteproducts.com). A frame was fashioned from one-inch by one-inch pieces of stained red oak, with a groove cut to contain the board. A penholder was made from an L-shaped piece of aluminum, bent into a more favorable angle. These components were glued together and to the whiteboard.

The easel was constructed in a similar fashion as the main white board, except that it does not harbor a pen holder. The easel support was made out of a plastic board and a reconfigured 5/16" steel beam. The beam was bent into a U shape with the top ends bent inwards. The plastic was made to fold out using two hinges, with a groove for the steel beam. The assembly was secured with epoxy glue and acrylic cement.

The support structure base uses 3" x 1 ½" aluminum rails (80/20, Inc.), configured in the shape of an "H". The base is attached to 3" casters to allow for easy movement around the hospital corridors. A large suction cup, designed to handle 100 pounds of force (Wood's Powr-Grip Co., Inc.), is attached to the base, allowing the structure to be locked in place. The suction cup is mounted to a vertical pipe that sits inside the main vertical support pipe. The user lowers the suction cup to the floor by twisting and lowering the inner pipe and activates the suction by pumping a foot lever. A stainless steel pipe with outer diameter of 1 ¼" is mounted to the base using U-bolts and a custom acrylic spacer that rests between the U-bolt and pipe, holding the pipe securely.

The teacher's white board is mounted to an acrylic plate, which is mounted to the vertical pipe. A custom acrylic cam, with an ergonomic handle, allows the board to rotate radially but lock in place easily. A collar on the bottom of the acrylic plate contains a through hole. A series of holes drilled in the vertical pipe allows the height of the white board to be adjusted by inserting a pin through the collar hole and the desired pipe hole.

A milk crate basket was bolted to the base to provide storage space.

Cost of parts was about $500.

Fig. 7.22. Portable Whiteboard.

CHAPTER 8
NORTH DAKOTA STATE UNIVERISTY

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MODIFIED ELECTRIC SCOOTER

Designers: Scott Bader and Scott Blegen
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INTRODUCTION

At the age of three, the client had both of his arms severed by a farm machine. Now nine, the client has learned to use his right and left arms, which measure 6" and 8 ½", respectively, for a wide range of tasks. As an active and sociable person, mobility is important to the client. Most traditional modes of transportation available to young people, such as bicycles, scooters, and roller blades, are not appropriate for the client. Various surgeries to improve the functionality of the client's arms have left his legs weakened; this fact further limits the transportation options that are available to the client. Attempts to adapt a traditional bicycle, for example, were unsuccessful.

The modified electric scooter (see Fig. 8.1) provides the client with an effective form of transportation. Each scooter modification was designed using the client's anthropometric data, which resulted in a custom device that accommodates his unique needs. The scooter is rugged and adjustable.

While there are many electric scooters available on the market, most are designed for geriatric clients. Few, if any, would pass as the type of scooter used by today's youth, and none appealed to the client. During the initial design meetings, the client communicated his desire for style as well as functionality. The client did not want an electric tricycle. Following a review of available two-wheeled electric scooters, the client selected an ESR 750 electric scooter manufactured by GoPed to serve as the platform for the project.

SUMMARY OF IMPACT

The scooter increases the client's independence. As reported by his mother, "the scooter is so good for him and especially in regards to confidence and mobility and keeping up with friends and their bikes. Once again, as spring approaches, I would like to say, 'Thanks'. He goes like a bandit on it."

Fig. 8.1. Modified Electric Scooter.

Fig. 8.2. Initial Scooter Adjustments.

TECHNICAL DESCRIPTION

The ESR 750 by GoPed is a high-quality, award-winning electric scooter that utilizes a 24-volt brush DC motor powered by 12-volt sealed lead acid batteries. In turbo mode, the scooter is capable of speeds up to 20 miles per hour and a range of approximately five miles. In economy mode, the scooter's top speed is reduced to approximately 12 miles per hour, but the range increases to around eight miles. Further, the scooter weighs a manageable 50 pounds.

To properly accommodate the client, the scooter required several modifications. First, the handle bars were fitted with foam grips that provide the client better grip and control than the factory default. Second, the post connecting the handle bars with the front wheel was modified to allow height adjustments within 0.5″ increments. Such adjustments are necessary to ensure comfortable riding posture as well as handle bars that will safely contact the client's arms as he grows. Proper height adjustment is also critical to ensure the client can manipulate the front caliper brakes. The brake lever was designed and positioned on the left handle to take advantage of the strength and leverage available with the client's left arm.

One of the most substantive modifications to the scooter was the speed control mechanism. The original thumb-actuated throttle was replaced with a right-foot actuated controller located on the front right portion of the scooter's standing platform. The throttle's range of motion, and thus the scooter's top speed, is parent-adjustable; initial settings limited the scooter's speed to less than 10 miles per hour. Lastly, the throttle surface was designed to withstand the forces associated with foot actuation.

The cost for the modified electric scooter, excluding labor and machining costs, was approximately $700.

Fig. 8.3. Maiden Voyage on Modified Scooter.

MOTORIZED TRANSPORTER

Designers: Chad Heidt, Forest Mandan, Paul Overman, and Wayne Shields
Client Coordinator: Bunnie Johnson-Messelt, Director of NDSU Disability Services
Supervising Professor: Subbaraya Yuvarajan, Ph.D.
Electrical and Computer Engineering Department
North Dakota State University
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INTRODUCTION

The motorized transporter is designed for individuals who have difficulty with heavy objects, such as carrying full backpacks, around campus (see Fig. 8.4). By moving the objects for them, the motorized transporter eliminates the need for the user to carry the objects themselves. The transporter contains two methods of control: a small joystick that can be controlled by the user's thumb and a leash control that uses a cable connected to the cart. The transporter has a built-in lift allowing objects to be brought up to waist height, giving the user the ability to slide objects from the unit onto a table. The motorized transporter is powered by a 12-volt battery which is recharged in a standard wall outlet by an onboard battery charger. The transporter is surrounded by a Plexiglas enclosure which extends with the lift to protect the user and others from moving parts.

Fig. 8.4. Motorized Transporter.

SUMMARY OF IMPACT

The motorized transporter gives the user the ability to easily transport heavy objects and removes the physical strain associated with lifting. The leash control allows the user to move around campus without the need to consciously steer the cart. The cart simply follows the movement of the user's hand. The joystick allows precise control of the cart in both the forward and reverse directions. The platform area is 26” by 21”, which makes it large enough to transport most objects students carry.

TECHNICAL DESCRIPTION

The motorized transporter consists of five main components: 1) control; 2) control circuitry; 3) motors and gearing; 4) lift; 5) battery charger. Fig. 8.5 shows a side view drawing of the motorized transporter and its components. Transporter speed and direction are controlled through a joystick or leash. The joystick is located inside the control handle and allows for precise 360-degree control. The leash cable extends, retracts, and swings side-to-side. These motions are sensed with potentiometers and cause the transporter to increase speed, decrease speed, and turn. Also located inside the control handle are a rocker switch that controls the lift, and a toggle switch that is used to select the operation mode.

The control circuitry consists of: 1) a 5-volt regulator; 2) a PIC16F876A processor; 3) three fully integrated automotive H-bridges. The regulator is used to step down the battery voltage from 12-volts to five-volts and maintains the voltage when the battery level drops. The processor converts the joystick and leash control signals to digital values. Using these values, the processor adjusts the duty cycle of the pulse width modulation (PWM) outputs to the motors, thereby controlling speed and direction. The H-bridges amplify the PWM signals to suitable levels for the motors.

The motorized transporter uses two 12-volt DC motors where each attaches to its own wheel. There is a five to one gear reduction between the motors and the wheels to reduce speed and increase torque.

Platform height is controlled with a scissors lift that extends 14” and can handle 50 pounds. Fig. 8.6 diagrams a top view of the lift components. The lift is driven by a 12-volt motor controlled by an H-bridge with a sprocket connected to the shaft. A gear connected to a threaded rod is driven by a chain connected to the sprocket. Two thresh washers hold the rod in place. The threaded rod passes through a ball screw that is inside of a track support. As the threaded rod rotates, the ball screw and support track move along the rod. There is a roller at each end of the support track for smooth movement.

The battery charger uses a UC3906 IC that monitors and controls the output current and voltage. The charger has three levels: 1) a high current bulk charge; 2) a controlled over-charge; 3) a standby state. The battery charger uses a standard wall outlet for power.

The total cost to build the motorized transporter was $731, which included all of the hardware needed to build the enclosure.

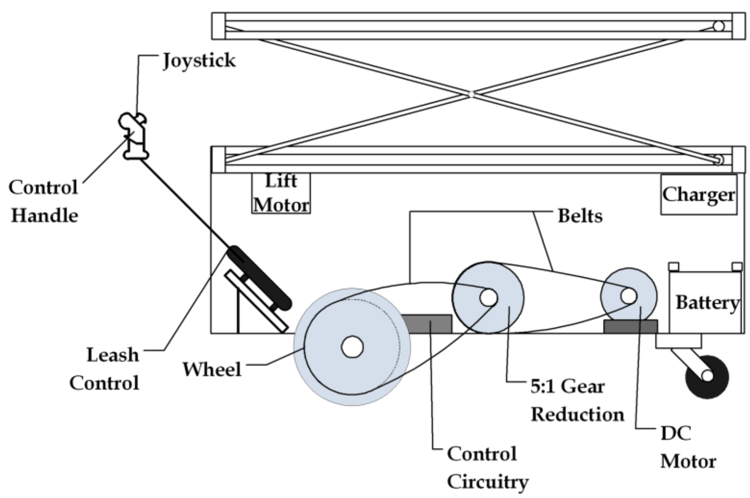

Fig. 8.5. Side View of Motorized Transporter.

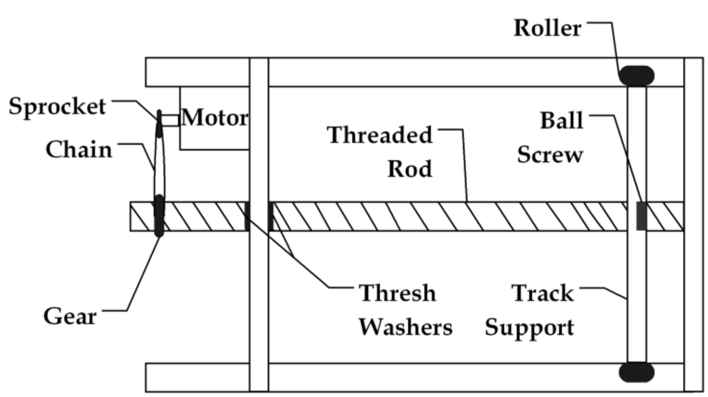

Fig. 8.6. Top View of Lift Components.

DOOR MONITOR

Designers: Craig Thingvold and Toby Johnson
Client/Coordinator: Todd Kollman, Adaptive Equipment Engineer
Supervising Professor: Jacob Glower, Ph.D.
Department of Electrical and Computer Engineering
North Dakota State University
Fargo, ND 58105

INTRODUCTION

The door monitor was designed for a children's facility that faced the risk of having certain children leave the premises unsupervised. The door monitor consists of a transmitter and a receiver (see Fig. 8.7). The transmitter device attaches to the child and is designed to be: 1) portable; 2) small; 3) durable; 4) inexpensive. The receiver module is unobtrusively located at the doorway and is able to detect multiple transmitters.

SUMMARY OF IMPACT

The door monitor system allows workers to supervise exits much more effectively. This increases the children's safety. Also, this design is simple enough to allow a facility to easily and inexpensively replicate or replace the transmitters. Upon delivery of the system, an adaptive equipment engineer for the facility remarked, "This is exactly what we needed." The transmitter is durable and easy to use.

TECHNICAL DESCRIPTION

The transmitter consists of three main components: 1) a 3-volt power supply; 2) a processor; 3) an RF transmitter. The block diagram for the transmitter is shown in Fig. 8.8. This device's dimensions are three inches by two inches by two inches. It has a clip that attaches to a belt loop or wheelchair.

The three volt power supply is composed of two AAA batteries connected in series. The batteries are placed in a battery compartment on the backside of the circuit board and a switch is used to allow power to flow throughout the circuit.

The processor, a PIC16F876A, controls the transmitter. This processor cycles the transmitter on and off to decrease power consumption. The transmitter is a LINX 418 MHz device that uses a 50 ohm whip antenna. To help conserve power, the transmitter's sleep mode is utilized by the processor.

Fig. 8.7. Transmitter and Receiver.

The receiver consists of six main components including: 1) a door switch; 2) an alarm reset; 3) a processor; 4) a receiver; 5) an alarm; 6) a five volt power supply. The block diagram for the receiver is shown in Fig. 8.8. The receiver must be positioned so that the entire doorway is within range of the receiver. The range at which the receiver can detect the transmitter is determined by controlling the power at the level adjust input on the transmitter. Based on facility requirements, the detection range is set to approximately six feet. This requires the receiver to be placed directly adjacent to the doorway.

The five volt power supply is an AC/DC converter that is plugged into a wall outlet. The power to the circuit is controlled by a power switch mounted on top of the receiver. The receiver is connected to a door switch that tells the receiver whether the door is open or closed. A piezoelectric speaker is mounted to the top of the receiver. This speaker is used as the alarm, and a potentiometer is used for volume control.

The receiver processor is a PIC16F876A and is used to control the alarm. When the door is opened, the door switch tells the processor to search for a transmitter. The processor actuates the alarm once the receiver sees the transmitter. The receiver is a LINX 418 MHz device. Once the door is opened and the processor determines that there is a transmitter in the area, the alarm is sounded and the user must press the reset button to silence the alarm. The processor will then wait ten seconds before it starts searching for the transmitter again.

The cost for the receiver was approximately $80, and the cost for each tag was approximately $70.

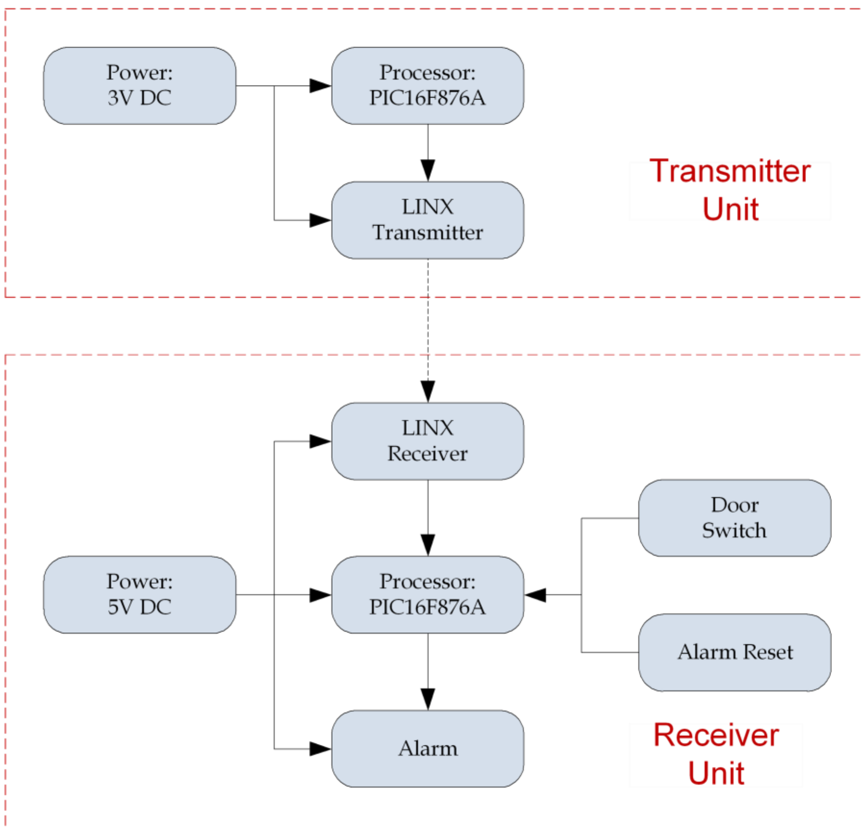

Fig. 8.8. Block Diagram.

PRIVATE DISTRIBUTION MAILBOX ALERT SYSTEM

Designers: Elizabeth Kueper, Ryan Boeshans, and Lance Sollid
Client Coordinator: John Stevenson
Supervising Professor: Jacob Glower, Ph.D.
Department of Electrical and Computer Engineering
North Dakota State University
Fargo, ND 58105

INTRODUCTION

The private distribution mailbox alert system is a continuation of an earlier senior design project. The previous system was designed for one mailbox. This project expands the design: 1) to provide functionality for multiple mailboxes; 2) to call individual users when mail is received; 3) to provide an interface for a mailbox user to change the phone number that is called. This system eliminates the need to make a trip to their mailbox unless mail is actually present. Whether the user calls into the system or the system calls the user, the user will know the status of his or her mailbox at any time of day.

An insert with infrared light sensors is placed at the base of each mailbox to detect mail. A central device connects to and polls each insert every 15 minutes. The central device consists of four microcontrollers as well as integrated circuits that: 1) keep time; 2) log each user's mailbox status; 3) store audio; 4) place and receive calls from a standard phone line. The device logs the date and time a user receives mail and dials out to the user's stored telephone number to play an audio message indicating that mail is present. Each user may also call into the system and enter his or her unique four-digit user identification number to check mail status or change his or her stored telephone numbers.

The key requirement for this design is the use of light sensors to detect mail. This is the patent-pending idea of the project's client and distinguishes the product from other products on the market. The use of infrared light sensors eliminates the potential for false readings because the light is only reflected back when mail is in the mailbox. Other systems, which use motion to detect mail, might cause false readings when the mailbox door is opened or closed.

Fig. 8.9. Private Distribution Mailbox Alert System.

SUMMARY OF IMPACT

The private distribution mailbox alert system is intended to be used where clusters of USPS-approved private distribution mailboxes are present, such as in an assisted living apartment complex. The system benefits users with limited physical mobility by eliminating unnecessary trips to their mailboxes. It allows users to know whether or not mail is present in their mailboxes with little effort.

TECHNICAL DESCRIPTION

The previous mailbox alert project developed a structure of four PIC 16F876 microcontrollers, one to interface with the phone chip, the voice chip, the real time clock chip, and the infrared mail detection sensors, respectively. This project builds on the previous project to create a fully functional prototype using custom printed circuit boards, and it provides added functionality. This includes developing a communication scheme and commands between each microcontroller, adding outgoing call functionality, supporting multiple mailboxes, and adding the ability for users to change telephone numbers. The system block diagram is shown in Fig. 8.10.

A standard wall outlet is utilized to transform 120-volt AC power into five volt DC. The microcontrollers are arranged so that each receives data from one microcontroller and transmits data to another. In this manner, data originating from one microcontroller is addressed to be received by another microcontroller and will propagate loop-wise through the system until received by the desired microcontroller.

A Dallas Semiconductor DS1305 real time clock chip provides an alarm every 15 minutes for the sensors to check for mail in each of the mailboxes. Each mailbox uses three bytes of RAM on the real time clock chip to store the hour, minute, day, and month that mail is received (these bytes are cleared when mail is not present). For each mailbox with mail, the device calls the owner using a Xecom XE0068DT Data Access Arrangement chip through a standard telephone line. As soon as a user answers the phone, or the call is forwarded to voicemail, a Winbond ISD4003 voice chip plays audio communicating over the phone line that mail has been received. Once the message has finished playing, the phone chip hangs up the phone line.

A user may also choose to call into the system for mailbox status. The phone chip detects and answers the incoming call, and the voice chip plays an initial audio message ("For mail status please enter your four-digit user identification number, for options please press pound"). The phone chip decodes what the user presses on his or her telephone keypad. If a valid user identification number is entered, the corresponding mailbox status is retrieved from the real time clock chip RAM. The voice chip plays a message back to the user indicating when mail was received or that no mail is present, and the phone chip hangs up the phone line.

Stored telephone numbers can be changed in the event that users are traveling away from home or if any of the mailboxes change individual users. Changing a phone number is accomplished by calling into the mailbox alert system. The user must press the pound key after hearing the initial system message. The system prompts the user to enter his or her user identification number and validates what the user has entered. The user may then enter a new ten digit telephone number and then the initial system audio message is played again.

The private distribution mailbox alert system cost $814 to develop.

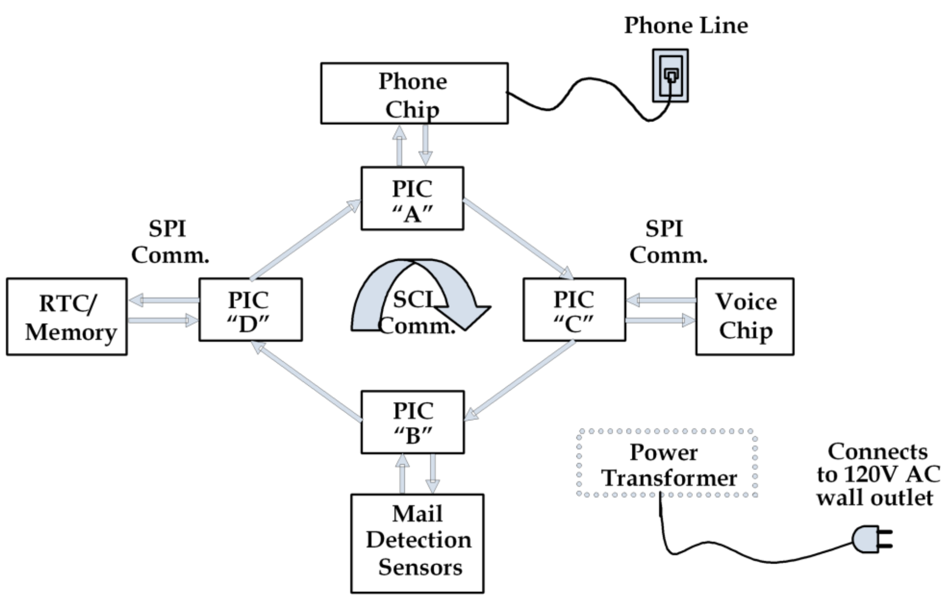

Fig. 8.10. System Block Diagram.

AUTOMATIC TOILET PAPER DISPENSER

Designers: Jay Sheldon, Eric Swenson, and Andy Wallace
Client Coordinator: Diane Wanner, Developmental Work and Activity Center
Supervising Professor: V. V. B. Rao, Ph.D.
Electrical and Computer Engineering Department
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INTRODUCTION

The client, a local center for individuals with developmental disabilities, supports approximately 50 adults. The center has problems with clogging toilets resulting from excessive toilet paper use. The automatic toilet paper dispenser solves this problem by limiting the amount of toilet paper used per stall visit (see Fig. 8.11). A person waves his or her hand in front of the sensor, and the device unrolls a set amount of toilet paper. After a preset number of dispenses, no additional toilet paper is given. An automated unit is needed because privacy concerns prevent staff from directly monitoring toilet paper use. While automatic paper towel dispensers are now prevalent, no known automatic toilet paper dispensers are commercially available.

SUMMARY OF IMPACT

The automatic toilet paper dispenser increases the independence of the clients by allowing them to use restrooms without supervision. Greater privacy is also achieved by requiring the user to close the stall door before toilet paper is dispensed. Although the device can be "fooled" into thinking that there is a new visitor to the stall by opening and closing the door, the act of getting up and opening the door is likely enough to discourage additional use. Through modification, the device could be outfitted for home use, which would help decrease the clients' reliance on others.

TECHNICAL DESCRIPTION

The system has ten main components (see Fig. 8.12). The device is battery powered to provide safer operation and allow installation in areas that do not have access to standard wall outlets. To prevent unnecessary power consumption, the device is powered only when the stall is in use. To accomplish this, a magnetic reed switch and bar magnet are mounted to the stall door. When the door openss, the switch is open, which breaks the circuit and cuts off power to all of the electronics. When the door is closed, the proximity of the bar magnet to the reed switch closes the circuit and powers the electronics. Since the electronic components and the motor require five volts to operate correctly, a voltage regulator is used to drop the input voltage from the batteries down to five volts. A low dropout voltage regulator increases battery life by allowing the batteries to be used further into their charge cycle than a typical voltage regulator would allow. The estimated battery life is over 300 days for six D cell batteries.

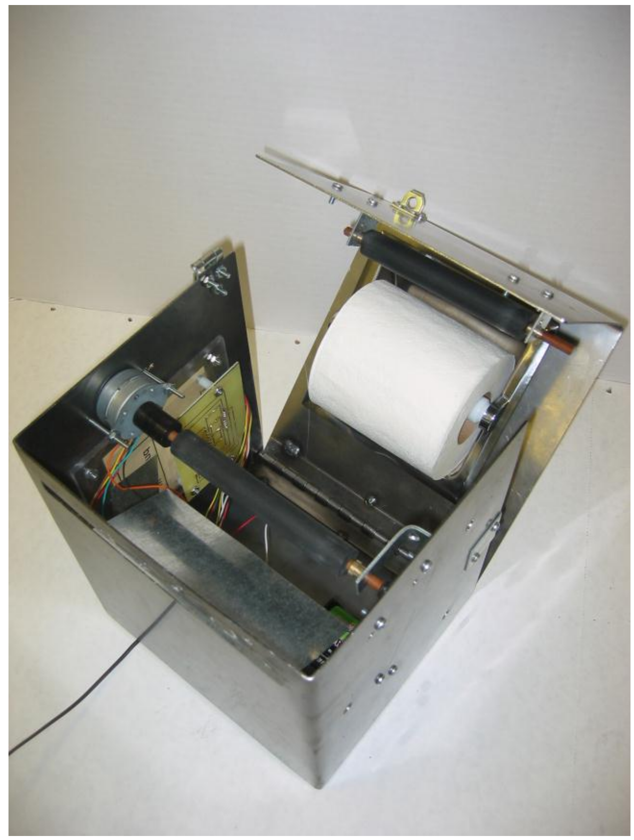

Fig. 8.11. Assembled Device.

The dispenser uses a capacitive transducer to detect when the user wants more toilet paper. A capacitive transducer allows non-contact detection, which provides a more sanitary method of activation. To increase the sensing range, a metal sheet mounted to the side of the enclosure is used as a sensing electrode. The size of the electrode can be adjusted to increase or decrease the sensing range. A hand within three to four inches of the electrode will trigger a sense. Starting the motor could cause momentary changes in the output voltage of the voltage regulator that could cause false touches to be recorded by the sensor. To prevent this, the capacitive transducer runs off its own voltage regulator.

A microcontroller detects touches from the capacitive transducer and controls the stepping pattern used to drive the motor. An internal counter is maintained to track the number of dispenses left. Once this counter reaches zero, the controller will no longer respond to touches signaled from the sensor. The microcontroller interfaces with an array of light emitting diodes (LEDs) indicating the number of dispenses left. The array also features an LED controlled by the voltage regulator that indicates when the batteries need to be replaced.

A stepper motor is used to drive the roller because it allows precise control of the amount of toilet paper to be dispensed and is easily controlled through a microcontroller. The toilet paper is unrolled by a pinch roller (see Fig. 8.13). The toilet paper is squeezed between two rubber rollers: the capstan and the idler. The capstan is driven by a motor, and the idler is allowed to turn freely. As the capstan is turned, the roll of toilet paper turns and gravity feeds the sheets through a chute and out of the enclosure. The pinch roller is superior to turning the entire roll, where the amount dispensed per revolution stays constant as the roll is used and the diameter of the roll decreases.

The overall cost of a single unit is about $154.

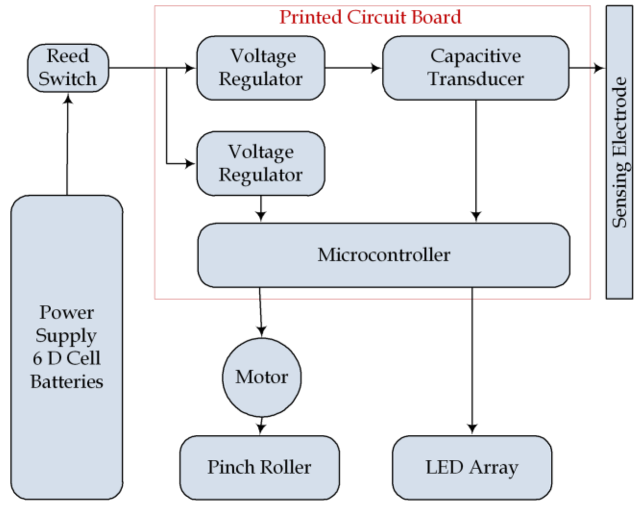

Fig. 8.12. Block Diagram.

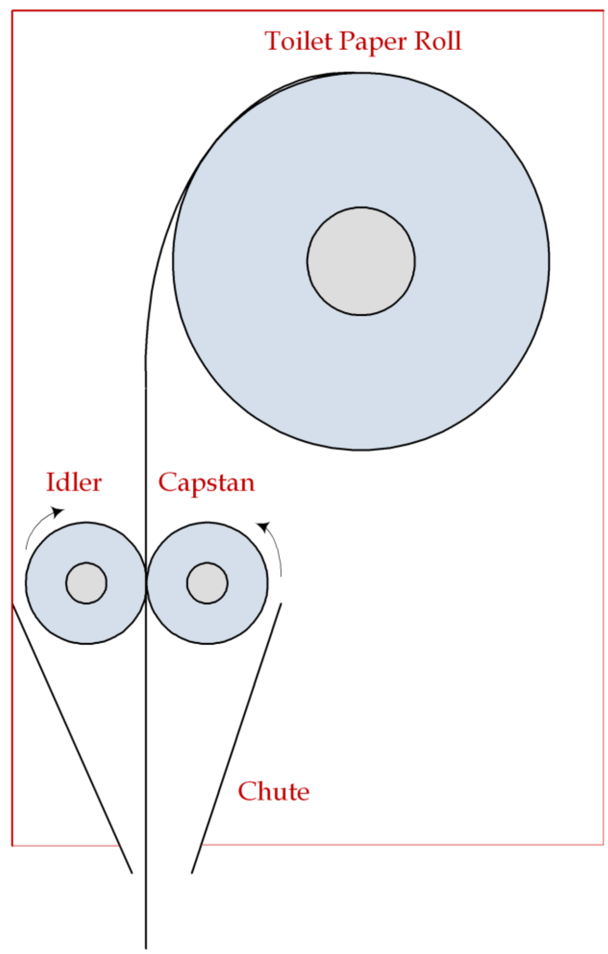

Fig. 8.13. Pinch Roller.

POWER LINE INSTANT MESSENGER

Designers: Oluwasijibomi Saula, Tyler Schumacher, and Andrew Teevens
Client Coordinator: Jana Sundbom, Services Director, SVEE Home
Supervising Professor: Chao You, Ph.D.
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INTRODUCTION

An assisted living home in North Dakota provides care for individuals with developmental disabilities. Given the limited staff of the home, automation is desired to improve services and quality of care. A major concern of the home is the proper use of appliances such as refrigerators and climate control systems. The power line instant messenger (PLIM) is a system that facilitates the communication necessary to efficiently control and monitor devices and appliances.

The basic idea of PLIM is to utilize the existing power lines of the home as communication channels. These communication channels serve as paths of automation. Messages and commands are sent over power lines to control and monitor devices and appliances. The PL 3150 smart transceiver from Echelon Corporation is integrated into the PLIM network to execute power line communication.

PLIM is a three unit prototype built to demonstrate the functionality of power line communication and appliance automation to the home. Two units demonstrate point-to-point communication over the power line network. The third unit functions as a PC interface and data logger. The completed prototype units are shown in Fig. 8.14.

SUMMARY OF IMPACT

There have been several attempts to improve automation and services at the assisted living home. These include: 1) radio frequency (RF) devices that monitor access to pantries; 2) an automated medication dispenser that distributes medication at specific times; 3) a system that controls access to the refrigerator at each home. Each of the individually designed devices operates independently and requires separate training and maintenance. Such characteristics are not convenient for the assisted living staff.

Fig. 8.14. Complete Assembled System.

The PLIM system forms an integrated and unified network for the home automation tasks. Instead of several appliances and devices acting on their own, they share a centralized communication network. Consequently, less time is required for training and maintenance. Although the PLIM prototype currently does not control any appliances, existing ones such as the refrigerator door control as well as future applications can be integrated into the system with some effort. The PLIM network requires the availability of wall outlet power and is susceptible to power disruptions and excessive power line noise.

The clients at the assisted living home were excited about this system and planned new additions for the network. The assisted home services director stated, "They plan to have one or more in each house".

TECHNICAL DESCRIPTION

The block diagrams of the three prototype PLIM units and their interconnections are illustrated in Fig. 8.15. The two point-to-point communication PLIM units, or instant messengers, are made up of three hardware parts: 1) a PL 3150; 2) an LCD; 3) a keypad. The PC interface and data logger simply consist of a PL 3150 and a serial cable.

At the core of each PLIM unit is a PL 3150 smart transceiver. The PL 3150 uses an Echelon protocol called LonTalk to transmit data over the power line. Custom code, programmed in the Neuron C language, establishes the communication network and implements point-to-point communication. The code also drives the LCD and keypad. Future applications only require minor code adjustments to add appliances or new PLIM units to the network. A wall transformer provides the 12-volts required to power the PL 3150. In turn, the PL 3150 provides five-volts of power to the LCD and keypad.

The LCD uses a serial cable to transmit and receive data from the PL 3150. The LCD is programmed with a character map. This character map enables the PL 3150 to identify which character to print on the LCD according to which button is pressed on the keypad. The keypad uses an eight-bit parallel connector to communicate button presses to the LCD. The LCD then relays the information to the PL 3150, which prints the appropriate character on the LCD. The LCD and keypad interface allows messages to be generated and viewed without a computer at any target location.

The third PLIM unit provides a PC interface, which is accessed through an RS-232 serial cable. The PC logs and displays messages via software that reads data from the serial port,. Data logging allows home supervisors to track network activities, such as refrigerator or pantry accesses.

The PLIM devices offer secure, sound, and efficient communication and control. Each PLIM uses a common wall outlet for power, so no batteries are required. The prototype system can be extended to incorporate a wide range of appliances and devices. Some appliances may require more effort than others to integrate into the network. The cost for one PL 3150 is $99.95. The prototype system uses three PL 3150s, two LCDs ($69.95 each), two keypads ($13.13 each), and three enclosures ($160.00), which brings the cost to $626.01.

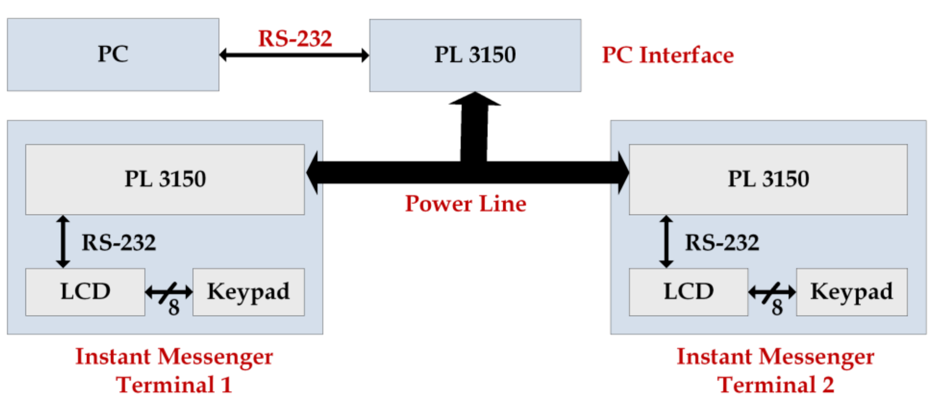

Fig. 8.15. Block Diagram of Prototype PLIM Units.

HANDS-FREE MOUSE

Designers: Jordan Lucht, Amber McNeal, and Cody Doll
Supervising Professor: Val Tareski
Department of Electrical and Computer Engineering
North Dakota State University
Fargo, ND 58105

INTRODUCTION

The hands-free mouse (HFM) was designed for a client who had a double-arm amputation following a farming accident (see Fig. 8.16). The device consists of a shoulder mounted package that communicates with a foot-pedal base via a three-wire bundle. The base controls the left, center, and right clicks. The arm package monitors all the movement functions normally associated with a mouse. The HFM pairs an arm-mount with a foot-pedal and offers advantages to the client over other products.

The HFM is not a perfect replacement of a mouse; response is somewhat sluggish by comparison. The cursor movement is not like that of a regular mouse. Instead, the cursor moves one of three set speeds selected by the amount of arm tilt (much like a joystick). Precision control is difficult at first but can be achieved with moderate use. During initial testing, most users were able to play online games with only a few minutes of practice.

SUMMARY OF IMPACT

The HFM is flexible and offers advantages to people with a range of disabilities. It can be used by anyone that has full use of one leg and at least a four inch appendage with a good range of motion. The arm unit can be programmed to work with an arm or leg from either the left or right side of the body.

The HFM is a more financially feasible when compared to other available products. It also takes advantage of the client's ability to move his shoulders and legs, encourages movement, and promotes flexibility in the client's shoulder.

TECHNICAL DESCRIPTION

There are two components to the HFM: an arm unit that is worn on the shoulder and a foot-pedal unit that controls the mouse clicks. The arm unit detects and transmits tilt data to the foot-pedal unit. The foot-pedal unit detects any clicks and communicates

Fig. 8.16. Arm Unit and Foot-Pedal Unit.

with the PC via USB 2.0. A block diagram is illustrated in Fig. 8.17. The three wires between the two units are: 1) five-volt power; 2) data; 3) ground. The wires meet at a connector between the two units. This allows them to be easily detached.

The arm unit (see Fig. 8.16) consists of an ergonomic enclosure manufactured by OKW that is specially designed to fit an arm or leg. This unit has a top-mounted on/off switch that is easily activated by the user's head. The enclosure contains a three-axis accelerometer that sends three analog signals to a PIC16F876A microcontroller. The PIC uses an onboard analog-to-digital converter along with programmed logic to determine the direction and magnitude of the tilt detected by the accelerometer. The PIC sends a seven bit data packet through the data wire to the foot-pedal. This transmission occurs every 20 ms at 9600 baud.

The foot-pedal (see Fig. 8.16) receives the signal from the arm unit. The data packet sent by the arm unit is received by a USB 2.0-compatible PIC18F4550. This data packet is then translated into change-of-position data for the x- and y-axes of cursor movement.

Given the capabilities of the client, clicking functions were built into the foot-pedal rather than the arm unit. There are six push buttons on the base's face that are seen as logic high or low by the PIC. These data are decoded into left, middle, and right click, plus killswitch and two programmable buttons. The PIC then combines the position and button data and writes them to a buffer that the PC reads via USB when it is ready. If the killswitch is active, the PIC writes all zeros to the buffer, indicating that there has been no activity from the mouse. This killswitch allows the user to effectively turn the unit off without unplugging cables or removing anything.

The foot-pedal is powered entirely through the USB port, which supplies +5 volts and more than enough current. No drivers are required to operate this product as it emulates a standard mouse. The user only needs to plug in the foot-pedal with a USB cable and then turn on the arm unit. This product only works with a USB 2.0 port.

The entire product cost approximately $230.

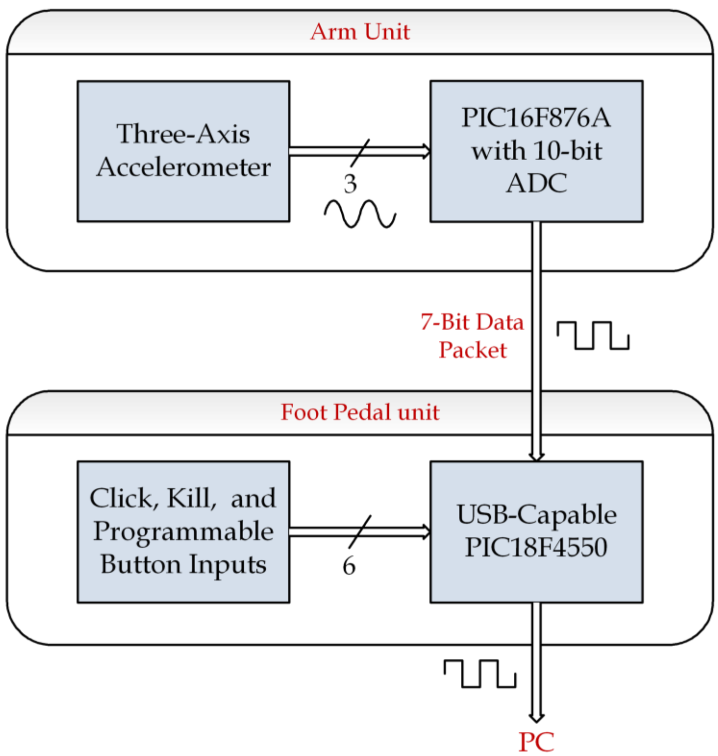

Fig. 8.17. System Block Diagram.

CONTROLLED ACCESS REFRIGERATOR

Designers: Tyler Weiers and Piyush Sharma
Client Coordinator: Jana Sundbom, Director of Services, SVEE home
Supervising Professor: Roger Green, Ph.D.
Department of Electrical and Computer Engineering
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INTRODUCTION

Caregivers in an assisted living facility desired a way to control refrigerator access that is easy to use for residents with refrigerator privileges but also ensures that residents without refrigerator privileges are not given access. The controlled access refrigerator accomplishes these goals by securing the refrigerator door with an electromagnetic lock until an access key is inserted. The controlled access refrigerator: 1) ensures only authorized residents have access to the refrigerator; 2) provides a system interface that is robust, simple, and easy to use; 3) installs without modification to the refrigerator; and 4) is packaged in a professional manner.

The locking mechanism (see Fig. 8.18) mounts with a card reader on the side of the refrigerator. A key card is carried by the user and is inserted into the card socket to gain access. The control unit (see Fig. 8.19) mounts behind the refrigerator. There are currently no aftermarket devices of this type available.

SUMMARY OF IMPACT

The assisted living home serves a range of clients, and each client requires a different balance between independence and direct supervision. The controlled access refrigerator allows the home staff to better meet the unique needs of each client. Lock simplicity enables residents of all skill levels to use the key card with ease.

TECHNICAL DESCRIPTION

The controlled access refrigerator (see Fig. 8.20) is composed of three main parts: 1) the lock housing; 2) the key card; 3) the control unit. When a user inserts a key card into the card socket, a digital signal processor (DSP) validates the key card's code. Once validated, the control unit triggers the actuator circuit and opens the lock for 15 seconds.

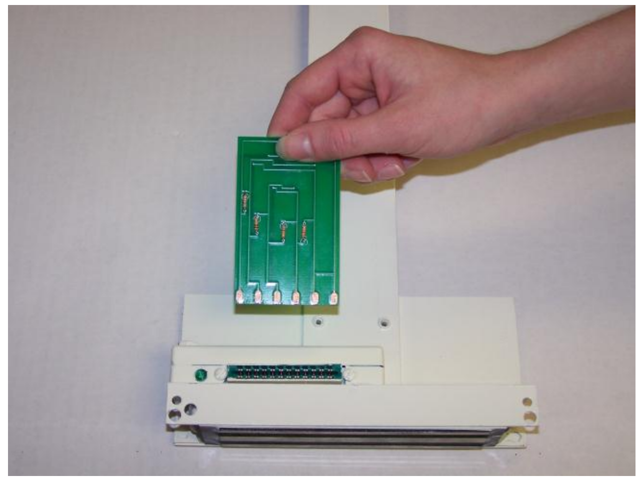

Fig. 8.18. Lock Housing.

Fig. 8.19. Control Unit.

The lock housing contains: 1) an electromagnetic lock; 2) a card reader; and 3) two LED indicators. With a pulling force of over 300 pounds, the electromagnetic lock secures the door with sufficient force to control refrigerator access. LED indicators provide a quick and easy way for the assisted living home caregivers to determine whether or not the lock is active. The lock mechanism is easy to install without modifying the refrigerator; installation relies only on existing bolt holes.

Key cards are distributed by the home staff and allow card owners to access the refrigerator. To gain access, a resident simply inserts his or her card into the card reader on the lock housing. When the key is inserted, it receives power over the +3.3-volt channel (see Fig. 8.21) and returns outputs INT and D1-D3 to the DSP. Data lines D1-D3 provide the lock combination of the card. The simplicity and rigidness of the printed circuit board design give the key card higher durability than most other key card options; the card will still operate if washed.

The control unit houses: 1) the DSP controller; 2) the actuator circuit; 3) the power supply. The DSP controls system operations and has sufficient processing power for alternate authentication schemes, such as biometric authentication. The key card's INT output triggers an interrupt on the DSP to signify the presence of the card. The DSP then performs an analog-to-digital (A/D) conversion on the three channels D1-D3. An average of 16 conversions is compared to pre-assigned ranges for each output. If the combination is valid, the DSP outputs 3.3 volts to the actuator circuit. The actuator circuit buffers the DSP output and then uses a transistor to switch a three-volt relay, which releases

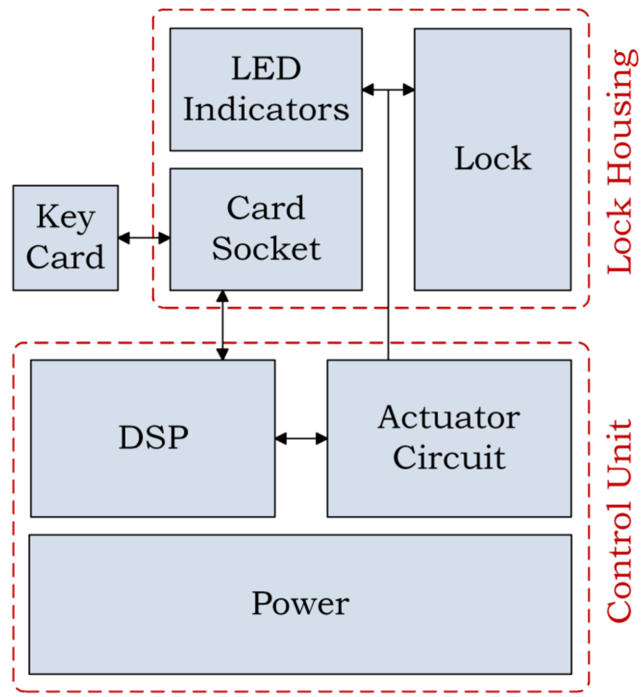

Fig. 8.20. Device Block Diagram.

the electromagnetic lock by cutting its 12-volt power supply.

The cost of the assisted living home unit was about $650.

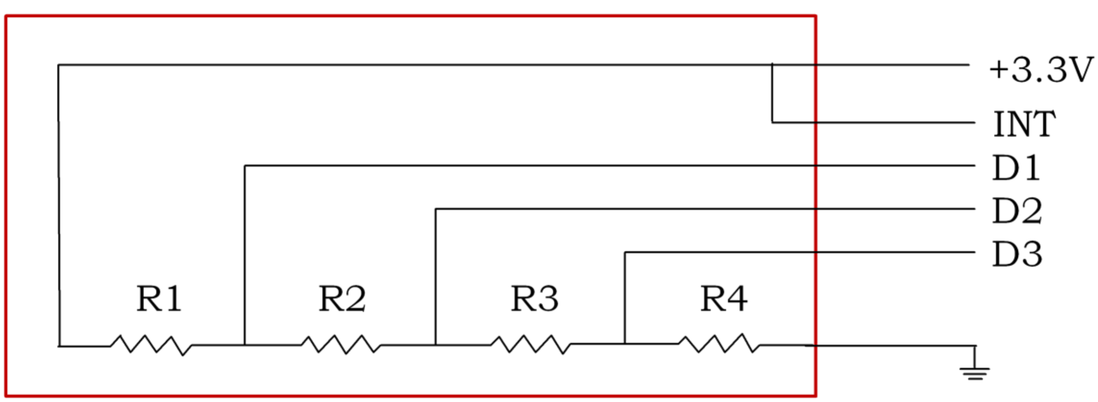

Fig. 8.21. Key Card Schematic.

AUTOMATIC LOCKER DOOR OPENER

Designers: Tushar Gupta and Jon Lussenden
Client Coordinator: Diane Wanner, Developmental Work Activities Center
Supervising Professor: Roger Green, Ph.D.
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INTRODUCTION

An activity center employs individuals with various disabilities. One employee with cerebral palsy lacks sufficient finger control and strength to open the door to his work locker. The automatic locker door opener is a device that opens a locker door with the push of a button.

The automatic locker door opener operates by lifting the door latch with a solenoid and then propelling the door open with energy stored in a spring. The door can be opened by pressing a button on the exterior of the door or by using a remote control (see Fig. 8.22). The solenoid for lifting the door latch and its corresponding control circuitry are enclosed on the inside surface of the door. A power supply and transceiver for communicating with the remote are located in an enclosure mounted on top of the locker (see Fig. 8.23).

SUMMARY OF IMPACT

The automatic locker door opener provides employees greater independence and freedom while at work. The door opener enables individuals to open their lockers at any time without needing to wait for staff assistance. This saves time for both the individual and the staff. The individual is also empowered to use his or her locker more frequently throughout the day. The design is robust and reliable.

TECHNICAL DESCRIPTION

The automatic locker door opener has three major components: 1) the locker unit; 2) a power supply and transceiver unit; 3) a remote control. The system is expandable to multiple lockers. In this case, only the locker unit must be duplicated and installed on each desired locker. All lockers share the same power supply and transceiver unit. A block diagram of the interconnection of these units is shown in Fig. 8.24.

Fig. 8.22. Locker Button and Remote Control.

The locker unit mounts to the locker door (see Fig. 8.23). The solenoid that lifts the locker door latch has greater lifting capacity than is typically needed. This provides reserve capacity for a sticky or jammed latch. To reduce mechanical wear on the solenoid and latch, the solenoid is driven with a PWM signal that is gradually increased until motion of the latch is detected. The PWM signal is maintained at the lowest level that provides upward motion of the latch. In this way, the solenoid applies the minimum amount of force needed to lift the latch each time it is opened. If the solenoid is unable to lift the latch in a time period of one second, the microcontroller shuts off the solenoid. At this point the cause of the jam must be determined. Each locker microcontroller saves statistical data regarding the PWM control signal as well as overall locker use. When needed, this data is displayed on the remote control's LCD.

The power supply mounts above the locker (see Fig. 8.23). The solenoid used to lift the locker door latch requires a 12-volt DC source capable of providing 30 amperes. This high current is needed for only a few hundred milliseconds each time the door is opened. A rechargeable 12-volt DC sealed lead acid battery provides this low duty-cycle high current. The transformer and circuitry output a regulated 13-volt DC to charge the battery. A regulated five-volt DC is required for the microcontroller and transceiver.

The remote control is capable of opening any locker on the system as well as recovering stored data from each locker. During use, the remote transmits an eight-bit number comprised of a seven-bit locker ID number and a single command bit. The command bit tells the locker with the matching ID whether to open the door or transmit its stored data. The power supply can only provide current to open one locker at a time. When a locker is commanded to open from a remote all other lockers deactivate their door buttons and wait for the remote to verify that the other locker is no longer in use.

The solenoid has adequate force to lift the locker latch, even under load. The enclosures and packaging of the power supply and locker unit are designed to withstand much physical abuse. The range of the remote is approximately 125 feet indoors. The use of a higher voltage solenoid would lower the current requirement of the power supply and make for a simpler and more efficient design.

The design cost about $550, with additional locker units costing $210 each.

Fig. 8.23. Locker Unit and Power Supply.

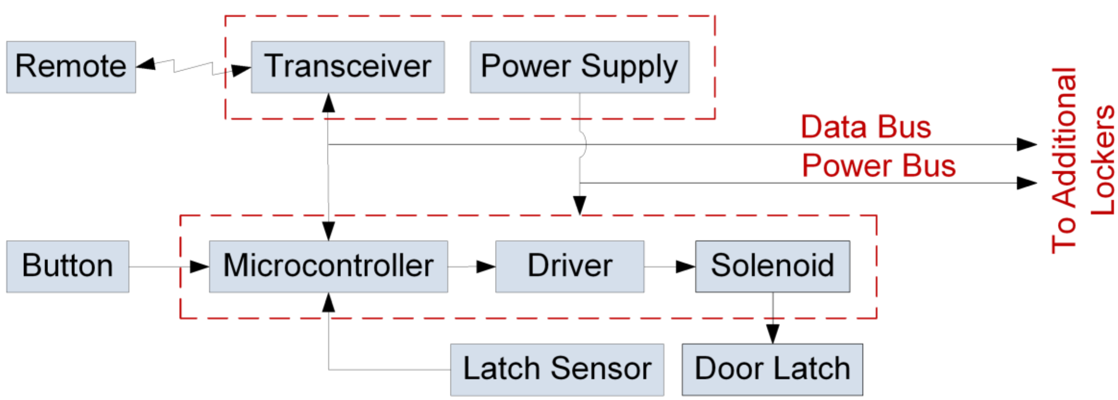

Fig. 8.24. Automatic Locker Door Opener Block Diagram.

COMBINTATION HAND AND ELECTRIC TRICYCLE

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Client Coordinator: Mark Schroeder Ph.D.
Supervisor: Subarraya Yuvarajan Ph.D.
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INTRODUCTION

The combination tricycle was designed for a client who is paralyzed from the waist down but retains the full use of her upper body. The tricycle provides the client with a new mode of transportation (see Fig. 8.25). The tricycle is driven by an electric motor or a hand crank. Mounted on the tricycle is a display unit that includes: 1) a speedometer; 2) an odometer; 3) a battery level indicator.

While there are several similar options on the market today, this tricycle uniquely combines a hand crank and an electric motor into one solution. The tricycle combines both functions into one cost-effective product.

SUMMARY OF IMPACT

Since the tricycle is powered by either a hand crank or an electric motor, the tricycle accommodates the client well. The tricycle's hand crank provides excellent upper body and aerobic exercise. The motor allows for casual recreation and assists in the transport of small items. The tricycle gives her the opportunity to get out and enjoy the world. The client was particularly excited about this tricycle because it brings back memories from her childhood

Fig. 8.25. Combination Hand and Electric Tricycle.

when she had a hand-driven tricycle.

TECHNICAL DESCRIPTION

The tricycle has two modes of operation: hand-driven and motor-driven. Both modes operate independently, so the rider can select which mode to use at any given time. A hand crank attaches to the front wheel and replaces the original foot pedals. A motor is attached to the rear wheels. The main modifications of the tricycle include: 1) a motor; 2) a hand crank; 3) batteries; 4) a PIC microcontroller; 5) an LCD display. Fig. 8.26 shows how these components integrate with one another.

The motor is a 24-volt 300-watt brushless DC motor. It can easily drive the tricycle with up to a 250-lb load. It is connected to the rear drive axle with a gear ratio of three and a half to one to permit speeds in a range of zero to 25 MPH. The motor speed is controlled by a thumb throttle, which is simply a 5k potentiometer that is connected to the motor controller unit. The thumb throttle has a spring resistance so that when the user releases the throttle, the motor disengages and the tricycle coasts. If a more urgent stop is necessary, a hand brake is available. For safety reasons, a 30-amp circuit breaker provides current protection for the motor. Should the circuit breaker trip, it can be reset through the manual switch next to the batteries.

The hand crank drives the front wheel and operates independently from the motor. A footrest replaces the tricycle's original foot pedals which are not needed by our client. The crank is attached to a newly fabricated handlebar assembly. The new handlebar assembly is designed to withstand the additional stress that results during hand crank use. The hand crank attaches to the front wheel through a chain and a set of sprockets. A spring tensioner keeps the chain taut.

Two 12-volt, 18-amp rechargeable batteries are attached in series to provide the necessary 24-volts to power the motor. At half throttle, the batteries can power the motor for approximately one hour. One of the batteries also provides the power for all of the electronics on the tricycle. The batteries are recharged using an included wall charger.

Using pulses from an optical sensor that is attached to the drive axle, the PIC microcontroller computes and displays speedometer, odometer, and battery level information. The sensor sends 24 pulses for every rotation of the axle, which ensures speedometer accuracy to within one MPH. The PIC also uses its analog-to-digital converter to read the current voltage on the batteries. This measurement is then converted into a ten-bar battery level indicator. The PIC updates the LCD panel with current speed, distance, and battery level values eight times per second.

The project cost approximately $2500.

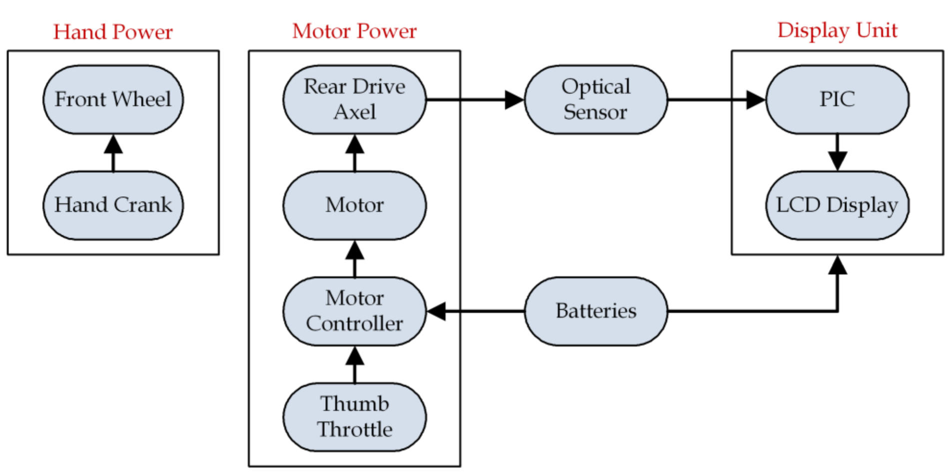

Fig. 8.26. System Block Diagram.

THE GIZMO

Designer: Jacob Doyle, Saurabh Garg, and Jyotsana Singh Phull
Client Coordinator: Connie Lillejord, Therapy Services Director, Anne Carlson Center for Children
Supervising Professor: Joel Aslakson
Department of Electrical and Computer Engineering
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INTRODUCTION

The Gizmo is a device that entertains and educates children at a local center for children (see Fig. 8.27). This center nurtures individuals with physical and mental health impairments through creative combinations of special education and training. The gizmo focuses on helping individuals understand the phenomenon of cause and effect through an interactive and entertaining interface. The device is: 1) easy to use; 2) durable; 3) wheelchair accessible; 4) safe; and 5) adjustable to three levels of difficulty.

The Gizmo includes: 1) a five-button interface; 2) a 16-by-16 colored LED display; 3) two speakers; and 4) three fans. Using a switch, the instructor selects the appropriate level of difficulty for the user. When the student pushes a sequence of one or more buttons, he or she is rewarded by hearing music, seeing blinking lights, feeling blowing air, or a combination of the above. Different sequences produce different combinations of sound, light, and air. A sequence length of one, two, or three corresponds to the easy, medium, and hard levels, respectively. These short sequences match the needs of the center and its clients. The Gizmo is different from other products on the market due to its number of sensory outputs, flexibility, and educational component.

SUMMARY OF IMPACT

The children's center is continuously looking for novel devices to teach and engage children. The center serves many children with pervasive developmental disorders (PDD). Children with PDD often respond positively to lights, sound, and air pressure. The Gizmo provides these features in an effective and creative way. As children progress through the three levels of difficulty, they learn cause and effect relationships. Knowing cause and effect, children are equipped to independently operate many everyday devices such as light switches.

Fig. 8.27. Completed Gizmo Device.

The Gizmo is entertaining and helps prevent children from getting bored or frustrated. The gizmo's outputs are well suited for young users due to the use of bright colors and fun sounds. Each button has a different texture, which helps children with visual impairments identify them. As a table-top device, the gizmo is wheelchair accessible. Such features make gizmo a unique device that can be used by most students at the center.

TECHNICAL DESCRIPTION

The gizmo (see Fig. 8.28) is composed of twelve primary components: 1) a 5-button interface; 2) a main microcontroller; 3) a slave microcontroller; 4) an instructor accessible switch; 5) flash memory; 6) two digital-to-analog converters; 7) two low-pass filters; 8) two amplifiers; 9) two speakers; 10) LED drivers; 11) a 16-by-16 LED display; 12) several fans.

The backbone of the device is a PIC16F876 microcontroller. The PIC is responsible for coordinating and managing system components and tasks. As the device powers up, the main microcontroller scans the instructor-accessible switch in order to set the level of difficulty, then it waits for user input. The PIC compares the user input sequence to predefined sequences stored in its memory. If a sequence matches, then the chip activates the appropriate combinations of outputs.

If the output requires music or sound to be played, then the main microcontroller uses a universal asynchronous receiver/transmitter (UART) bus to send the desired file number to the slave microcontroller. The flash memory and slave microcontroller communicate across a serial peripheral interface (SPI) bus. The PIC receives data from the flash memory at 128-kbps. The flash memory sends serial data in 512-bit packets to the slave microcontroller, which converts it into 8-bit parallel data and writes each word to a digital-to-analog converter (DAC) at the appropriate time. The signals are then filtered using low-pass filter (LPF) chips. These filters are linear phase to ensure constant group delay and minimal waveform distortion. After filtering, the signals are sent through audio amplifiers and output to the speakers. The result is an eight-bit stereo quality sound with an eight-kHz sample rate.

To create a flashing pattern on the LED display, the main microcontroller sends control data via SPI bus to the two MAX6960 matrix graphic LED drivers. These chips provide individual intensity and pattern control of the LEDs using a minimal number of data and control lines.

When fans are needed, the main controller activates the fan circuitry. The fan circuitry is composed of transistors and diodes that are required to properly drive the fans.

The device cost about $520.

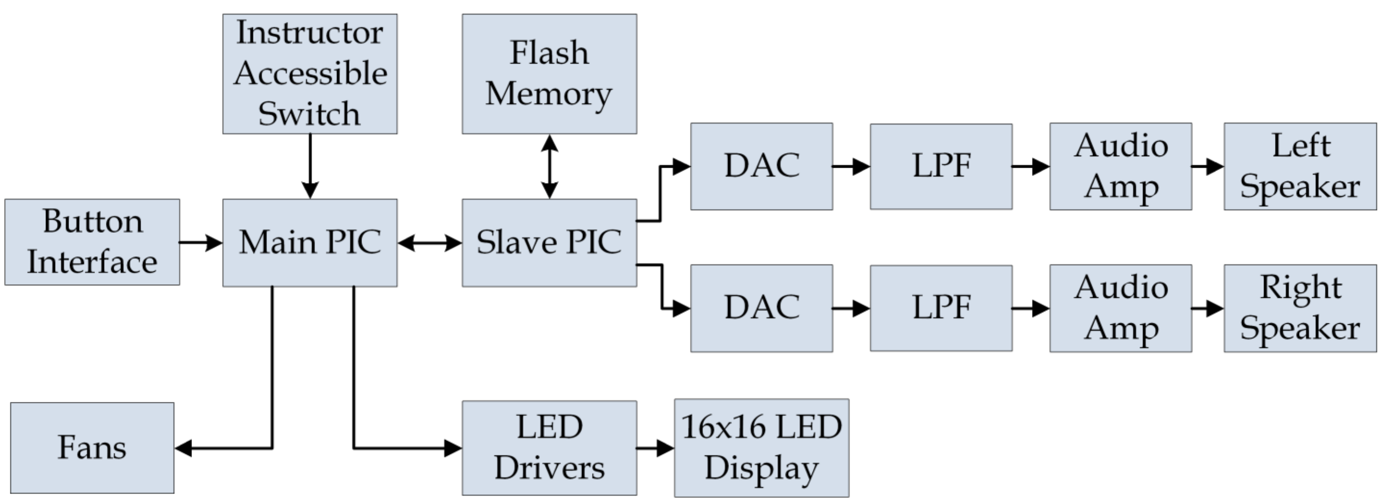

Fig. 8.28. Gizmo Block Diagram.

CHAPTER 9
ROCHESTER INSTITUTE OF TECHNOLOGY

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ONE–WAY COMMUNICATION BOARD

Electrical Engineering Designers: Travis Driscoll, Sue Sie Kim, Jeff Park, and George Shieh
Industrial and Systems Engineering Designer: Salim Maani
Mechanical Engineering Designer: Ryan Larcom (team leader)
Client Coordinator: Amy Feekes, Arc of Monroe County
Supervising Professors: Dr. Daniel Phillips and Dr. Elizabeth DeBartolo
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INTRODUCTION

A one-way communication board was designed and specially customized to fit the lifestyle and preferences of a client. The client is part of a program that focuses on individuals with mental retardation and developmental disabilities, promoting life-long learning opportunities. This individual can hear and understand others, has normal vision, and uses a wheelchair without assistance, but she has limited verbal and spelling capabilities. The individual currently uses a loose-leaf picture book to communicate with others, but could benefit from a device with speech output to supplement pointing to pictures. The device helps improve the client's communication skills.

SUMMARY OF IMPACT

The team was able to provide the client with a new communication device customized to her needs and tastes. The user interface (see Fig. 9.1) allows for easy browsing through a series of topics. The device is preprogrammed with the names of friends and will say "hello" in additional languages to those friends as desired. In accordance with the customer requests, the team packaged the device in a pink housing (see Fig. 9.2).

TECHNICAL DESCRIPTION

The device is made up of four main components: 1) a Liquid Crystal Display (LCD); 2) a Touch-Screen (TS); 3) a Single Board Computer (SBC); and 4) a battery. The SBC is a miniature motherboard which runs the communication software and maintains the audio and picture databases stored in Compact Flash (CF) memory. The SBC display is hooked up to the LCD/TS, which takes the place of a keyboard and mouse in a normal computer. The client uses the touch screen to interact with the communication software created for the ARC communication board. To provide power to the system, a high-capacity rechargeable battery is used.

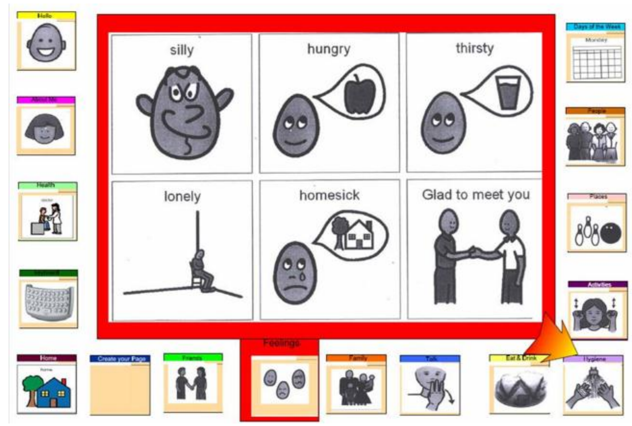

Fig. 9.1. Communication Board GUI Screenshot

The two main constraints that guided the selection of specific components were cost and size. The LCD/touch-screen (#ETL121C-7SWA-1) was donated by Elo TouchSystems. As the touch-screen was the largest physical component in the system, it was possible to focus on the selection of the other components based on engineering requirements: capabilities, size, and cost. The single board computer was chosen based on the minimum specifications to run Linux [3], which included: 1) the speed of the processor (300MHz); 2) the size of the RAM available (128MB); and 3) its ability to use CF as storage memory (two GB). It also required a video output for the LCD and a serial output for the TS, and had to be low-cost. The single board computer selected was an Acrosser AR-M9919.

When the SBC was received, Debian Linux 3.1 (Kernel version 2.4.27) was installed as the OS because it was open-source and one of the popular distributions of Linux, which provided many sources for help. A major problem was encountered when the SBC was configured to communicate with the LCD. The driver installation instructions confirm that the drivers would interface with the Debian kernel, but when they were loaded, they failed due to a kernel mismatch. Debian Linux 4.0 (Kernel version of 2.6.18-4) was then installed as the OS, which required a switch of file type extensions for the drivers. They were successfully recompiled to match the kernel version being used. Upon reinstallation, the drivers were successfully installed and verified.

Other software that was installed was: 1) the X-windows system (aGraphical User Interface (GUI)); 2) Mozilla Ice-weasel web browser (based on Mozilla Firefox); 3) Mozilla m-player plug-in (for playing music files). This software was installed based on the amount of space it occupies on the hard drive and its ability to support the client's needs.

After the software was implemented, a noticeable lag was encountered during screen refreshes. The SBC's RAM was increased from 128MB to 512MB in order to provide increased processing power to the CPU, thus improving the overall performance of the computer and aiding in enhancing the client's experience with the device.

Specifications of similar communication devices (found in "Product Benchmarking") were used to determine a target battery capacity. A lithium-ion rechargeable battery was chosen because the battery was required to supply power to the system for long periods of time at a steady voltage. In addition, the Li-ion class of batteries can provide a high degree of amp-hours required by a high power-drain device. The battery selected was the Powerizer LCH3P6S2R2WR-2P2 which provided 7.4 volts at 15.6 Amp-hours.

Fig. 9.2. Final Communication Board Design.

The software's GUI was developed based on the design requirements specified by the customer and ergonomic analysis. It includes: 1) an active display area (ACDA); 2) menus for each category; 3) scrolling arrows. The ACDA consists of six pictures that deliver a sound and text output when clicked. The scrolling arrows change the ACDA pictures to the next set of six pictures within a category. The category menus load the ACDA with pictures associated with that category.

The product is hosted by a local Apache web server where the user interface is displayed via the Mozilla Firefox web browser. The scripting language, PHP, defines image placement, size, and overall setup. PHP is also used to create background colors, border colors, and text display. JavaScript is used to control client-side interactions (i.e. sound output when an image is clicked). The MySQL database stores the images and sounds to be displayed at the output. All images are in jpeg format and sounds are in wav and mp3 format.

The total cost of the project was about $1705.

TWO-WAY COMMUNICATION BOARD

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Mechanical Engineering Designers: Nathan Q. Holland and Scott Keller
Client Coordinator: Sharon Rasmussen, National Technical Institute for the Deaf @ RIT
Supervising Professors: Dr. Elizabeth DeBartolo and Dr. Daniel Phillips
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INTRODUCTION

When college students who are deaf or hard of hearing seek extra help during professor office hours or tutoring sessions, interpreters are rarely available. Faculty and tutors at a university found that communicating effectively with students who are deaf and hard-of-hearing is challenging. The current method of communication with these students is slow and frustrating, limited to a communication method consisting of handwritten notes. The goal of this project was to design a device that would make communication faster and easier, encouraging more students who are deaf and hard of hearing to visit their instructors' offices for help. The design team interviewed faculty and students to determine what features they would most like to see included in the device and they used these interviews to determine lists of the most commonly used phrases and terms that would be used during office hours or a tutoring session.

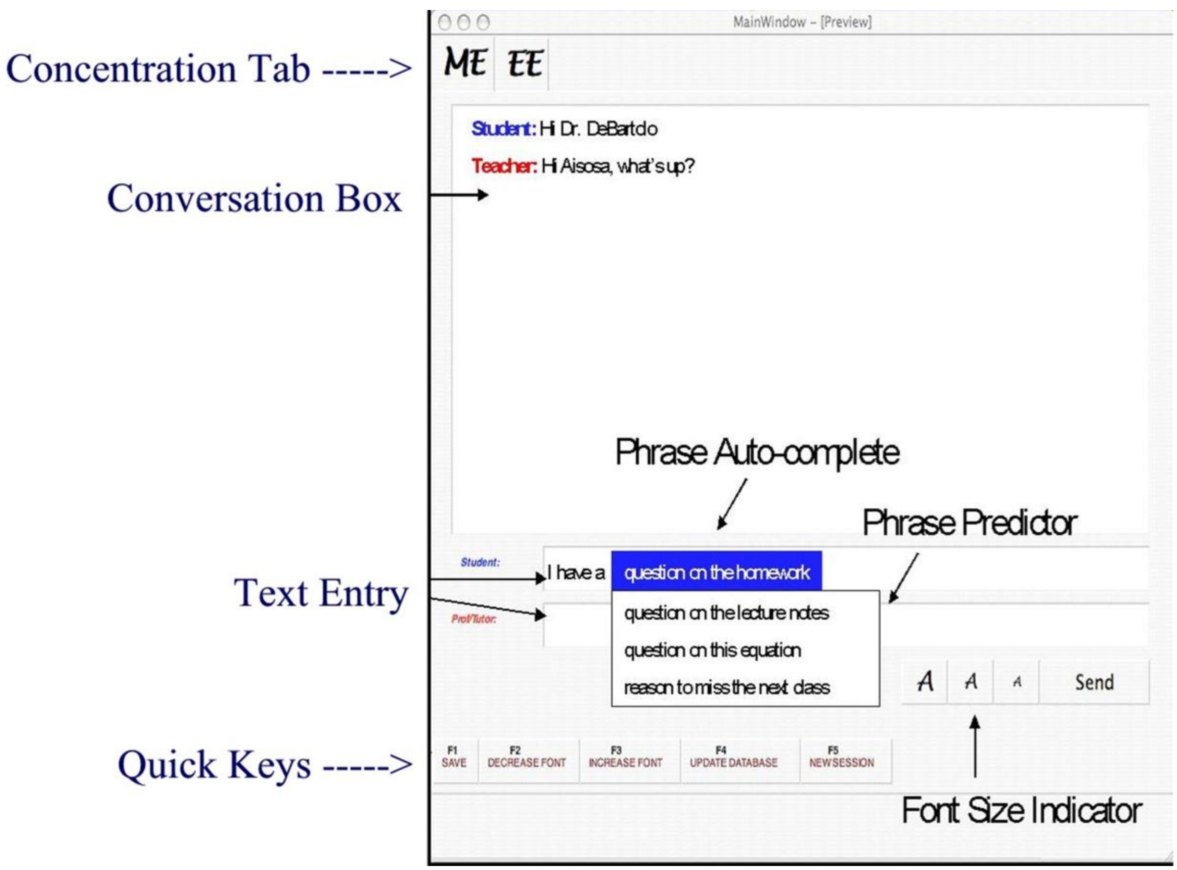

Fig. 9.3. Screen Shot of GUI for Two-Way Communication Board.

SUMMARY OF IMPACT

The project team designed a device that uses a messenger style interface (see Fig. 9.3). The communication method allows users to type to each other with any relevant phrases auto-completed to increase efficiency of communication. This project will enhance the learning experience for students by easing the method of communication with the professor or tutor. The device is powered by a single board computer, with a monitor built into the case and a detachable flexible keyboard.

TECHNICAL DESCRIPTION

The primary hardware components required for the Two-Way Communication device were: 1) a single board computer (SBC); 2) a power supply; and 3) a Liquid Crystal Display (LCD). The single board computer is the brain of the device and is comprised of a micro-processor and memory. Requirements for the SBC include 386 MHz processor speed, 4 MB of RAM, and 40 MB of storage that are driven by the team's decision to run an Embedded Linux operating system. Additionally, the SBC had to fit within the specified casing dimensions. A PCM-9371 single board computer was selected, with 650 MHz of processing speed, 128 MB of DRAM, and a one GB Compact Flash Drive. The 10.4" LCD and SBC were purchased from the same manufacturer, to ensure that the LCD was compatible with its SBC. The power requirement for the PCM-9371 single board computer is 14-Watts and 5-Amps. Initially, the goal of the team was to purchase the hardware components from the same manufacturer to avoid compatibility issues. Hence, the team selected a 150-Watt ATX power supply from the PCM-9371 manufacturer. This was the minimum power supply rating offered that met the single board computer's power requirement. However, this power supply significantly increased the overall case dimensions and violated the design specifications. An alternate power supply that generated 60-Watts was selected from a different manufacturer.

Software development was one of the main components of the project and it encompassed the selection of the appropriate operating system, programming language, and the Graphical User Interface (GUI). Preliminary design for software development started with selecting the appropriate operating system to accommodate the SBC. The embedded version of Debian Linux was chosen as the operating system because of its capability to run with a smaller processing speed than a Windows operating system. Furthermore, the supplier of the single board computer provided a customized version of Embedded Linux along with X-Windows and one year technical support. Programming for the GUI was done in Java, a high-level language that is widely used for GUI development and Web applications. It runs on different platforms such as Windows, Linux, Solaris, and Mac. This cross-platform capability made Java very well suited for the application of this project.

The design of the GUI was developed after several meetings to solicit ideas from students who are deaf or hard of hearing, as well as tutors and professors. An "instant messenger" GUI style design was found to be most effective in meeting client requirements. The GUI was designed to have adjustable font size and the ability to save the session to a flash drive. It also starts a new session with the press of a single key. An auto-complete feature for phrases and sentences was added, which reduces typing time by auto-completing phrases or sentences that have already been typed by another user and added to the database. The suggested phrase and sentences feature also reduces typing time by allowing the user to select from a list of sentences that start with the same word he or she has typed. The device has a database update feature that allows the user to add phrases or sentence to the database.

Currently the design is limited to a single physical device. This means only one student can use the device at any given time. In order to broaden the number of users who can benefit from the design, it is recommended that the software be transformed into a website that any student can access via the Internet. This will allow students to bring their laptops to the professor's office and launch the program immediately. Students would also be able to use the program for more than one purpose including peer-to-peer communication.

The total cost of the project was approximately $1147.

MOBILE CAMERA CONTROL SYSTEM FOR A CANON EOS 1DS MARK II DIGITAL CAMERA

Electrical Engineering Designers: Jennifer Grant, Emmanuel Maceda, Chris Nimon, and Edward Yiu
Industrial and Systems Engineering Designer: Claudia Forero-Ruiz (team leader)
Mechanical Engineering Designers: Ruth Ayalon and Erin Gillespie
Client: Dr. Alfred Loeb
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INTRODUCTION

The client, a 79 -year-old retired engineer, was involved in a serious bicycle accident. As a result, his left arm is fully paralyzed and he is severely limited in terms of movement of his head, neck, and right arm. With limited range of motion in his right arm, he was able to lift his hand to approximately shoulder level and could operate a mouse with one finger, but he was no longer able to use his camera because of the dexterity and strength needed to lift it and manipulate its settings. The objective of the project was to design a control unit to allow the client to use his Canon EOS 1DS Mark II digital camera via a user-friendly software interface.

To complete the design, the team constructed a small portable computer with an attached screen to run the user interface. A trackball mouse allows the user to control it. The system made use of the Software Development Kit provided by Canon to access and control settings in the camera's software through a computer interface that the team designed (see Fig. 9.4). The final prototype was thoroughly tested for functionality and durability.

SUMMARY OF IMPACT

Because photography was one of the client's lifelong hobbies, regaining the ability to use his camera significantly improves his quality of life. The device also increases the client's independence.

TECHNICAL DESCRIPTION

The design implementation was divided into three sub-sections: 1) hardware; 2) packaging; 3) software.

Implementation of the hardware began with the selection of the appropriate electronic components. The primary electronic components included were: 1) the Central Processing Unit (CPU); 2) the liquid crystal display (LCD); 3) the hard drive; and 4) the rechargeable battery. The main factors considered in selecting the electronics were: 1) the client's requirements; 2) the project budget; and 3) the compatibility of components. A NEC NL6448DC26-01 LCD screen was donated by a corporate sponsor.

The most essential component was the (CPU). A VIA 10000M Mini-ITX motherboard was chosen. Based on the client requirements, there were several minimum system requirements for the motherboard: 1) one-GHz Processor speed; 2) one and a half GB hard drive space; 3) 256 MB RAM; 4) LCD interface capability; 5) two USB ports; and 6) the ability to add an external hard drive. A Seagate Momentus 5400.2 60 GB hard drive was chosen to provide significant space for storage of pictures. A rechargeable battery was then chosen. Preliminary research had shown that the system would consume approximately 35-Watts of power operating at its nominal state. Thus, it was calculated that a battery capacity of at least 4500-mAhrs would be required, thus NiMH batteries were chosen. The final selection was a 10-cell NiMH 12-volt, 4500-mAhr battery pack produced by BatterySpace with a compatible charger.

The project software was created and implemented using the Canon Software Development Kit (SDK) for camera control and Visual Studio 2005 for the GUI. Windows XP was selected due to its compatibility with the SDK and its availability at a reduced cost.

The software development process followed in this project was different than a normal software development process due to the use of the SDK. The first step in the process for this project was a review of the Canon SDK. Canon had used a modular approach to the SDK, with each function that the camera performs indicated by a software function. The actual code for each function was not available to the programmer, so the way in which these functions performed could not be manipulated. However, the modularity of each function did allow for combinations of functions to perform more complex steps. For instance, a function like downloading a picture or taking a picture could not be modified, but the two codes could be combined in order to tell the camera to take a picture and download it in response to one command from the user. Each function was implemented linearly; one function was completed and tested prior to implementation of the next function. This allowed for performance review of the software at each step in the process. Regression testing was completed at each step of development, so if problems emerged, the fault could always be traced to the last code added.

The final packaging design consisted of a rectangular box with a hinged lid for adjusting the screen angle and a three-sided bellows to enclose the internal components while still allowing movement of the lid. The case was constructed from an aluminum frame with plastic sides to reduce the overall system weight. Static-dissipative ultra high molecular weight polyethylene (UHMWPE) was chosen as the plastic used for the outside of the case because of its: 1) high durability; 2) strength; 3) resistance to static charge; and 4) recycling purposes. The amount of heat dissipated by the enclosed electronics was calculated to determine whether any additional heat removal systems would be required to prevent overheating of the system. The heat energy generation, at maximum power use, was estimated to be 39-Watts, and the maximum allowable temperature for proper operation of the electronic equipment is 50º C. It was found that with a room temperature of 25º C and the given surface area of the box, the surface temperature would have to be at least 70º C in order for 39-Watts of thermal energy to dissipate through natural convection. Thus, ventilation holes and air circulation were required. To determine the required mass flow rate of air through the system, all sides were assumed to be perfectly insulated, with all heat transfer occurring by removal of warm air. The resulting required volume flow rate to keep the inside of the case below 50º C was calculated to be 4.5 ft^3/min, so a fan with a flow rate of 7.4 ft^3/min was installed. Once the system was assembled, heat levels inside the case were measured while the system was running to ensure that temperatures were within acceptable levels.

The total cost of the project was approximately $1168.

Fig. 9.4. Screen Shot of Camera Control GUI.

ADAPTABLE POOL LIFT SEAT

Industrial Engineering Designer: Michael Webb (team leader) and Myong Choi
Mechanical Engineering Designers: David Alas, Alecia Eppelsheimer, Jeffrey Klaus, and Brian Walsh
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INTRODUCTION

A 2005-06 senior design team had built a lift mechanism that could lower people into a pool as well as raise them out. A new seat for the lift was requested to better fit variable client needs, such as the degree of incline of the seat required. Additionally, staff users of this new lift requested the ability to get one individual in the locker room ready for a pool session while another is being wheeled out and lowered into the pool.

The final project is a PVC frame with a custom hinge design that allows the seat to operate in either an upright or a reclined position. Six removable stainless steel casters allow a therapist to transport the user from the locker room to the pool deck and a forklift-like linkage allows the integration of the new chair into the existing lift system. Fig. 9.5 shows the final chair design. Two chairs were constructed to allow personnel to prepare two individuals for pool sessions at once.

Fig. 9.5. CAD Model of Final Product.

SUMMARY OF IMPACT

The chairs better fit the needs of the clients and aid the staff in helping the clients.

TECHNICAL DESCRIPTION

Once a final design concept was chosen, calculations were performed to determine the minimum PVC pipe size that would support the weight of the users. The entire system was then modeled and simulated using ANSYS. The system was determined to be feasible, passing with a maximum Von Mises Stress that was well below the yield stress of the PVC with a factor of safety of two.

Upon finalization of the design, the first prototype was constructed using PVC pipe and fittings. This was not glued during the initial phase of construction so that pipe lengths could be adjusted to allow proper alignment of all sections of the seat assembly. Once the entire seat was assembled properly, it was disassembled and all sections of pipe were measured for final length and labeled. The seat was then reassembled using PVC cleaner and cement. The seat was assembled from the inside out, with the front hinge glued first, followed by the rear hinge and seat back subassemblies that had sections passing through the front hinge. The armrests, footrest, and diagonal braces were built next. The main seat frame was built last, with sections passing through all of the other subassemblies. The adjustable end of the footrest and the caster assemblies were constructed separately and attached with removable stainless steel pins. This process was repeated for the second prototype. The seat material (Phifertex Plus®, a PVC-coated polyester mesh) was sewn to fit the completed assemblies, and the three sections (seat bottom, seat back, and foot rest) were then attached to the seat assemblies using Sta-Set® polyester rope.

The linkage was constructed of stainless steel tubing. Four square tubing sections were welded together to form a rectangle. Two round tubing sections were then welded perpendicular to the rectangle to form the "forklift" arms. On the back of the rectangle, two rectangular sections were welded vertically in the middle to form an attachment point for the lift.

Extensive testing was performed on the seat components (see Fig. 9.6). First, a 16" x 22" x 13" L-shaped PVC frame was constructed using 2" diameter PVC pipes, two three-way fittings, and four elbows. The frame was dropped from varying heights to simulate a sharp impact or blow to the chair frame. The frame was originally dropped from a height of three feet and progressively increased in order to have the frame fail. Again, a failure was considered a significant crack in the pipes or a separation of the joints. Next, a 50-lb weight was dropped on the same L-shaped frame from varying heights while the frame rested and supported on the ground. Finally, a standard three-point bend test was performed on corroded and pristine cemented PVC sections to determine the effect of bromine in the pool on the adhesive. In both cases, failure occurred in the coupling rather than at the adhesive.

The total cost of the project was about $1463.

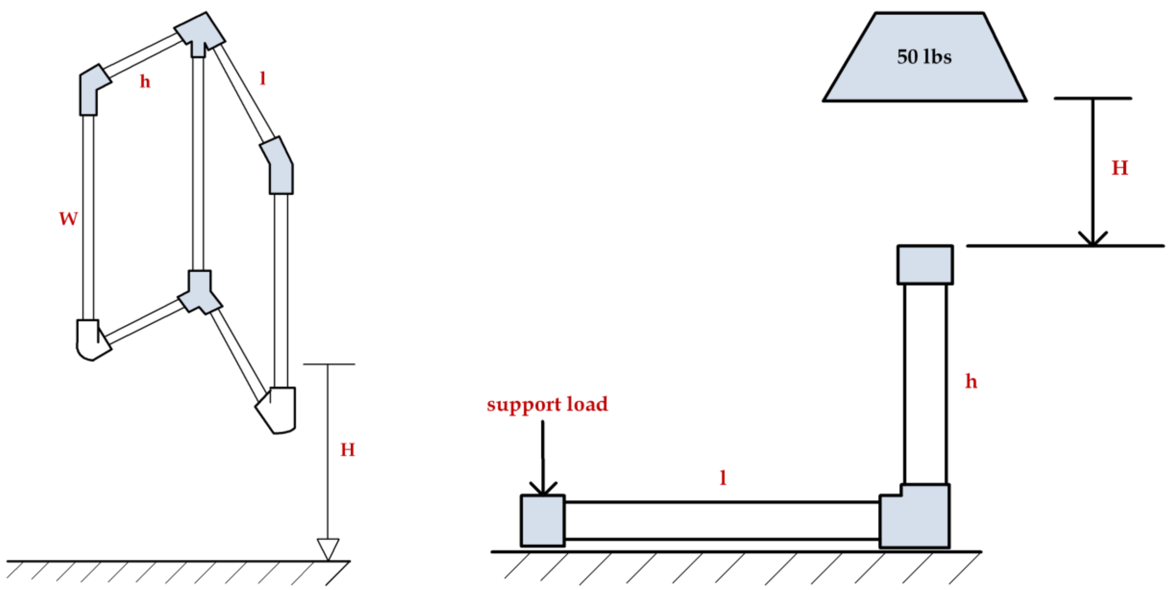

Fig. 9.6. Schematics of Drop Test and Weight Test.

UPPER EXTREMITY EXERCISER

Industrial and Systems Engineering Designers: Eduardo Borges, James Letts (team leader), Christopher Reed, and Renzo Salazar
Mechanical Engineering Designers: Dennis Bradford, Daniel Kelly, Park Perkins, and Julie Watkins
Client Coordinator: JJ. Mowder-Tinney, Nazareth College Physical Therapy Clinic
Supervising Professors: Dr. Matthew Marshall and Dr. Elizabeth DeBartolo
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INTRODUCTION

The objective of this project was to create a rehabilitation aid for individuals recovering from stroke or other neurological traumas. It was to facilitate stretching and strengthening exercises to help lift and reach for objects. A physical therapist requested that the device provide assistance throughout a lifting motion and constrain arm motion to the sagittal plane. The device was to: 1) provide an adjustable, assistive force to help lift the arm in front of the client; 2) be adjustable for height and weight; 3) be able to be used on the left or right arm; and 4) be portable while in the use phase.

The final product (see Fig. 9.7) consists of an acetal beam that extends over the client's shoulder. The beam is tapered to a thinner width and thickness toward the end in order to create more flexibility while maintaining strength at the base. Attached to the beam is a rubber exercise band that, in turn, attaches to the hand or wrist of the client at the therapist's discretion. The combination of the flexible beam and rubber cord creates a force that assists in lifting the arm of the client up and away from the body in the sagittal plane. The amount of assistive lifting force can be varied between 4.4 to 8.3 pounds by turning a ratcheting hand crank, thereby increasing the initial tension on the exercise band.

SUMMARY OF IMPACT

The device aids the physical therapist and clients during upper-body rehabilitation.

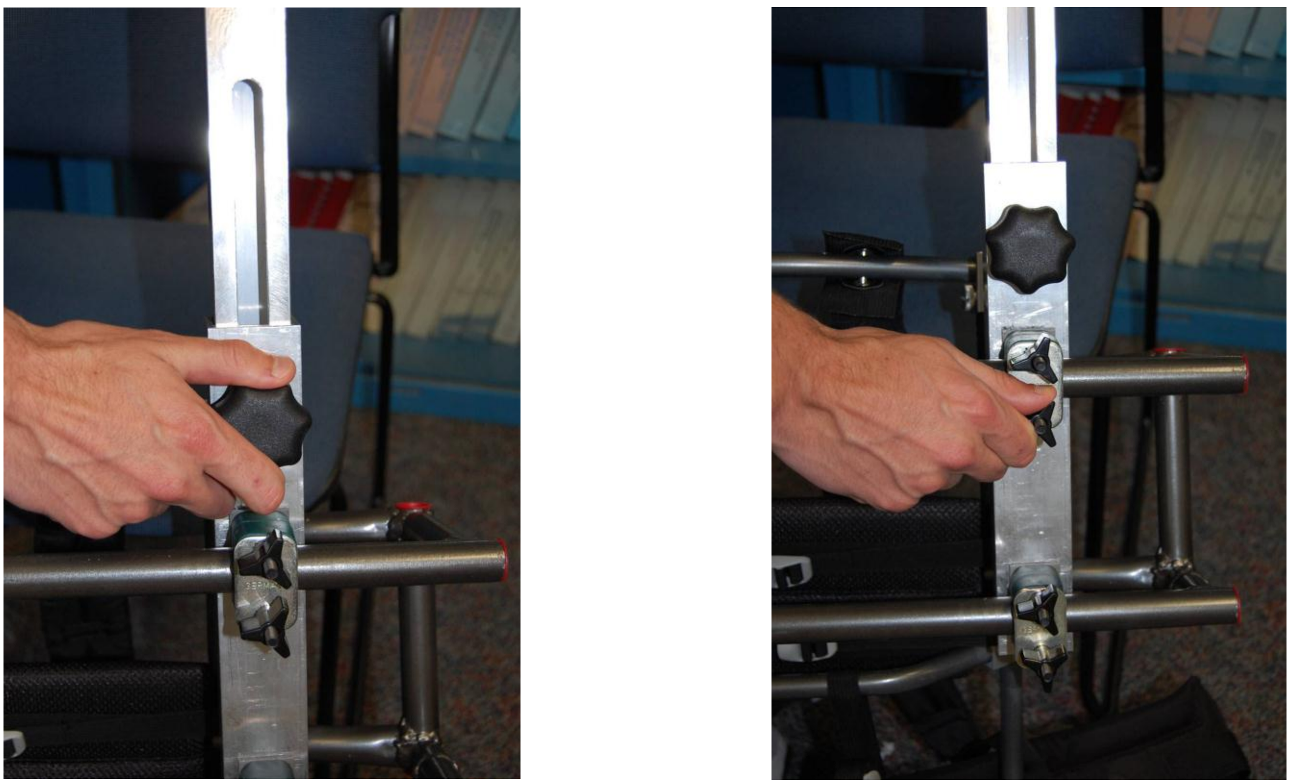
TECHNICAL DESCRIPTION

The final product is a cantilever beam assembly mounted on a lightweight backpack frame (see Fig. 9.7). The device slides horizontally on two rails attached to the frame and vertically in a sleeve mounted to the frame (see Fig. 9.8). All adjustments can be made by hand. The hand attachment point is interchangeable with a number of different hand grips, depending on the ability of the user. The cable running to the hand grip passes through a telescoping guide that maintains motion in the sagittal plane. The mechanical assistance is provided by an exercise band that runs from the hand grip, down the length of the beam, and back to the vertical post.

Fig. 9.7. Student Team Member Demonstrating Use of Upper Extremity Exerciser.

The cantilever beam was made from acetal, and extends over the client's shoulder. The project started with a wider beam machined to a smaller size to determine the actual stiffness of the material supplied. Attached to the beam is a rubber exercise band that attaches to the client's hand or wrist at the therapist's discretion. As with the acetal, the exact modulus of the exercise band was unknown and had to be determined experimentally. The combination of the flexible beam and rubber cord creates a force that assists in lifting the patient's arm up and away from the body in the sagittal plane. The completed device was used with a BTE II Simulator machine to determine the actual lifting forces. The physical therapy clinic was also provided with a calibration scale to enable therapists to set the amount of lifting force by tightening the exercise band with a certain number of turns of the ratcheting mechanism.

The total cost of the project was about $649.



(a) (b)

Fig. 9.8. (a and b): Vertical Adjustment (a) and Horizontal Adjustment (b) of Device Mounted to Backpack Frame.

PHYSICAL THERAPY CLINIC LAYOUT REDESIGN

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Client Coordinator: JJ. Mowder-Tinney, Nazareth College Physical Therapy Clinic
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INTRODUCTION

The goal of this project was to improve the layout of a physical therapy facility in order to improve effective utilization of the facility and its equipment. Therapists at the clinic cited several examples of problems with the facility and instances in which the existing conditions had prevented them from delivering the best care possible to their clients. Using multiple pieces of equipment at the same time was problematic (see Fig. 9.9). The therapists had to work around one another and sometimes would not use particular pieces of equipment because of the lack of free space.

SUMMARY OF IMPACT

By reorganizing the clinic, the team was able to make significant improvements in both free space and accessibility of existing equipment. The new layout reduced the amount of overlap in work space from almost 300 ft^2 to just over 30 ft^2, and areas where work space overlapped among pieces of equipment were reduced from 120 ft^2 to 3 ft^2. Free space in the clinic was increased by 238 ft^2. In addition, a ramp and a platform (50- and 55-lb, respectively) used for therapy were modified to be more mobile so they can be taken out only when needed. By adding handles and caster wheels, the force needed to move each item was reduced to 17 pounds.

TECHNICAL DESCRIPTION

Halo diagrams were created to estimate the amount of overlap between equipment spaces. The halo is

Fig. 9.9. Physical Therapists Attempting to Use Neighboring Pieces of Equipment in Clinic.

the area around a piece of equipment required to use it. Physical therapy clients require constant supervision when using the equipment, so 30” halos were drawn surrounding each piece of equipment. The clinic was reorganized as shown below. Fig. 9.10 shows the old layout with halos indicated by dashed lines and Fig. 9.11 shows the new layout.

The total cost of the project was $0.

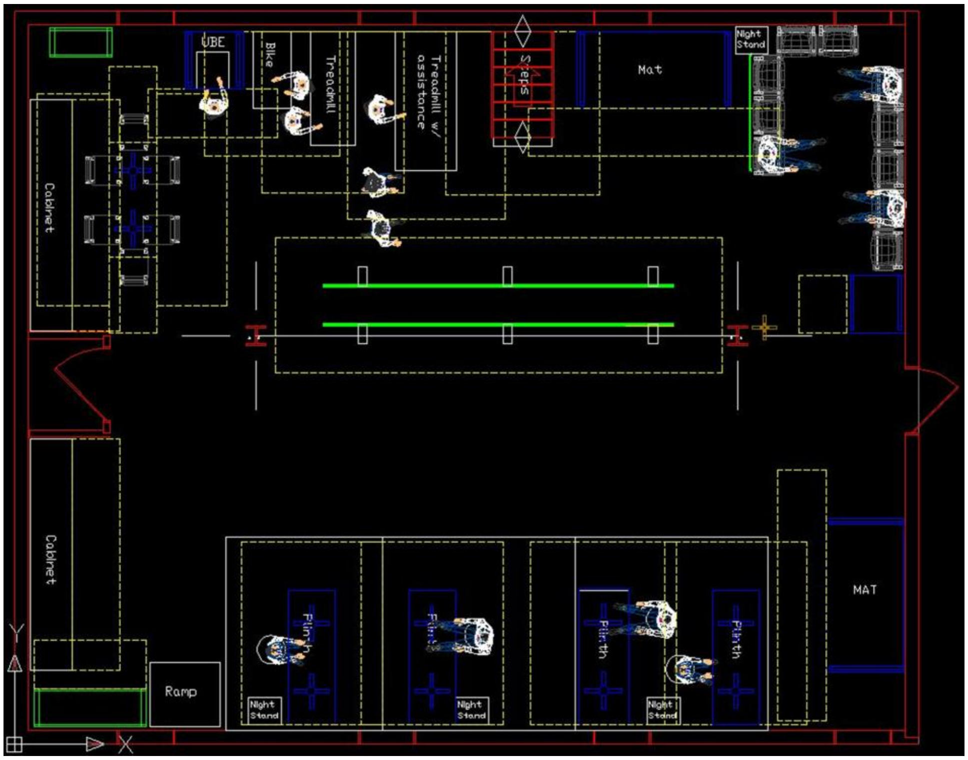

Fig. 9.10. Old Clinic Layout; Dashed Lines Indicate Halo of Space Required to Use Each Object.

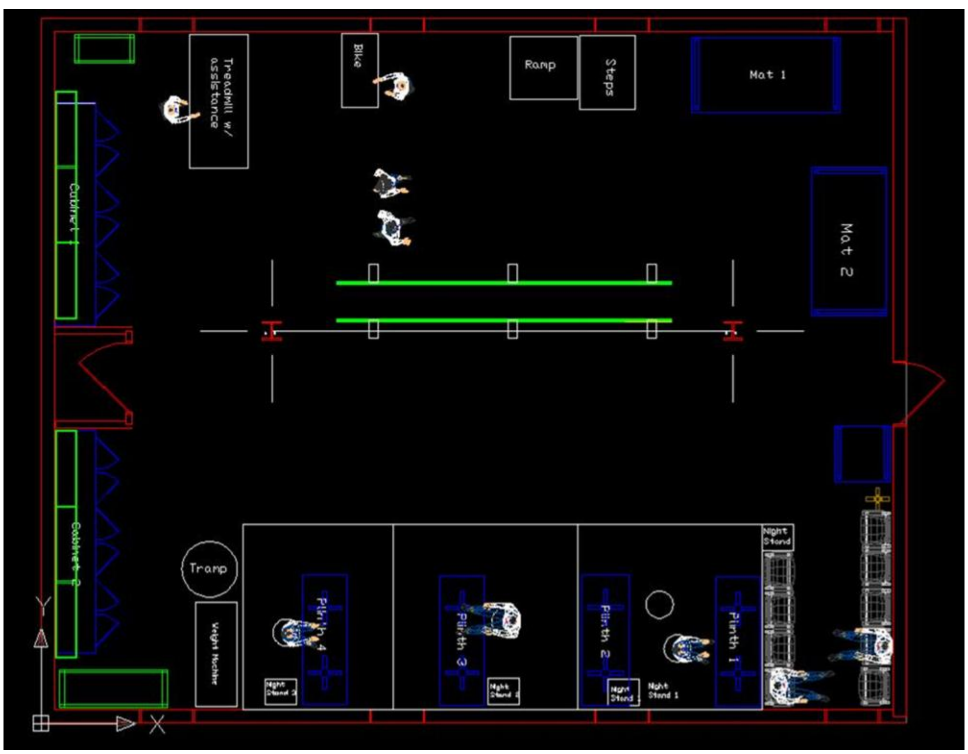

Fig. 9.11. New Clinic Layout After Useful Equipment was Moved to Optimal Positions and Unused Objects Were Cleared.

AUTOMATED HOME ENTRY CONTROL SYSTEM

Electrical Engineering Designers: Wenbo Chen (team leader), Meklet Kidane, and Tanvir Rasel
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Supervising Professors: Dr. Daniel Phillips and Dr. Elizabeth DeBartolo
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INTRODUCTION

A 2005-06 project entailed an adapted home entry system designed to give home access to two individuals who use wheelchairs and were unable to open their home's front door without assistance. The system was designed so that the two individuals would be able to enter and exit their home without any assistance. By utilizing a remote control system, the clients could open, close and lock the home's front door. The opening and closing of the door was implemented using an electric motor driving a mechanical lever attached to the door's upper surface. The locking capability was provided by incorporating an electric strike plate. A prototype system was initially implemented to

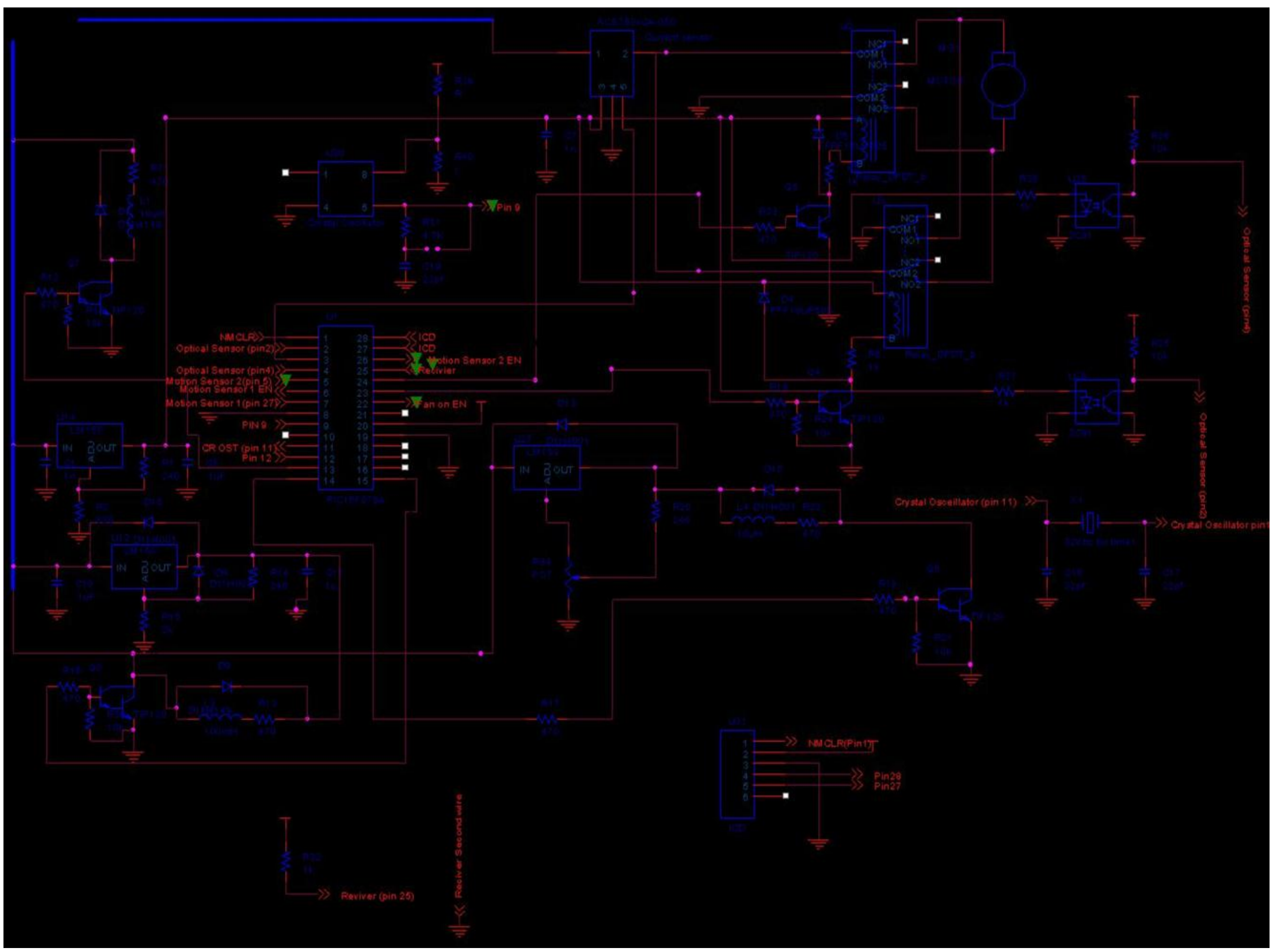

Fig. 9.12. Control System Schematic Diagram.

demonstrate the feasibility of providing an integrated solution. The original prototype system stopped functioning properly after a short period of time. The management agency associated with the operation of the group home requested that: 1) the prototype system be removed; 2) any modifications to the original doorway be repaired; and 3) any revised system be tested and approved prior to its installation. The task was to build a robust control system for the existing electro-mechanical hardware that met the original requirements, including those associated with the Americans with Disabilities Act.

The original system was viewed in its failure mode. The resulting discussions, review, and analysis provided the impetus to design a more integrated and sophisticated electronic control system, as well as a more robust enclosure and mounting strategy. After the inoperative system prototype was uninstalled, the entire door and door frame assembly was removed and replaced with new construction. It was agreed that the new revised design would be implemented and tested on a mock-up comprised of the old door and door frame to the complete satisfaction of the management team of the residence before it was actually installed at the residence.

SUMMARY OF IMPACT

The new design includes a number of improvements, including a new enclosure and the use of printed circuit boards for the electronic control circuitry. The control system was designed to be more robust. It incorporates a programmable microcontroller and multiple non-contact sensors to ensure safe operation of the door in case the door is obstructed. The system also enables manual operation by other residents of the house or if power to the system is interrupted. The prototype system was well received by both the residents and management associated with the residence. They endorsed the redesign and looked forward to its installation.

TECHNICAL DESCRIPTION

The system entails remote radio frequency transmitters that communicate with a radio frequency receiver unit mounted in the door opener enclosure. The signals from the receiver and from a combination radio-frequency or infrared proximity sensors, a motor current sensor, and non-contact position sensors are used to determine the position of the motor shaft that drives the mechanical door opening assembly. These signals serve as control inputs to a PIC 16F876A microcontroller that is programmed to operate the door in a safe and controlled fashion. The major outputs controlled by the microcontroller consist of: 1) the drive input signal to a 90-volt DC motor; and 2) the activation signal to an electromechanical clutch, which transfers force from the motor to the mechanical door opener mechanism, sending a signal to the electromechanical door strike mechanism to lock and release the door. A system-level 120-volt power supply provides appropriate DC voltage levels for the motor, clutch, door strike, and control circuitry. The power for the overall unit is provided by a standard 15-ampere, 125-volt AC outlet.

The team designed a robust enclosure and mounting platform for the device, with a great deal of advice and assistance from one of the mechanical engineering machine shop technical staff,. The new enclosure was fabricated from aluminum sheet. It includes a cooling fan for the electronic circuitry and the electromechanical devices that comprise the system.

The total cost of the project was about $1185.

ARCWORKS WASH BOTTLE ASSEMBLY ADAPTATION

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Mechanical Engineering Designers: Stephen Bennice, Gabriela Jaramillo, Eric Van Hemel, and Robert Veiders
Client Coordinator: John Syrkin, ArcWorks
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INTRODUCTION

The purpose of this project was to develop an assembly system that would improve the existing process of manually attaching a spout to a wash bottle and to reduce the material flow issues of a local facility. The existing bottle assembly required the operator to apply between 40 and 50 lbs of force to attach the spout to the bottle. This was done with a T-shaped manual tool that caused significant contact stress on the user's hands, which was then transferred to the wrist and arm (see Fig. 9.13). Residual effects of this repetitive action ranged from reduced productivity, to pain and discomfort that could result in disability.

Fig. 9.13. Current Assembly Process.

The system consists of a pneumatically operated machine that minimizes the force and motion required to assemble the wash bottle (see Fig. 9.14). The operator inserts a bottle into the bottle holder and a spout into the plunger, moves the slide latch into position, and activates the two hand tie-down. The new process reduces the force exerted by the operator from 40 to 50 pounds to less than one pound. In addition, lean manufacturing concepts were incorporated in order to provide a more efficient and smoother material flow. The material flow is one-piece and was standardized so that it is clear to the user where the raw materials and the final assemblies are to be placed.

The device was tested extensively, including a simulated six months of use (54,000 cycles), ten consecutive E-stop firings, and assembly of two full cases of each bottle size to ensure zero defects and improved cycle time over the current process.

SUMMARY OF IMPACT

The overall system ensures greater productivity by having relieved virtually all ergonomic hazards and through reduced material handling distance. Force and motion required to assemble the wash bottle are reduced with the design.

TECHNICAL DESCRIPTION

Since the bottle assembly was automated with this design solution, engineering analysis was done to establish how the bottle would behave under the pneumatic loads, in addition to determining how the assembly machine itself would react to the force being applied by the pneumatic cylinder. All static analyses were made either using ANSYS version 9.0 or ANSYS Workbench version 10. Three different sized bottles are currently being assembled by employees: 250-mL, 500-mL, and one-L. The one liter bottle was used for all analyses since it undergoes the most deformation of all three due to its size. The bottles are manufactured by Nalgene and are made using low density polyethylene. Analysis showed that the maximum force that can be applied before the yield strength of the bottle is reached is 175-lb. Since the air cylinder used in the design will be running at an air line pressure of 80-

psi (which gives a cylinder force of 72-lb), the bottles would have a factor of safety of 2.43. The most critical part of the assembly system is the bracket that supports all force applied by the pneumatic cylinder; its factor of safety was found to be 10.2.

The first, and one of the most important features of the system, is the OSHA compliant "lock-out-tag-out". This allows the system to be safely depressurized when not in use, and must be un-locked by a supervisor to begin production. Immediately following the "lock-out-tag-out" is a filter/regulator unit with an indicator to regulate the incoming air pressure to the specified 70 to 80-psi. Post regulator is an E-stop which will vent all potential energy in the system.

The heart of the system is based on the two-hand-tie-down feature. The two pneumatic push buttons are placed in line with a pneumatic logic controller. The buttons must be depressed within a half second of each other to generate an output from the logic, ensuring that the operator's hands can only be on the buttons when the machine fires and not in danger from the moving cylinder. Air is then sent directly from the supply through a limit valve to the cylinder, upon which there is a flow control for the forward stroke. When the cylinder extends to the point of a "good assembly", a ball actuator valve is initiated, indexing the counter and pressurizing the green indicator to signal the operator of a completed assembly. The buttons are then released and the cylinder returns to its rest position. The pneumatic schematics are shown in Fig. 9.15.

The total cost of the project was about $1105.

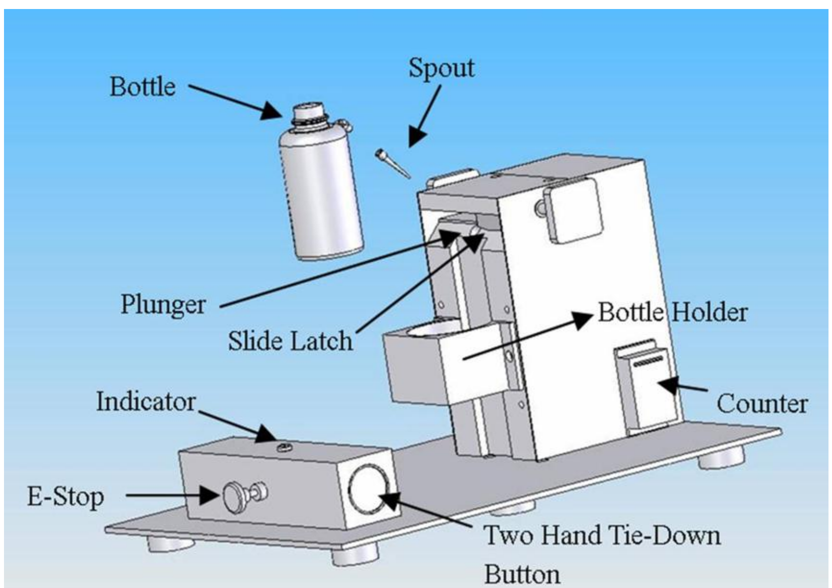

Fig. 9.14. New Wash Bottle Assembly System.

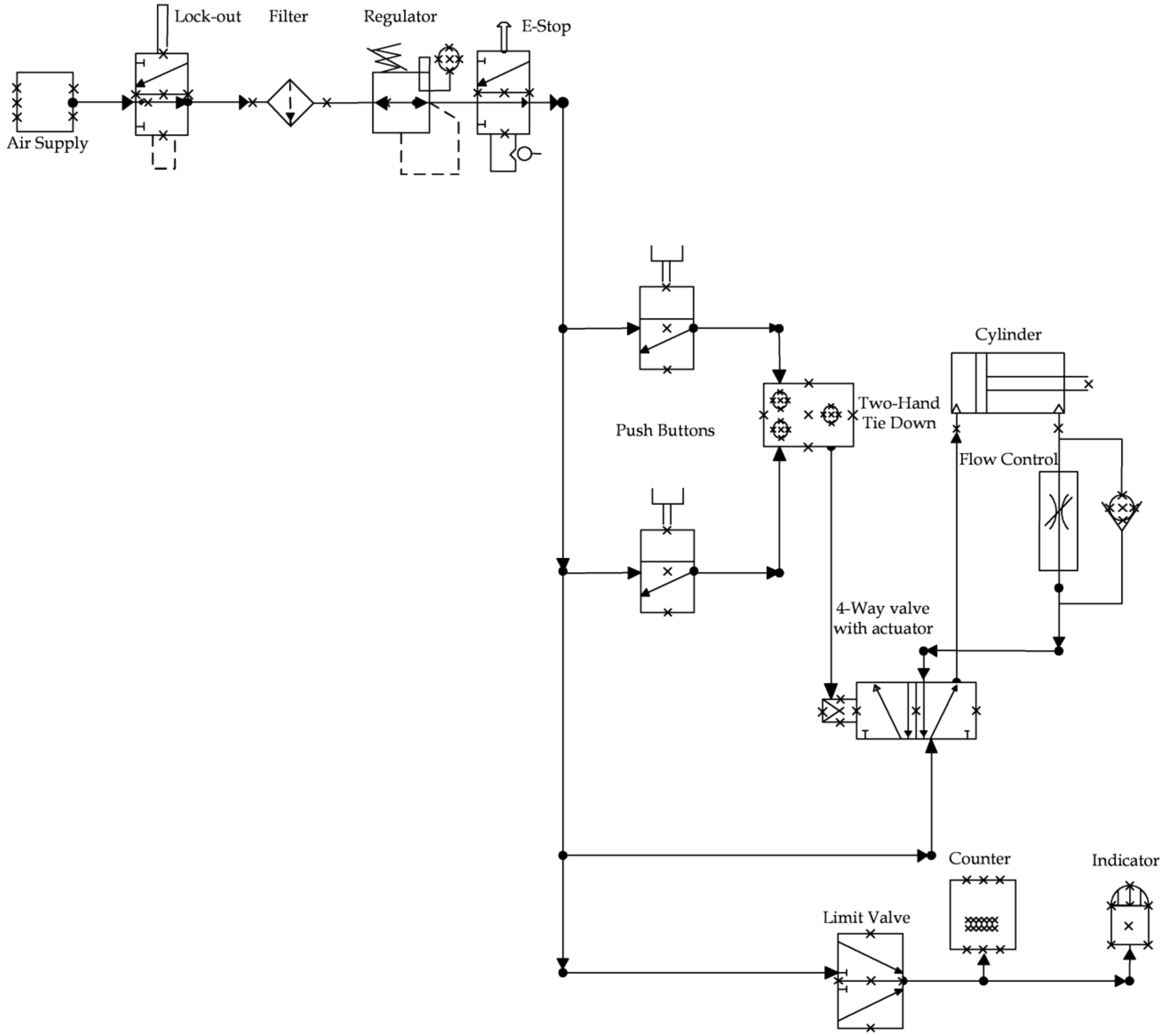

Fig. 9.15. Pneumatic Schematic for Automatic Wash Bottle Assembly System.

CHAPTER 10
SAN DIEGO STATE UNIVERSITY

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Principal Investigator:

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KNOT-TYING DEVICE

Student Designers: Meral Demir and Ed Beail
Supervisors: Peter C. Newman and Dr. Karen May-Newman
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INTRODUCTION

Knot tying, an essential task in sailing, requires a high level of dexterity. The goal of this project was to design a device that would enable someone with limited dexterity (pincer grasp) of at least one hand to tie a bowline knot for a range of rope sizes. The requirements for the device were that it be: 1) portable; 2) capable of operating for an extended time in a marine environment; 3) secured easily during use; and 4) safe from cut or pinch hazard.

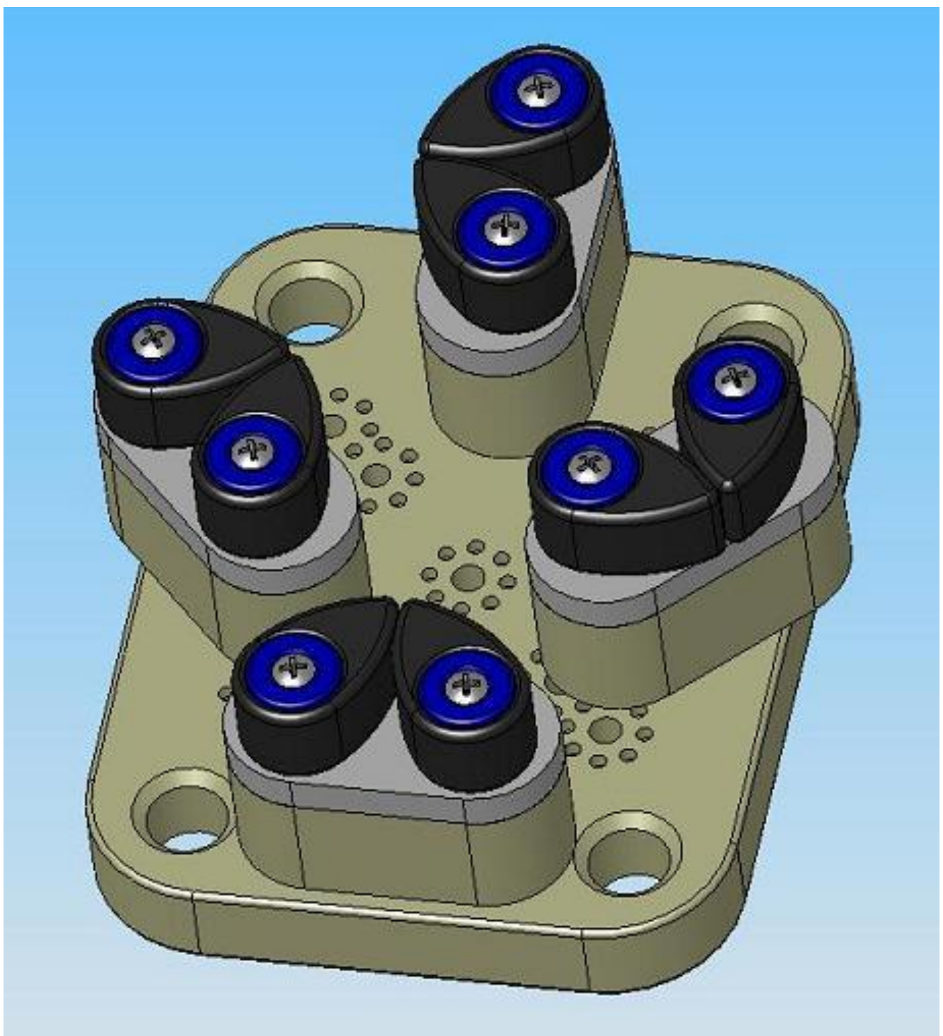

Fig. 10.1. CAD Model of Knot-Tying Device.

Important considerations in the design included: 1) user comfort; 2) safety; 3) protection from saltwater corrosion, temperature extremes, and dynamic loading forces due to motions of the boat; 4) accounting for electric power and weight limitations inherent in a racing boat.

SUMMARY OF IMPACT

The bowline knot is used to secure lines to sails, lash other objects to the boat, and is one of the most common knots needed on a sailboat. This device enables an individual with limited hand mobility to tie a bowline knot unassisted. No other device is known to be available as an assistive technology for tying knots.

TECHNICAL DESCRIPTION

A hand-held board with cleats attached to one side is used to hold a rope in position while tying a knot. The cleats can be positioned on the board in different arrangements to best facilitate a particular type of knot. The device consists of a plate machined of ABS, which can accommodate risers attached by a single threaded screw and oriented with pins. The risers have cleats attached that can be positioned to allow rope slippage in one direction but fixing it along the other. Four cleats (see Fig. 10.2) are needed to tie the bowline knot. The device can also be used to tie a half-hitch knot. Other knot styles are being tested.

The total cost of the project was $130.

Fig. 10.2. Final Prototype of Knot-Tying Device.

CENTER PEDESTAL GRINDER WITH PIVOTING BASE FOR RACING SAILBOAT

Student Designers: Alex Antonio, Mike Tam, and Ray Jalisi
Supervisors: Peter C. Newman and Dr. Karen May-Newman
Department of Mechanical Engineering and Rehabilitation Technology Program
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San Diego, CA 92182-1323

INTRODUCTION

Winches are a common mechanical device used on sailboats for hauling in and tensioning a variety of sail handling and control lines. Traditional winches use a crank handle mounted directly to the vertical axis of the drum, which is wound in a circular direction. This arrangement requires the user to have substantial trunk and lower body strength to power the lateral motions required of the handle. This motion can pose an ergonomic challenge for able-bodied sailors and can be nearly impossible for individuals with physical disabilities or lower body strength limitations. The center pedestal grinder

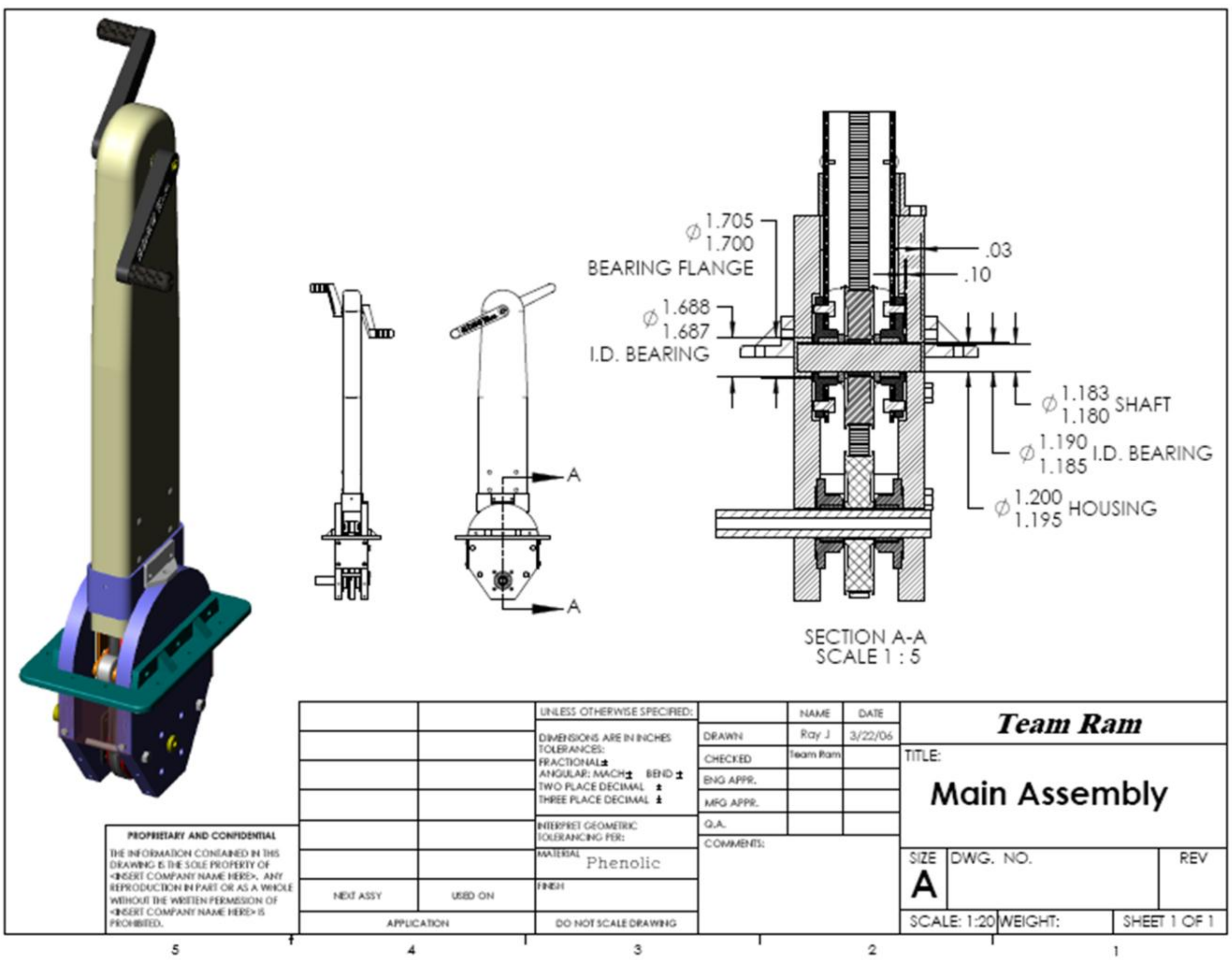

Fig. 10.3. CAD Model and Assembly Drawing of Pedestal Winch Grinder.

allows a single user to control the motion to several winches by interfacing with a gearbox mounted under the deck. The gearboxes provide multiple speeds and allow the user to direct power to different winch drums.

The goal of this project was to design a mechanical interface with a commercially available pedestal winch that could be rotated for use by a crewmember sitting on either the port or starboard side of the cockpit of a 40′ racing boat. The pedestal would mate with commercially available gearbox and drive shaft components mounted below the deck.

SUMMARY OF IMPACT

The center pedestal grinder enables crew members with limited lower or upper body strength and mobility to control sailing line tension to raise and adjust the sails of a boat. The center pedestal allows crew members seated on deck-mounted chairs to work a variety of winches from a single position.

TECHNICAL DESCRIPTION

The pedestal grinder (see Fig. 10.4) is a common device in larger racing sailboats today, and is typically operated with both hands while in a standing or crouching position. The center pedestal winch grinder employs a “coffee grinding” mechanism that is mounted in the center of the boat's cockpit and is connected to winches on either side of the boat. The design enables crewmembers in a seated position, such as those with paraplegia or lower limb amputation, to effectively grind with a powerful, bicycle-like hand motion at chest level.

A belt drive pedestal from Harken served as the starting point, with Harken representatives providing help in securing the proper drive elements. Stock parts were chosen for the upper portion of the pedestal, including the hand crank assembly, bearings, pulleys, and toothed drive belt.

Once the standard moving parts were identified, the design tasks shifted to designing a pivoting base assembly to support the modified pedestal at the desired position and interface with the standard below-deck drive components. This assembly transfers the drive power from the pivot to the output shaft. This base includes a quick-release position lock accessible to the user and also holds a flange to mount the device to the deck. Prototype assembly as well as patent disclosure filings are in progress.

Fig. 10.4. Prototype Pedestal Grinder.

The total cost of the project was $3500.

WHEELCHAIR LUGGAGE ASSIST DEVICE

Student Designers: Erik Allegoren and Brady Mills
Supervisor: Dr. Karen May-Newman
Department of Mechanical Engineering
San Diego State University
San Diego, CA 92182-1323

INTRODUCTION

A woman who uses a wheelchair and is an avid traveler requested a device that would aid her in travelling through airports with carry-on bags. There are devices currently marketed for attaching luggage to wheelchairs, but they are all rear-mounted, bulky, and meant to be used with an assistant.

The objective of this project was to design a luggage assist device that would allow people who use wheelchairs to view and access their carry-on luggage, enabling them to travel more independently. The design of the device was to minimize any negative impact on wheelchair mobility and maneuverability. Specific criteria included that the device: 1) not hinder the maneuverability of the chair; 2) enable the user to

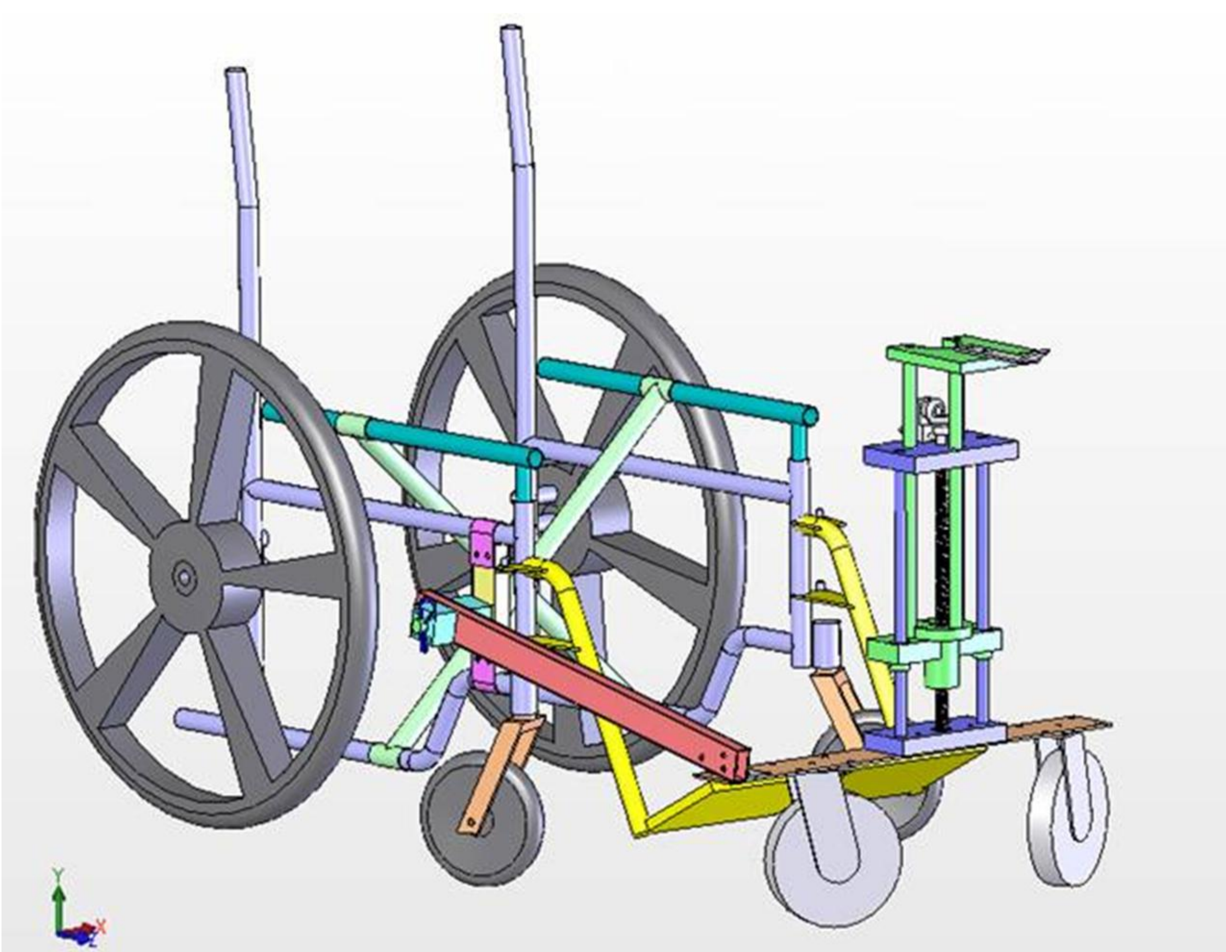

Fig. 10.5. CAD Model of Wheelchair Luggage Assist Device.

load and unload the packed bag without assistance; 3) allow for a standard carry-on size bag; and 4) allow the chair to collapse for storage; 5) be able to be mounted to a majority of standard chairs; 6) not touch the user unintentionally; and 7) allow the user to transfer in and out of chair.

The wheelchair luggage assist device (see Fig. 10.5) is used to assist people in wheelchairs in transporting their luggage without using their hands. It consists of a rack mounted in front of the wheelchair that can be tilted for loading and unloading and easily removed for storage (see Fig. 10.5).

SUMMARY OF IMPACT

The device carries the luggage in front of the user, keeping the bag in plain view at all times. The user can reach forward and add or remove things from the bag. Rear-mounted systems require the user to twist around to view or reach into the bag and typically require an assistant. The front-mounted design provides greater independence by keeping the bag in view and within easy reach of the wheelchair user. This design aids in security and compliance with airport safety regulations.

TECHNICAL DESCRIPTION

The wheelchair luggage assist device is mounted to the right front side of the wheelchair. It consists of an attachment plate and a pivoting arm that extends forward to a trolley. The design employs casters on a pivoting arm to keep all wheels and casters in contact with the ground when encountering uneven or transitional surfaces. The trolley has a base plate supported by two casters. On the base plate is a lead screw, connecting one stationary plate and one sliding plate, serving as the lifting mechanism. A hand crank operates the lead screw and moves the sliding plate upward, lifting the luggage. A prototype is shown in Fig. 10.6.

The device was made to fit to a common thread design available in most manual wheelchairs on the market. The most critical feature is the arrangement of the lower frame and down tubes connecting the drive wheels and casters along the bottom of the chair's frame. The design of the attachment plate is an "S" shaped rise that allows the caster to clear the otherwise low-slung tube. Future improvements of the design would be to improve the lifting mechanism for ease of use and to reduce the weight of the device.

The total cost of the project was $350.

Fig. 10.6. Prototype of Luggage Assist Device.

CHAPTER 11
STATE UNIVERSITY OF NEW YORK AT BUFFALO

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Principal Investigator:

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POWER-LIFT TOILET SEAT

Designer: Alan R. Sattelberg
Client Coordinator: Howard R. Sattelberg
Supervising Professor: Dr. Joseph C. Mollendorf
Mechanical and Aerospace Engineering Department
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INTRODUCTION

Many of the devices that assist people who are physically challenged in positioning themselves on toilets rely on the available leg and upper body strength of that individual. Usually, one must grasp adjacent side rails mounted near the commode in order to lower and raise himself or herself from the seat. This could be a monumental task for many people who use wheelchairs and those with chronic back pain and/or arthritis. A powered lift seat was designed that enables users to lower and raise themselves to and from a toilet at variable heights with little effort.

An appliance that lowers and raises a person to an existing elongated toilet was developed. The appliance in Fig. 11.1 is the "Power-Lift Toilet Seat." The device fits over the toilet and attaches to the holes where the seat would be fastened. The seat movement patterns the motion of an automatic lift chair. The prototype consists of a stationary lower

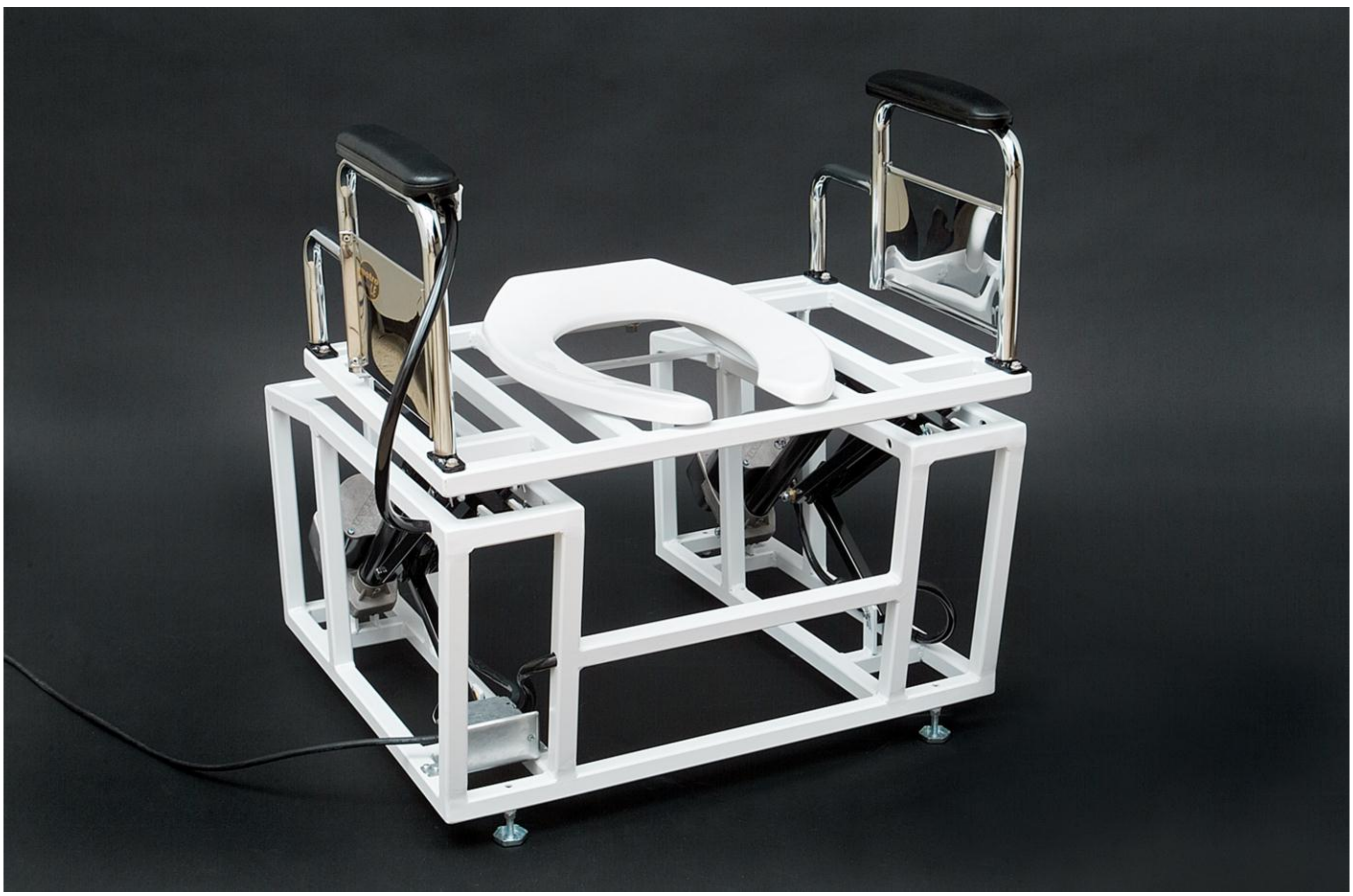

Fig. 11.1. The Power-Lift Toilet Seat.

frame and a mechanically moveable upper frame (where the seat is fastened). These frames are constructed of one-inch by one-inch steel tubing with a one eighth inch wall thickness and welded joints. This device weighs approximately 110-lbs and is capable of safely lifting a person that weighs 300-lbs. The framework of the prototype is exposed but could be protectively covered with a plastic or sheet-metal housing. Moveable parts with the potential of inflicting injury to the user could also be shielded.

SUMMARY OF IMPACT

Devices of this nature are non-existent in hospitals and nursing homes, so the demand for this device is certain. The Power-Lift Toilet Seat allows the client to have privacy and freedom to use a toilet without assistance. The device decreases the physical strain of sitting and standing while using a toilet. With respect to the hospital staff and management, assistive duties could be reduced, thereby reducing a facility's operating costs. Implementation of this device in the private sector would benefit the user as well as reduce the burden of family members serving as caregivers.

TECHNICAL DESCRIPTION

The major goal of the design process was to create a safe device while minimizing complexity of the structure and mechanics. This was important for minimizing production costs for eventual commercialization. A key challenge was to make the device as compact as possible in order to fit into limited surroundings (adjacent to the toilet) and to house the moveable parts. Another challenge was to design a linkage that raised and lowered the seat at a moderate angle comfortable to the user. This obstacle was addressed via re-design procedures (i.e., force diagrams).

The lower frame is 27.5″ wide by 25″ deep and has four levelers at its base, enabling a height from 15.5″ to 17″. The height adjustment (see Fig. 11.2) allows the device to be leveled and installed over most existing toilet bowls and compensates for uneven floor surfaces. The lower framework houses most of the mechanical parts that enable the functionality of this device. These parts include two 120-volt AC, 15-amp powered linear actuators, each with a lifting and lowering force of 1100-lb. The linear actuators (see Fig. 11.3) straddle the toilet bowl to evenly distribute the lifting and lowering load of the upper

Fig. 11.2. Device Installed Over Existing Toilet.

Fig. 11.3. Linear Actuators, Linkage Mechanism, and Armrests.

frame. The linear actuators are synchronized to start, lift or lower, and stop at the same rate. They enable a seated person to be lifted from the lowest horizontal position to the maximum vertical seat height of 32″ (from the floor) at 35 degrees to the horizontal in about 30 seconds. The same is true for the lowering function. This rate is comparable to that of the lift chair mentioned in the introduction. The upper frame is 27.5″ wide by 19″ deep and 1″ high. Any standard elongated toilet seat can be fastened to the frame. In addition, Fig. 11.3 shows two modified armrests (10" high) from a wheelchair that is fastened to the frame. A momentary up-down switch (see Fig. 11.4) is mounted directly under the armrest to the seated person's right. Thumb pressure to the front of the switch lifts the seat, while pressure to the back lowers the seat. The switch is wired to the linear actuators, which deliver the drive force to identical levering linkage mechanisms straddling each side of the toilet bowl. The linkages are made from 1″ by 1″ steel square tubing (1/8″ thick) for the main linkage and ¾″ by ¾″ steel square tubing (1/8″ thick) for the sub-linkages. The main linkage carries the center of gravity load, while the sub-linkages work off the main linkage to position the front part of the upper frame at an angle comfortable for the person on the seat. This angle changes from zero to 35 degrees to the horizontal as the seat lifts. The 35-degree angle (at the maximum lifting height; see Fig. 11.5) was found to be comfortable and adequate for the project's many test subjects.

The linkages attach to each other and to brackets that are welded to the upper and lower frames. These connections are made with 5/16″-diameter clevis pins, which are held in place by retainer clips. Frictional wear, caused by the contact of moving surfaces, is reduced by the implementation of brass washers placed between them. All connections are tight with the intent of promoting little or no lateral movement of the upper frame while offering little resistance to the force exerted by the linear actuators and the weight of the person on the seat frame.

The device is electrically grounded to the frame and has a ground fault circuit interrupter plug wired to the cord going to the power source. It protects the user from electrical shock from water contact with the electrical components or any short circuit in the system.

The total cost of the design prototype was $393.

Fig. 11.4. Armrest and Switch Location.

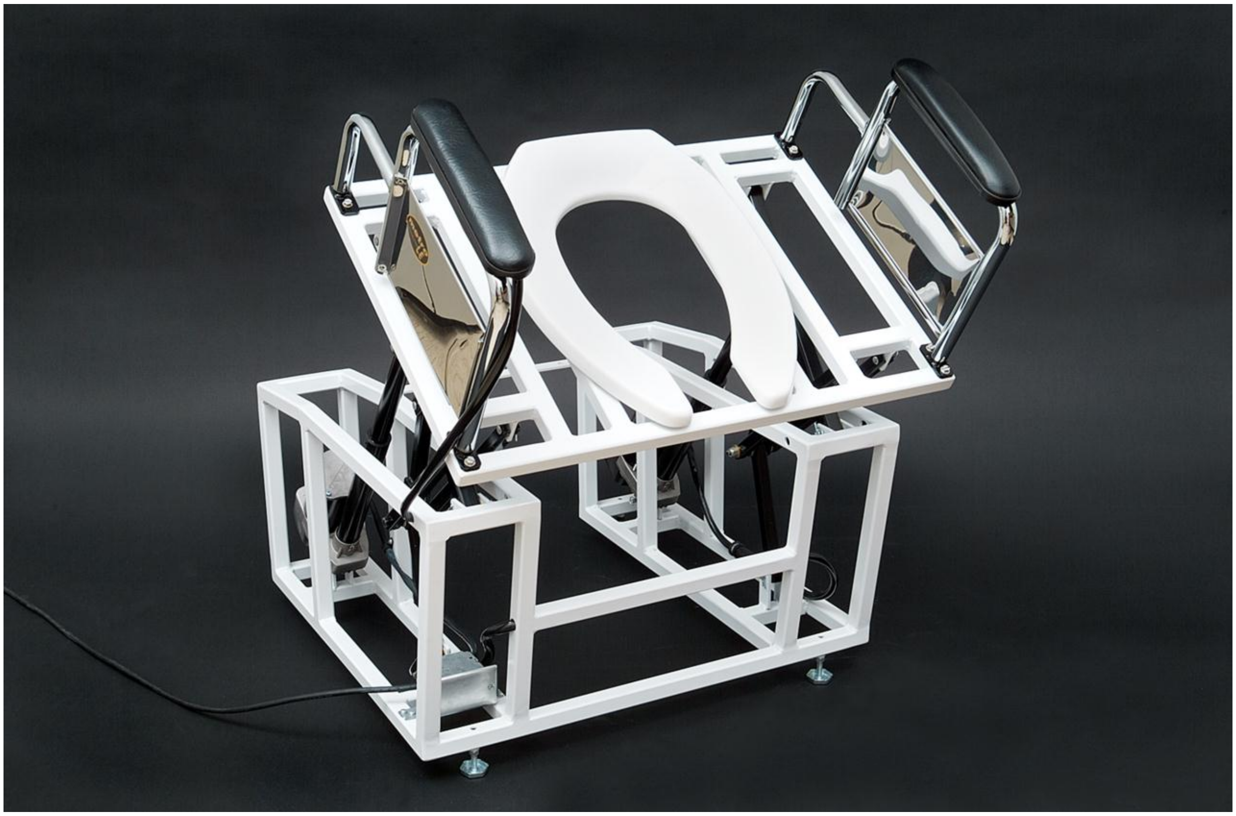

Fig. 11.5. Device at Maximum Height.

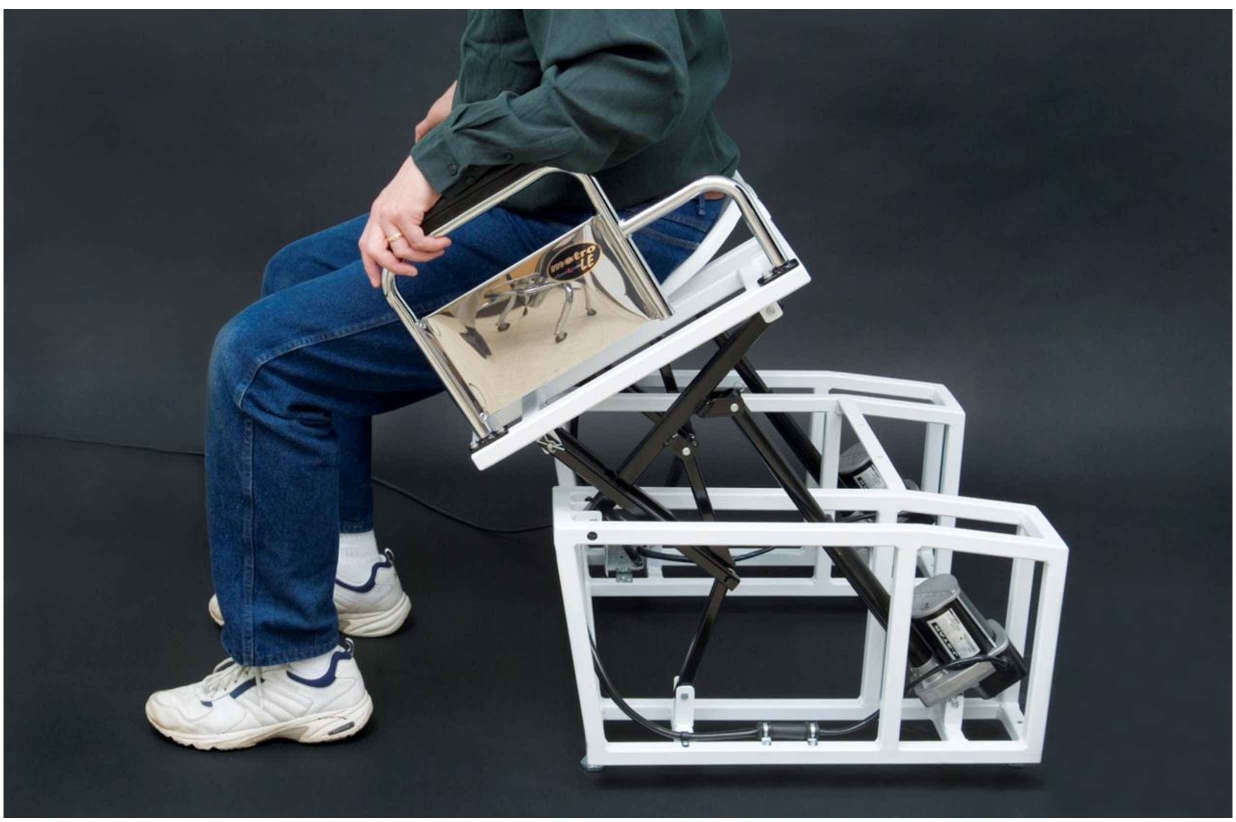

Fig. 11.6. Device in Use at Maximum Height.

REMOTE-CONTROLLED COMPUTER MONITOR STAND

Designers: Muhammad Haniff Abdul Aziz and Te Ian Lim
Supervising Professor: Dr. Joseph C. Mollendorf
Mechanical and Aerospace Engineering Department
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INTRODUCTION

For some individuals, the process of adjusting the view of a computer monitor in a public computing setting is difficult to perform independently. The objective was to design and build a motorized platform on which a monitor can be supported in order to allow the user to control the position of the monitor screen using a controller and not his or her hands. This device is useful for people with disabilities who are using self-propelled or motorized wheelchairs. In some situations, when a person using a wheelchair wants to use a public computer, the gap between the wheelchair and the desk causes the person to be too far away from the monitor and it leads to lack of hand control. The overall design was meant to ease this problem and help users with disabilities become more self-sufficient.

SUMMARY OF IMPACT

As a result of this device (see Fig. 11.7) a person using a wheelchair is able to adjust his or her view of the monitor without using his or her hands to physically move the monitor.

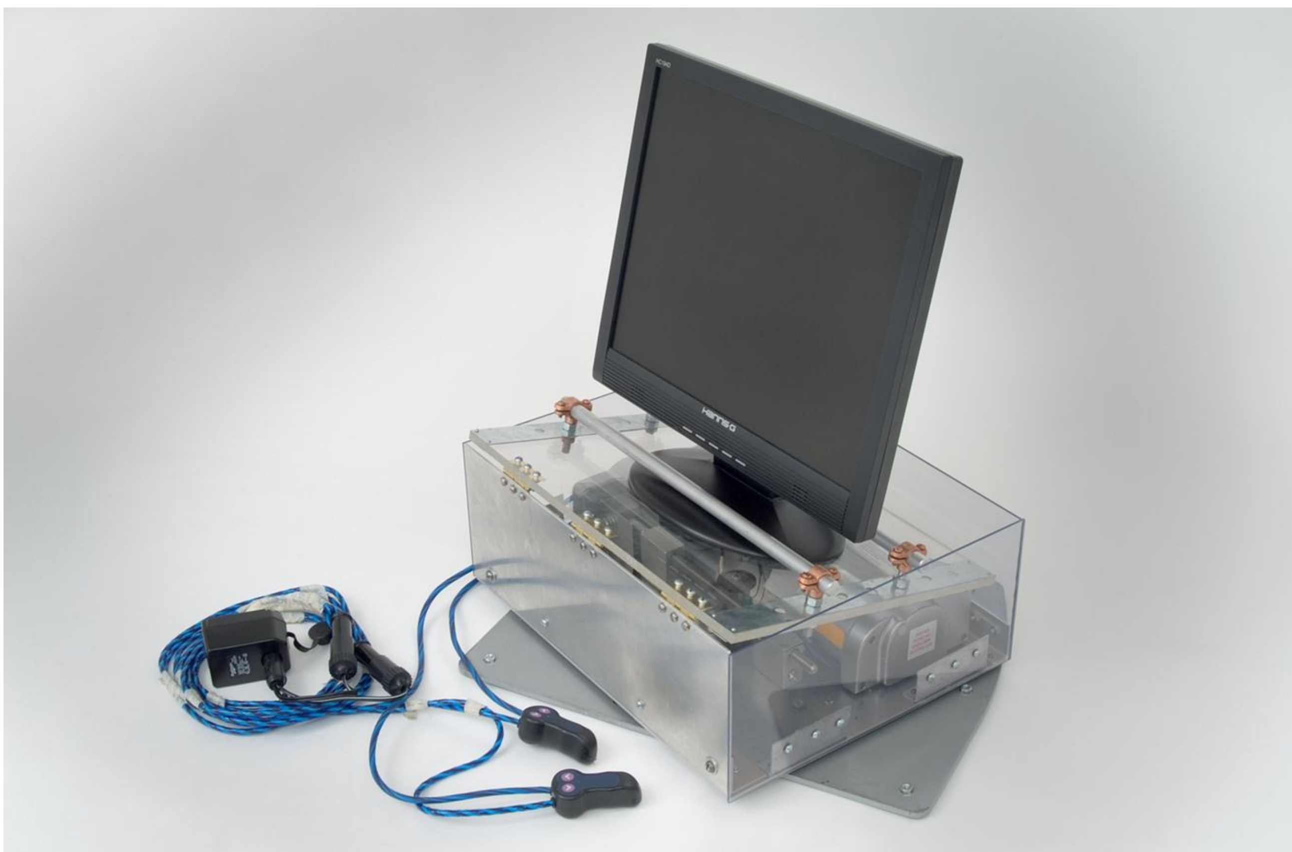

Fig. 11.7. Remote-Controlled Computer Monitor Stand.

TECHNICAL DESCRIPTION

All the internal components sit within a box constructed of Plexiglass and aluminum plates. A lazy-susan is placed between the base of the aluminum plate and the box to allow for rotation. Two controllers are used to control the tilt angle and the rotation angle. Both of the angles are controlled using two electric car jacks (see Fig. 11.8), one of which has been modified for the rotation angle. The unit is powered using an adapter which converts the 110-volt AC from the wall plug to 12-volt DC 1-amp.

TILT ANGLE

The tilt angle is driven by one electric car jack connected to a controller. A piece of Plexiglass is mounted to the top of this car jack by three hinges, which provide support. The electric car jack height can be adjusted up or down according to the person who is using it. The maximum weight that can be supported by the Plexiglass and the electric car jack is approximately 50 kilograms. The speed rate of the tilt angle is five degrees per second.

ROTATION ANGLE

The rotation angle is driven by the other electric car jack that has been modified to perform this function. The jack has been dissembled from the system, leaving the worm shaft and the motor, which is connected to a controller. A fixed worm gear that is mounted to the base of the aluminum plate engages the worm shaft from the electric car jack (see Fig. 11.9). When the worm shaft rotates, the Plexiglas box casing also rotates. The rotation angle has a rate of approximately five degrees per second. The limiting angles of rotation are 30° in either direction from center (60° total).

ELECTRICAL SYSTEM

An adapter converts the standard 120-volt AC to 12-volt DC for the electric car jacks. A controller is wired and connected between the electric car jacks and the power outlet. The controller wire is about a half meter long and can easily be reached by the user.

SUPPORTING BARS

The supporting bar system is mounted to the top of the Plexiglass case and consists of two aluminum bars that can be adjusted according to the size of the LCD monitor base. These bars ensure that the monitor will not shift or fall during the adjustment of the tilt angle.

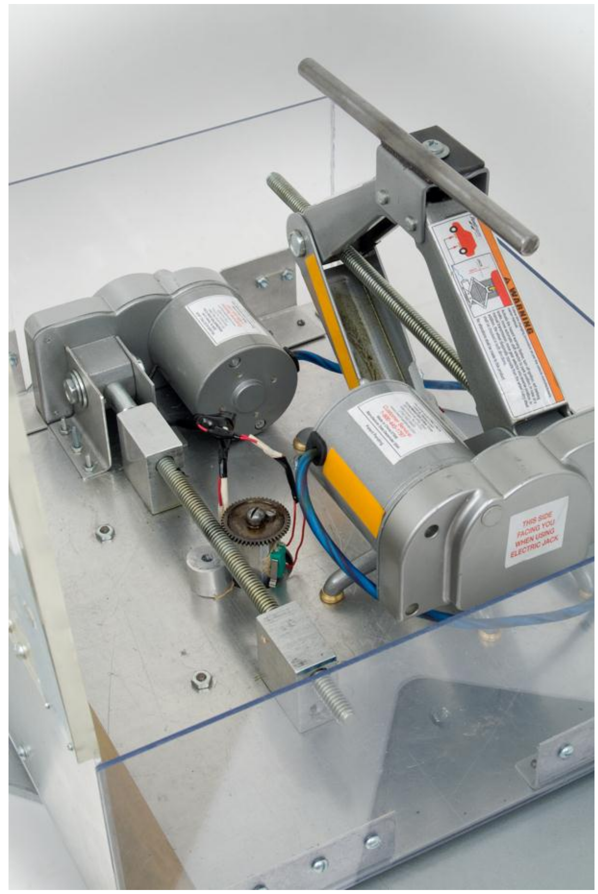

Fig. 11.8. Electric Car Jacks Used for Rotation.

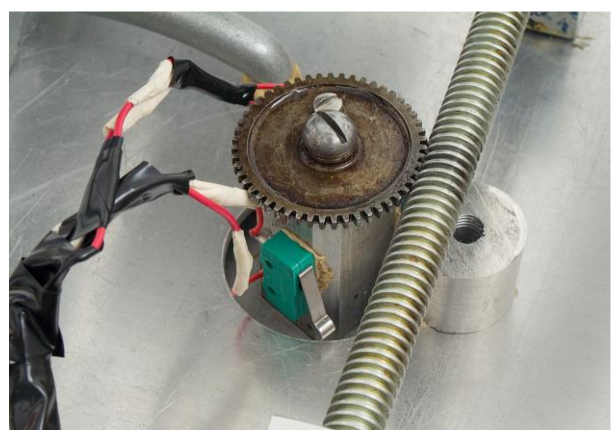

Fig. 11.9. Worm Gear Used to Control Rotation Angle.

The total cost of this project was $113.

ALL-TERRAIN TRACKCHAIR

Designers: Douglas Babicz and James Hudson
Supervising Professor: Dr. Joseph C. Mollendorf
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INTRODUCTION

This device is a mechanized chair that uses a tank track system in order to easily allow a person to go up and down stairs at a 30-degree angle, with respect to the ground. People who use wheelchairs or do not have the strength to walk up stairs will benefit most from device. The system consists of a four-bar mechanism that keeps the seat of the chair parallel to the ground, preventing the user from falling backward or tipping over (see Fig. 11.10 and 11.11). The complete system is easy to operate and is controlled using manual switches to move the four-bar system. This device can be completely automated by using a potentiometer and an RC servomotor.

SUMMARY OF IMPACT

The device will allow persons with disabilities the ability to travel over rough surfaces that they could not have traversed with a normal wheelchair. It will allow the user to go about his or her daily routine with more maneuverability, a good level of comfort, and confidence by enabling the rider to.

TECHNICAL DESCRIPTION

The four-bar drive system consists of three worm

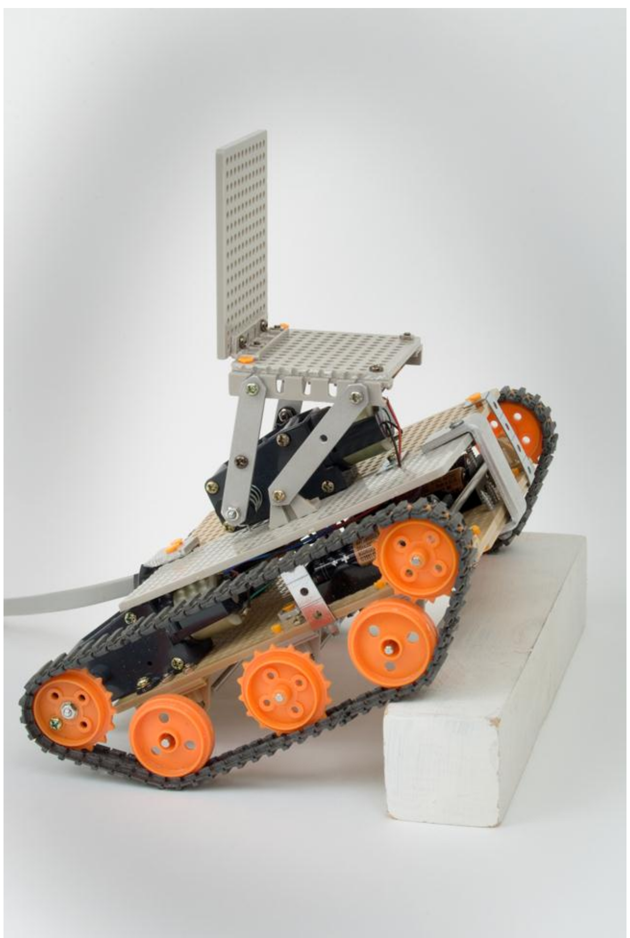

Fig. 11.10. All-Terrain Trackchair on an Incline.

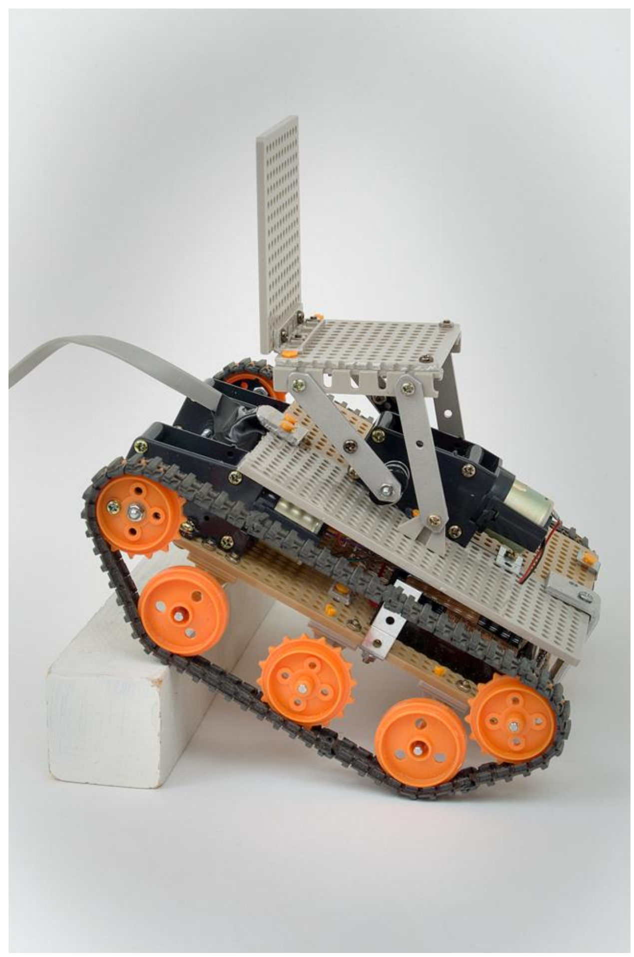

Fig. 11.11. All-Terrain Trackchair on a Decline.

gear electrical motors with 336:1 gear ratios. The system is operated by two manual toggle switches (see Fig. 11.12): one that operates the two drive motors and one for the Grashof double-crank four-bar mechanism, which controls the chair's position. The Grashof double-crank four-bar mechanism aligns the rider's center of mass with the track system's center of mass. This will prevent the device from flipping over when climbing obstacles.

The prototype is a 1/12 scale model of the actual system. It is powered by four AA batteries. The majority of the materials used for the prototype are plastics including the: 1) tracks; 2) chair; 3) gears for the motors; 4) base and chair platform; 5) driving sprockets and idler wheels for the track system; and 6) motor housings. Aluminum was used for the links of the four-bar mechanism, driving and idling axles, and support brackets. Steel springs were used to increase the tension on the four-bar mechanism links to reduce the mechanical slop created by the four-bar mechanism's driving motor gear train.

To automate the chair's four-bar system, a potentiometer would be mounted on the chair with a mass attached to its shaft to act as a pendulum. When the system ascends or descends an incline, the mass would turn the potentiometer, creating an output voltage. The potentiometer output voltage would be read by an RC servomotor and output a step input voltage to the four-bar motor. The RC servomotor would be programmed to give voltage outputs based on the potentiometer voltage to prevent the chair from oscillating.

The total cost of this project was $251.

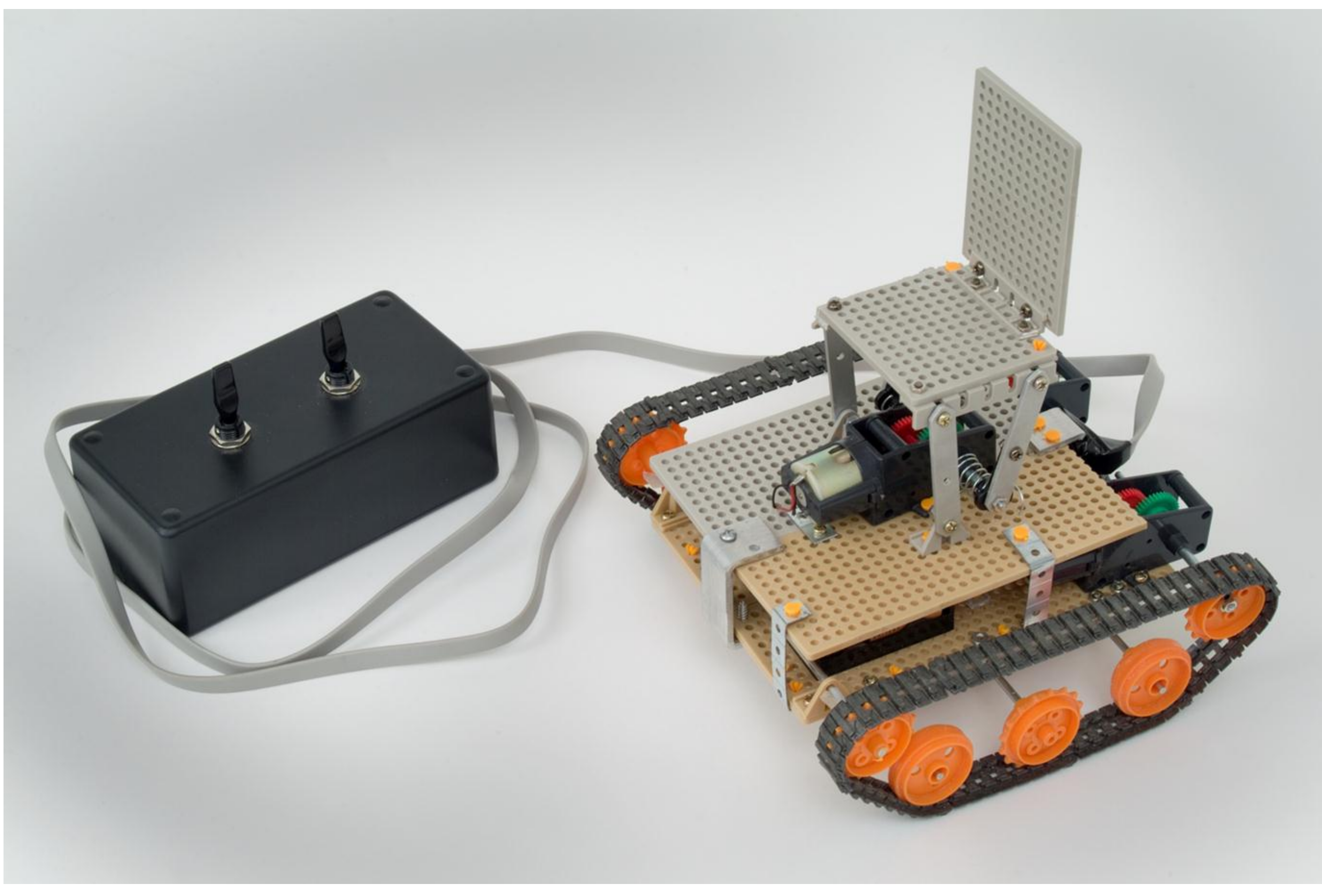

Fig. 11.12. All-Terrain Trackchair with Controller.

WHEELCHAIR/WALKER HYBRID

Designers: Cory Berardi and Daniel Coffey
Supervising Professor: Dr. Joseph C. Mollendorf
Mechanical and Aerospace Engineering Department
State University of New York at Buffalo
Buffalo, NY 14260-4400

INTRODUCTION

The task of walking in a mall can often be strenuous even with the aid of a walker. A device was designed to help people with disabilities to travel short distances without assistance. This device can transform from a wheelchair to a walker and vice versa with minimal effort.

SUMMARY OF IMPACT

The wheelchair/walker hybrid will help people with disabilities become more mobile and independent. It is important that people stay active and get exercise, but it is also important they not overexert themselves. The user can operate the device as a walker (see Fig. 11.13) to exercise his or her legs until he or she gets tired and then he or she can sit down and operate the wheelchair using his or her arms (see Fig. 11.14).

TECHNICAL DESCRIPTION

This device was constructed by making several modifications to an existing Rollator (a walker with a seat). The first modification was to replace the small rear casters with two 20-inch wheelchair wheels. Each wheelchair wheel was mounted onto the Rollator frame using an aluminum block clamp (see Fig. 11.15). These clamps were manufactured by machining a block of aluminum so that it would fit the contour of the frame after being cut into two separate pieces. Five holes were drilled into each block for five separate bolts. One hole was drilled for the wheelchair wheel axle and another four holes were drilled and tapped so that the block could be drawn together and tightened onto the frame.

Once the wheelchair wheels were mounted, the original brakes were removed from the front casters and fastened onto the wheelchair wheels. These brakes were securely attached by the use of two U-bolts for each of the two brakes. Two U-bolts were used to ensure no unintended alignment of the brakes after repeated use.

Fig. 11.13. Wheelchair/Walker Hybrid Being Used as a Walker.

Fig. 11.14. Wheelchair/Walker Hybrid Being Used as a Wheelchair.

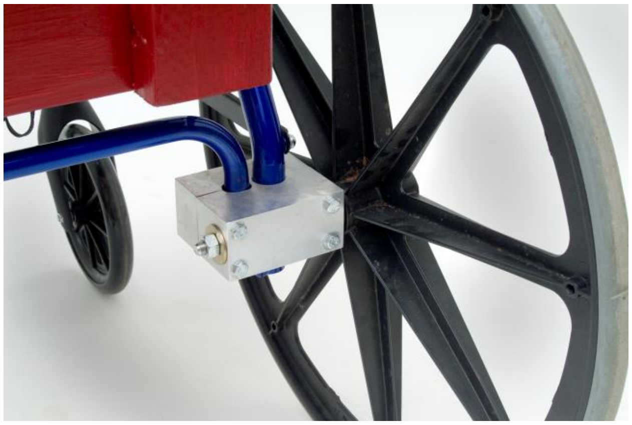

Fig. 11.15. Wheelchair Wheels and Mounting System.

Fig. 11.16. Caster Wheels and Mounting System.

The original rear caster wheels were then mounted on the front of the Rollator through the use of an adapter piece (see Fig. 11.16). Each adapter piece

Fig. 11.17. Wheelchair/Walker Hybrid.

consists of a small rectangular aluminum block with a hole through it, fitting the tube portion of the caster. A tension pin was then used to fasten the caster to the adapter piece. To attach the adapter piece to the Rollator frame, a solid aluminum round bar was welded to the adapter piece at a 60-degree angle, which fits properly into the frame. The existing split clamp on the Rollator was then used to securely tighten the round bar portion of the adapter to the frame.

To make the final product more comfortable, the original seat on the Rollator was replaced because it was too small and had no back support. The replacement seat is an actual wheelchair seat and backing donated by a surgical supply company. It was mounted on a wooden frame and attached to the Rollator through the use of wood screws. A coating of red paint was applied to the wooden frame to make it more cosmetically pleasing.

The final cost of this project was $174.

CONTACT LENS STORAGE CASE AND INSERTER

Designer: Michael Bonarski
Supervising Professor: Dr. Joseph C. Mollendorf
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INTRODUCTION

A prerequisite to wearing contact lenses is that the user possess the ability to perform the daily tasks necessary to wear and care for the lenses. The objective of this project was to provide individuals with a device that allows them to use contact lenses despite limited functionality of one hand.

SUMMARY OF IMPACT

The device provides people with the ability to clean, store, insert, and wear contact lenses independently using only one hand. It acts as an easy-to-use staging area for performing all daily tasks required by contact lens use.

TECHNICAL DESCRIPTION

Primary design considerations were ergonomics, comfort, simplicity, and ease of use. The device is comprised of four major components (see Fig. 11.18): 1) base; 2) center rod; 3) outer cylindrical shell; and 4) piston. Attached to the top of the center rod is a small plastic piece on which a contact lens may rest. This contact holder is a small ring that is approximately 7/16″ in diameter. A ring was chosen as opposed to a solid concave piece to minimize the surface area between the holder and a wet contact, thus minimizing the adhesive forces between contact and holder. The device stands approximately 6″ high in the piston-down position and 8″ high in the piston-up position. The base measures 6″ in diameter.

Hovering around the center rod is the main piston, the diametrical position of which is restricted by the outer cylindrical shell. Near the top of the piston, a chamber was machined so that its height coincides with that of the contact holder. This feature, in addition to the installation of an O-ring into the piston, allows for the chamber to be filled with saline solution and doubles in function as a storage case. The piston is held in place vertically by friction with the O-ring and the close tolerances of the piston, shell, and rod.

Mounted on the base of the device is a small holding cell on which a contact may be set temporarily and cleaned with saline solution. The contact is then

Fig. 11.18. Contact Lens Aid's Components.

placed on the contact holder on the top of the rod and the chamber filled with saline solution. Fig. 11.19 shows the piston in its up position, where it is possible to fill the bottom of the piston with saline solution, immerse a contact lens, and store it overnight.

When a user wishes to insert a contact, he or she simply pushes down on the piston, revealing the top of the rod and the contact resting on it. The saline solution level lowers with the piston. Holding his or her eyelids open with one hand, and supporting his or her elbow on a table top, the user slowly moves his or her eye to meet the contact. As with initially learning how to insert contacts, this procedure takes practice to become efficient.

An additional feature of the device is the application of "soft-touch" gel to the top perimeter of the piston and an optional spring that fits around the center rod below the piston. Using this configuration, it is possible to install a contact with or without using hands. The high friction of the gel restrains a user's eyelids as he or she pushes down with his or her head on the spring-supported piston, raising the contact into his or her eye.

This "no-hands" configuration was initially the intended design of the project. However, testing the device showed that for the same amount of practice, the repeatability of success was much lower than for usage with one hand. In addition, if success could not be attained nearly 100% of the time with this configuration, then its use by someone requiring its aid would be impractical. Replacing a contact lens on the holder from a failed attempt cannot be done by someone without use of at least one hand.

Polycarbonate was selected for the center rod and the piston for its strength, machinability, and light weight. The use of polycarbonate for the piston was also needed for its transparency; it allows light into the chamber so the user can see the contact. The base and outer cylindrical shell were both machined from acrylic because of its lower cost and machinability.

The total cost of the project was $48.

Fig. 11.19. Contact Lens Aid with Piston in up Position.

Fig. 11.20. Contact Lens Aid in Use.

MOBILE LAPTOP WORKSTATION FOR PATIENTS IN BEDS

Designer: Jermaine R. Brown
Supervising Professor: Dr. Joseph C. Mollendorf
Mechanical and Aerospace Engineering Department
State University of New York at Buffalo
Buffalo, NY 14260-4400

INTRODUCTION

Patients who lie in a bed have a difficult time using a laptop due to the inconvenience of overheating and the risk of damage if the laptop should fall. This device addresses the problem that patients lying in bed face when attempting to use a laptop by keeping the laptop elevated above the user. The mobile laptop workstation has an adjustable-height horizontal boom arm that extends across the bed to the user (see Fig. 11.21). The device can also be used in a household environment.

SUMMARY OF IMPACT

This device provides more freedom of movement for the user while reducing the risk of the laptop being damaged by falling. It provides added safety for patients in bed by keeping the laptop away from flammable objects, such as the sheets, should overheating occur.

TECHNICAL DESCRIPTION

The device is designed to have the free end of the U-base slide under the bed. The actuator (see Fig. 11.22) sits on the closed end of the U-base next to the bed. The boom arm extends from the top of the actuator over the bed. At the end of the boom arm is a tray that holds the laptop in place while in use (see Fig. 11.23).

To operate this device, the user places the laptop securely onto the laptop tray and uses the necessary controls to adjust the actuator. The switch (see Fig. 11.22) controls the up-down motion of the actuator. The clamps have adjusters that permit changing of the boom arm angle and the orientation of the laptop tray.

The base is constructed from aluminum 6063-T5 tubing with cross-sectional dimensions of one inch by two inches and a wall thickness of one eighth inch. Aluminum was chosen due to its light weight and high strength. The four caster wheels have locking mechanisms that keep the device stationary when required.

Fig. 11.21. Mobile Laptop Workstation.

The actuator used is a 12" Stroke Square Tubular Actuator that supplies 40 lbs of force at a rate of one and three quarters of an inch per second. The actuator has limit switches at the beginning and end of its stroke. It is powered by a 12-volt DC adaptor that is plugged into a three-pronged electrical outlet.

A manual momentary double-pole double-throw switch allows the actuator to move for as long as the user's finger is held on the up or down position of the switch.

Initially, the actuator had clevises at the bottom of its base. It was removed and replaced with a flat base to allow for easy attachment to the U-base. For added support, triangular braces were added to the base in order to counteract the movement and torque produced by the force at the end of the boom arm. The bar that extends out from the actuator was extended four inches to make room for the clamp when the actuator is at its lowest height.

The boom arm clamp allows for the mounting of the aluminum boom arm to the actuator beam. It allows the user to pivot the boom arm if necessary. This boom arm has an outer diameter of one inch, a wall thickness of one eighth inch and a length of 30 inches. The laptop tray is attached to a ball and arm system which has a U-bolt mount on one end. The U-bolt mount is connected directly to the boom arm while the ball and arm system permits orientation adjustments of the laptop tray.

The total cost of this project was approximately $400.

Fig. 11.22. Actuator and Switch Assembly.

Fig. 11.23. Mobile Laptop Workstation with Laptop Tray Shown.

RESTROOM LIFT-ASSIST DEVICE

Designer: Agustinus Chahyadi
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INTRODUCTION

The purpose of this project was to create a device that helps people with disabilities stand up from a wheelchair and transfer to a toilet seat. This device is easy to use, since it is simply operated by a remote control that moves the crutch up and down (see Fig. 11.24). The crutch functions as a support for the user and can be adjusted to different heights. This device was designed to be used in conjunction with the support bar that is already installed in many restrooms.

SUMMARY OF IMPACT

The use of this device helps the user transfer to a toilet seat without assistance. A device of this type provides the user enhanced independence and privacy.

TECHNICAL DESCRIPTION

The crutch, which has an adjustable pin, is shortened so that it can be used by a person when he or she is sitting in a wheelchair. The crutch also has a handle so that when it is used, the user will be able to stabilize himself or herself. The bottom of the crutch is connected to an electronic jack (see Fig. 11.25) that is powered by a 12-volt, 10-amp motor using a solid aluminum cylinder. The jack provides a force that is capable of lifting the person's weight; it provides enough power to lift up to 2000 pounds. A rechargeable 12-volt 10-amp battery, as seen in Fig. 11.26, is used to power the electronic jack; this will enable the jack to operate for maximum of 10 hours before it has to be recharged. A cover for the battery was built from acrylic clear glass and connected to a hinge, which provides easy access. This cover has the purpose of protecting the battery from possible water splash.

Fig. 11.24. Restroom Lift-Assist Device.

A switch and fuse are also used in the device. The switch was installed to maximize the life of the battery to at least 10 hours a day. The user may easily turn it on and off by using this switch. The function of the fuse is to protect the battery whenever the motor gets stuck or jammed, therefore preventing battery burnout. As for the base, ¼″ thick aluminum was used to provide stability when weight is applied to the top of the crutch. A wider base would give more stability to the device; however, a larger base would increase the overall weight of the device. Therefore, a 20″ by 11″ aluminum plate is used.

The final cost of this project was $105.

Fig. 11.25. Electric Jack Assembly.

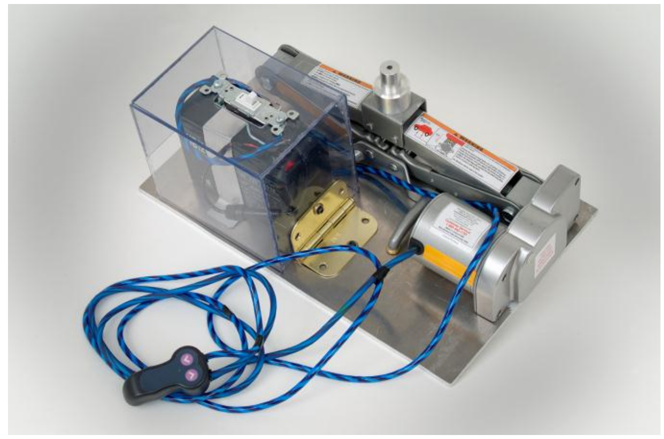

Fig. 11.26. Battery Box and Switch Assembly.

Fig. 11.27. Restroom Lift-Assist Device in Down Position.

IN-SHOWER BACK CLEANING AID

Designers: JiTai Chen, and Tin Ng Chin
Supervising Professor: Dr. Joseph C. Mollendorf
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INTRODUCTION

This shower chair is designed to provide back cleaning assistance for people with limited flexibility using rotating loofah rollers and a simple hand-powered crank system. Power from this rotating crank is transmitted to the loofahs by sprockets and a chain system; a series of gears transmit power to all five loofah rollers.

SUMMARY OF IMPACT

This device helps an individual with limited flexibility to clean his or her back in the shower.

TECHNICAL DESCRIPTION

The shower chair consists of a main supporting structure: the rolling loofahs and the power system. This device was designed to accommodate people of different heights, from five feet four inches to six feet four inches. The design incorporated as many non-corrosive (plastic) parts as possible, suitable for prolonged exposure to water in the shower. For some parts, this specification was compromised due to budget and manufacturing capabilities.

The main structure is made of one-and-a-half-inch diameter PVC pipes; the joints supporting the greatest amount of weight are cemented to achieve maximum load capacity. The maximum load has not been tested nor calculated, but it can be assumed to safely carry most people due to the high strength properties of PVC piping (Tensile Strength: 50-80 MPa). The back structure was not cemented together to allow for future replacements of the loofahs, and to provide access for repairs.

The rollers are constructed from short PVC pipes wrapped with loofah material that entails a sheet of sponge with a coarse texture. Each loofah has a three- eighth-inch aluminum rod fixed in the center that mounts to the back frame. Power is transferred to all of the rollers by the use of plastic gears secured to the aluminum rod in each roller. The gears of each roller engage one, then the other, which rotate in the opposite direction as the adjacent roller. The gears used were actually K'NEX toy gears; these were used due to the low cost compared to custom gears. They also have a relatively high strength that proved to be adequate for this application.

Fig. 11.28. Crank and Roller System.

Sprockets and a chain (see Fig. 11.28) were installed to transfer power from a rotating hand crank to the gears. The sprockets are constructed from a nylon material and the chain is steel. This system is mounted to the support bars attached to the seat; both the support bars and seat were made of wood. The user sits on the chair and moves the rotating hand crank that operates the entire device (see Fig. 11.29). The maximum speed of rotation is 80-RPM.

The total cost of the project was $169.

Fig. 11.29. In-Shower Back Cleaning Aid in Use.

FOOT-FREE DRIVE ASSIST DEVICE (FDAD)

Designers: We Jeff Chiam and Sann Myint Naing
Supervising Professor: Dr Joseph C Mollendorf
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INTRODUCTION

The Foot-Free Drive Assist Device (FDAD) assists people with a leg disability while driving (see Fig. 11.30). It was specifically designed to be used with an automatic-transmission automobile and can be used by people of all ages with a large range of leg disabilities. The FDAD allows people with limited mobility to enjoy traveling without depending on others. The FDAD can be installed on basically every passenger car, and was designed to support the majority of arm lengths. The mechanics of the FDAD are rather simple; when the lever is pulled up the automobile will accelerate, and when it is pushed down the automobile will decelerate and eventually come to a stop. In order to comply with driving safety requirements, the FDAD was designed to be handled by the driver's left hand and it will reset to its steady state position (no-throttle and no-brake) when the lever is released. The driver handles the steering wheel using his or her right hand while controlling the velocity of the vehicle with his or her left hand.

SUMMARY OF IMPACT

The revolutionary design behind the FDAD not only makes driving possible for people with leg disabilities, but it is also: 1) lightweight; 2) easy to install; 3) easy to maintain; and 4) affordable.

TECHINICAL DESCRIPTION

The Foot-Free Drive Assist Device is made from round aluminum tubes with: 1) one-inch diameter, one-eighth-inch thick aluminum plates; 2) plastic buckles; and 3) nylon straps. Two adjustable telescoping tubes are fitted with two different-sized aluminum clamps, which are used to grip the acceleration and brake pedals. The two ends of the aluminum tube are attached to a control bar, to be grasped by the driver's left hand. A tension spring was added to prevent unnecessary braking when left idling. The driver is required to pull the control bar towards himself or herself to accelerate and press it straight down to stop. Webbing assemblies,

Fig. 11.30. Foot-Free Drive Assist Device.

made of nylon straps and plastic cam buckles, are used to secure the structure. This is done by wrapping the webbing around the steering shaft housing protruding from the dash board. The control bar should be horizontal to the ground and there should be no difference between the brake arm height and the throttle arm height, regardless of differences in height between brake and throttle pedals. When properly installed, there should not be any binding or hesitations of any of the movements and the device should be able to apply full throttle and brake.

The final cost of this project was $91.

Fig. 11.31. Foot-Free Drive Assist Device Installed in an Automobile.

CONVERTIBLE AWNING FOR WHEELCHAIRS

Designer: Robert Collins
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INTRODUCTION

A device (see Fig. 11.32) was designed to protect wheelchair users from sun, rain, wind, and snow. The Convertible Awning for Wheelchairs allows wheelchair passengers to choose when to protect themselves from the elements of nature.

SUMMARY OF IMPACT

The rigid lightweight frame is easily converted from its closed position to a position that protects the wheelchair passenger without changing how the wheelchair is used. The Convertible Awning for Wheelchairs minimizes the weight load by eliminating power sources, motors, and mechanical linkage systems.

TECHNICAL DESCRIPTION

The U-shape uprights of the awning are made from galvanized steel electrical metal tubing (EMT). Steel EMT is an ideal material choice it can easily bend into a U-shape. Once bent, the steel EMT remains rigid due to the cold working properties inherent in steel. The galvanized surface treatment ensures that the steel will not rust. At each end of the U-shape tubes there is a three-inch-long piece of solid steel which is riveted into place. When the awning is mounted, these four pieces of steel fit into where the wheelchair arm rests once mounted. When the awning is in its closed position, the front upright is secured by two torsion spring-loaded steel clamps.

The cover of the awning is made of synthetic leather. It is sewn with heavy nylon thread around the front upright and is attached with Velcro around the vertical part of the rear upright.

The armrests are mounted on top of one-quarter-inch thick aluminum cross-members. When the awning is in the open position, the aluminum cross-members provide stability for the awning structure. The bars are joined in a manner that does not allow the awning to collapse accidentally.

Fig. 11.32. Convertible Awning for Wheelchairs.

The total cost of this project was $70.

Fig. 11.33. Wheelchair with Awning Retracted.

INSTRUMENTED SHOE FOR INDIVIDUALS WITH LOWER EXTREMITY WEIGHT-BEARING LIMITATIONS

Designer: Daniel R. Cumm
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INTRODUCTION

Individuals who have had orthopedic surgery are commonly prescribed partial weight-bearing limitations on the lower extremity. The Instrumented Shoe for Individuals with Lower Extremity Weight-Bearing Limitations helps in the treatment of patients after orthopedic surgery.

SUMMARY OF IMPACT

The patient wears the shoe during treatments to help the therapist monitor how much weight is being applied throughout the shoe and how it is distributed. The Post-Orthopedic Surgery Shoe can either be placed over a shoe that is on the patient's foot or worn by itself as a shoe.

TECHNICAL DESCRIPTION

There are two main components to the assembly: a shoe and a microcontroller (see Fig. 11.34). The shoe contains strain gauges (CEA-06-240UZ-120) that are bonded together by epoxy to sheet metal plates and then wired in a Wheatstone bridge configuration to measure bending moments (see Fig. 11.35). When the shoe is twisted or bent, it has a positive or negative moment, depending on how it is bent. This is reflected in the signal output.

The microcontroller (CME-11e9-EVBU MC68HC11E9) contains the machine language logic that controls the system. The output from the strain gauges is fed through the strain gauge conditioner (6202-2965 / BRIDGE AMP) and read as an input to the microcontroller. The microcontroller has a portable power source consisting of two dual AA battery holders. The liquid crystal display (16x2 LUMEX LCD) displays a real-time reading of the force being applied to the shoe. The logic of the machine language is developed so that if the applied force exceeds the prescribed force, a Piezo electric buzzer goes off until the force drops below the prescribed force. The logic is a continuous loop so the prescribed force can be changed during treatment. The shoe is wired in such a way that if the logic is developed, the shoe can be used to inform the therapist about the patient's step characteristics.

The total cost of this project was $255.

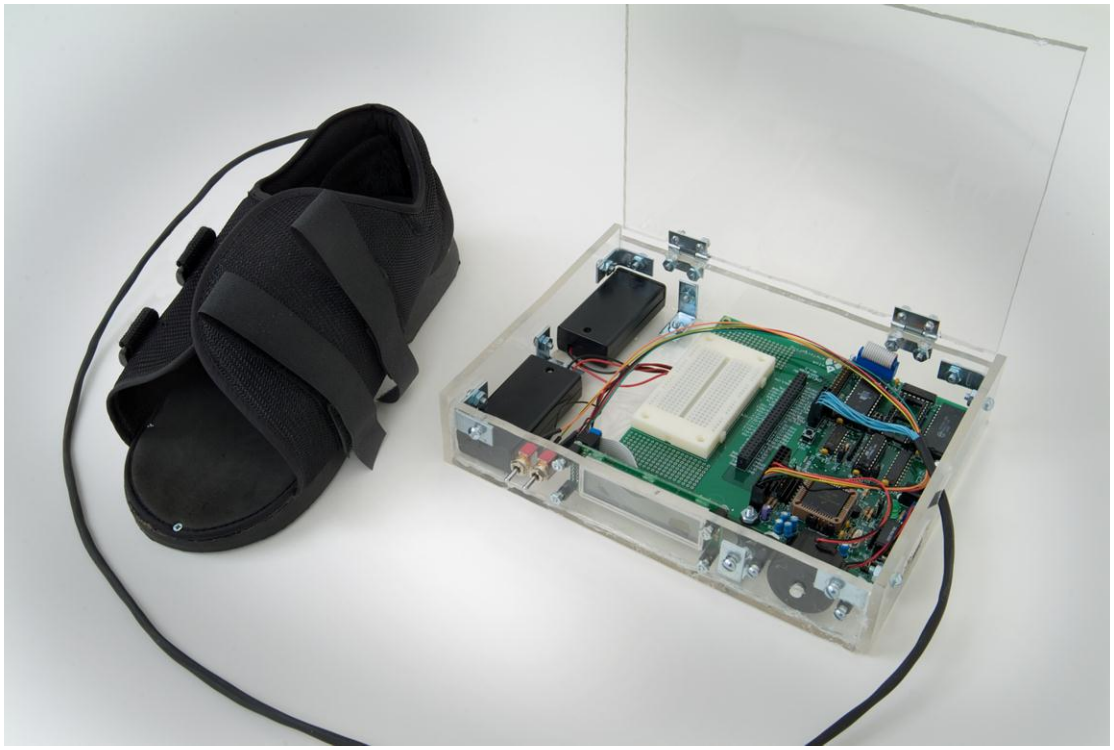

Fig. 11.34. Instrumented Shoe for Individuals with Lower Extremity Weight-Bearing Limitations.

Fig. 11.35. Shoe and Strain Gauges.

AUTOMATIC MILK AND CEREAL DISPENSER

Designers: Nandan C. Dabhade and Thomas C. Law
Supervising Professor: Dr. Joseph C Mollendorf
Department of Mechanical and Aerospace Engineering
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INTRODUCTION

Certain people cannot necessarily lift a heavy jug of milk or hold it steady for the extended period of time required to pour the desired amount on breakfast cereal. This device allows the user to simply press a button (see Fig. 11.36) and automatically receive his or her breakfast in a quick, coordinated, and regulated manner. This product is also extremely versatile in that the cereal or milk containers may be used to fill and dispense almost anything that is snack-sized, (e.g., peanuts, popcorn) and almost any liquid, such as water or juice. This product also has a built-in cooler attached at the top, which eliminates the need for refrigeration. It features a door that can be opened and closed above the cereal container, which allows for quick and easy refilling of the dry food of choice.

Fig. 11.36. Automatic Milk and Cereal Dispenser.

SUMMARY OF IMPACT

This product allows people with disabilities the ability to make themselves a quick and healthy breakfast, which aids in improving their day-to-day health. It will also enhance independence. Furthermore, this product's customer base is expandable to those that are simply pressed for time, such as busy parents and school children who do not necessarily have the time to cook breakfast.

Fig. 11.37. Milk and Cereal Storage Containers.

TECHNICAL DESCRIPTION

The main engineering features utilized in the Automatic Milk and Cereal Dispenser (Fig. 11.37 and 11.38) include: 1) a modified shaft and gearbox; 2) a fluid pump; 3) a power converter; and 4) a cooling unit. An existing hand-powered cereal dispenser was purchased and the shaft was removed and modified by grinding down half of it to a flat edge. This was then replaced in its original location, which was in between a hand-powered set of spinning paddles that allow the cereal to drop into the bowl. The part of the shaft that was extruding from the paddle mechanism was then connected to two sets of gears and secured with set screws. These gears are in turn driven by an electric motor. Initially, the motor did not provide enough torque to allow for smooth flow of cereal. Therefore, an external torque multiplier was purchased. This multiplier provided a gear ratio of four to one. This unit was mounted onto the existing motor and allowed the paddles to spin at a rate of approximately one revolution per second.

The fluid pump used was purchased from a hobby store and was originally designed to regulate the flow of fuel into model airplanes. This pump was attached to the existing fluid-containing column through a one-quarter-inch copper pipe and composite tubing. The fluid pump exit pipe was placed next to the cereal dispensing tube, allowing it to be poured into the bowl at the same time. The pump used provides the ability to dispense fluid at approximately one ounce per second. The power converter was homemade and reduced the voltage from 12-volt to 6-volt. It is important to note that the power converter is restricted to DC through the use of diodes. This is due to the fact that the cooling unit can only receive a lower voltage of DC current (as opposed to most household outlets) since it was designed to be incorporated into a car cooler. It then required a converter that would make it safe to use for this application. Lastly, this cooling unit was placed at the top of the chassis and allows for it to be a self-refrigerating device. While it takes approximately one full night after initially plugging in to actually cool the fluid, it is an extremely consistent temperature regulator and can hold a temperature of approximately 40 degrees Fahrenheit.

Total cost of the prototype was $180.

Fig. 11.38. Automatic Milk and Cereal Dispenser Being Filled.

BED-MAKING DEVICE

Designer: David J. Dedo
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INTRODUCTION

The bed-making assistive device (see Fig. 11.39 and 11.40) can help anyone with a disability perform the daily task of making a bed. This device was built on a half scale but is capable of fitting any size bed. Although this device does not fully pull off or help replace the bottom sheets, it is capable of moving top sheets and comforters up and down the length of the bed. The device is installed under a bed and, once installed, the sheets are clipped to the device and the operator can control the sheet location by flicking a switch. It takes about five seconds to move the sheets fully up or down the length of the bed.

Fig. 11.39. Bed-Making Device.

Fig. 11.40. Bed-Making Device with Sheets Retracted.

SUMMARY OF IMPACT

This device helps people with disabilities make a bed. It may reduce pain and enhance independence.

TECHNICAL DESCRIPTION

The system is powered electrically by a DC gear motor that is plugged into a common wall outlet. A bridge rectifier is needed to convert the AC current from the wall outlet to a DC current, which is required by the motor. A double-pole double-throw switch is used to control the direction of the motor. As for the safety mechanism, there are limit switches at each end of the bed to prevent the device from destroying itself. There are pulleys on the dual output shaft of the motor and V-belts used to translate the rotational motion to linear motion (Fig. 11.41). In this prototype, the V-belts are approximately 100″ long. There is a wooden cross-member fixed to the pulleys via two U-bolts. The wooden cross-member comes from under the bed to the side of the bed at a height level equal to the top of the mattress. Most of the structural parts and the bed frame were constructed from wood because it was easy to manipulate and it was readily available.

The total cost of this device, with a donated motor, was approximately $160.

Fig. 11.41. Electric Motor and Pulley Assembly.

GEARED MANUAL WHEELCHAIR WITH VARIABLE SPEEDS

Designers: Seth Fleitman and Justin Malpiedi
Supervising Professor: Dr. Joseph C. Mollendorf
Mechanical and Aerospace Engineering Department
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INTRODUCTION

A modified wheelchair (see Fig. 11.42) with high and low gears was designed to allow the user to control his or her speed while traveling on inclined and declined surfaces. It will also allow the user to turn the handrail used to drive the wheels with less force and make it easier for one to move while going uphill or downhill.

SUMMARY OF IMPACT

This device addresses the challenge faced by persons with disabilities in wheelchairs while they are traveling up a hill or an inclined ramp. Many find it hard to turn the handrails and drive the wheels since it requires more force to push themselves up the incline. It also addresses the problems that wheelchair users have of controlling their speeds while traveling down hills or declined ramps. This is done by allowing them to slow down the wheelchair by using the different speed gears.

TECHNICAL DESCRIPTION

The modified wheelchair with high and low gears uses a driving system similar to a bicycle on each

Fig. 11.42. Geared Manual Wheelchair with Variable Speeds.

wheel. There are two separate driving systems, one for each wheel with three different speed ratios (high speed, normal speed, and low speed). For each drive system on the wheelchair, there is a drive shaft, transfer shaft, derailleur wheel hub, and handrail (see Fig. 11.43). All of these components were assembled together inside the gear box housing, which connects to the wheelchair by three bolts on each side.

On the drive shaft, there is one 19-tooth sprocket aligned with the middle gear on the spline from the transfer shaft, which is connected with a chain. This sprocket is mounted to the shaft by a needle bearing that allows it to spin freely in one direction and lock in the other.

On the transfer shaft (rear shaft) there is a spline that is welded in place. The spline has three sprockets with different tooth counts (14-tooth, 19-tooth, and 25-tooth). Also on the transfer shaft there is another sprocket with 20 teeth that is aligned with the 20-tooth sprocket ,which is on the wheel hub in the front of the gear box. These two sprockets are also attached by a separate chain.

On the wheel hub, there is a 20-tooth sprocket attached to the inside end that attaches the wheel hub to the transfer shaft. On the inside of the wheel hub, there are two ball bearings pressed into place that allow the drive shaft (handrail shaft) to spin freely. A bracket that holds another needle bearing was attached to the outside of the wheel hub.

The gear box is split into two different sections: the left side and the right side. Down the center of the gear box, about seven inches from the bottom, there is a support beam that runs down the length of the box. Both the transfer shafts and the drive shafts are supported by this beam, which allows them to turn freely. On the back of the gear box, a bracket that holds the derailleur in place was mounted and aligned with the smallest sprocket on the spline from the transfer shaft. The chain that connects the spline to the sprocket on the drive shaft also runs through this derailleur, which allows the wheelchair to have variable speeds.

The derailleur on each side and the tension in the cables are controlled by a friction shifter connected to each cable. This allows the tension to change in

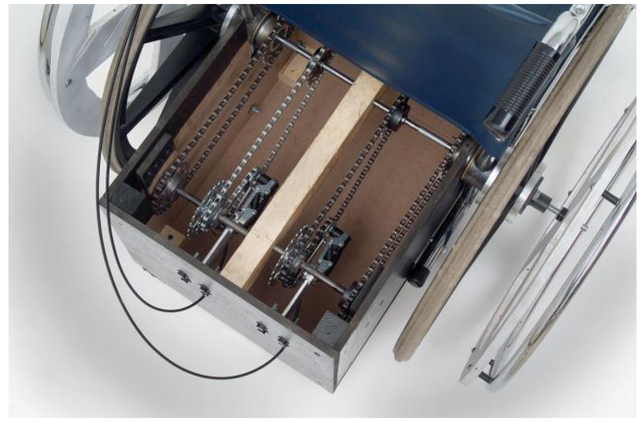

Fig. 11.43. Wheelchair Gear System.

both cables with just one shifter. A custom part was machined to connect the two cables into one.

The wheelchair is operated by turning the handrail, which is attached to the drive shaft. When the drive shaft is turned, it turns the 19-tooth sprocket, which has a chain that runs to the three sprockets and through the derailleur. This chain drives the spline, which is connected to the transfer shaft. When the transfer shaft is being turned, it turns the 20-tooth sprocket as well. This sprocket is connected to the 20-tooth sprocket on the wheel hub by another bike chain. When the 20-tooth sprocket on the transfer shaft in the back is turned, it moves the 20-tooth sprocket, which is connected to the wheel hub. When the wheel hub turns, the wheel will also end up turning in the given direction. When one wants to shift gears and make the wheelchair go faster or slower, all he or she has to do is turn the shifter knob to a higher or lower setting while in motion. When this is done, the tension in the cable will either tighten or loosen and change the gearing accordingly.

To travel in reverse, all one needs to do is start turning the handrail backwards and the needle bearings that are positioned in the system either lock or spin freely. This allows the tension in the chains to remain constant, which will drive the wheelchair smoothly.

The total cost of this project was $186.

WHEELCHAIR PROPULSION ASSIST LEVER

Student Designer: Jonathan Gutierrez
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INTRODUCTION

Many wheelchair users have difficulty independently operating their wheelchairs. A reduced range of joint articulation makes it difficult to grab the rear wheel as intended and to propel oneself. This project was intended to allow people using wheelchairs to mobilize themselves with greater capability and independence.

SUMMARY OF IMPACT

This design ideally enhances independence, self-confidence, and privacy of people using wheelchairs.

TECHNICAL DESCRIPTION

The Wheelchair Propulsion Assist Lever (see Fig. 11.44) has a simple design with a few moving parts that imitate a ratcheting mechanism. The design uses a spoke brace to apply the driving torque to the wheel instead of using a bearing to transfer the torque.

This device consists of a two-foot shaft that has a hand grip on its top end to allow the user to apply a forward push and initiate operation. The shaft connects to the wheelchair with a bearing fitted around the axle screw already connecting the rear wheel of the chair (see Fig. 11.45). The bearing is attached mid-shaft to allow for some shaft to extend beyond the bearing. The piece of the shaft beyond the bearing is where a counterweight is attached. A counterweight is necessary to provide a restoring moment about the bearing. This restoring moment ensures that the counterweight is directly below the bearing and the other end of the shaft with the grip is above the wheel in a region reachable by the user.

To transfer the torque there is a brace hinging on the shaft, which transfers the rotational motion of the lever in only one direction. The hinge allows for the spoke brace to interfere with the spokes on a forward stroke of the lever, transferring the lever's rotational motion to a driving torque. On the return stroke, the hinge allows for the spoke brace to sweep out and over the spokes, transferring no torque to the wheel on a return stroke. This provides for a design restriction of no propulsion assist in the rear direction. This could possibly affect the practicality of the device, but it was assumed that the majority of wheelchair traveling is in the forward direction.

Fig. 11.44. Wheelchair Propulsion Assist Lever.

In order to function properly, the spoke brace must extend laterally from the wheel shaft and be perpendicular to the plane of the rear wheel. To ensure that this spoke brace returns to this perpendicular orientation after each time it sweeps over the spokes on a return stroke, a tension spring was connected to the shaft and the side of the spoke brace. The spring returns the spoke brace to its operating orientation during use to ensure that it can interact with the spokes in a forward stroke at all times. It is in this way that the Wheelchair Propulsion Assist Lever provides a driving torque to the rear wheel by means of a limited forward rotation. The final cost of this project was $60.

Fig. 11.45: Installed Assist Lever.

Fig. 11.46: Wheelchair Propulsion Assist Lever in Use.

REMOTE-CONTROLLED AUTOMATIC DOORKNOB OPENER

Designers: Michael Harlach and Joshua Morss
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INTRODUCTION

A remote-control device was designed for people who cannot turn a doorknob. The Remote-Controlled Automatic Doorknob (see Fig. 11.47), allows the user to simply press a button on a remote control, sized to fit on a keychain, and have the door latch release. The device also functions as a regular doorknob with full locking functionality.

SUMMARY OF IMPACT

This device addresses the challenge any person with limited hand use may face. This could include, but is not limited to, people with arthritis or missing fingers. It has been designed to fit on the common household door.

TECHNICAL DESCRIPTION

There were three goals that this project was intended to accomplish. The first was to create a doorknob which would retract the door latch with a remote control. Second, this doorknob had to function as a regular doorknob for users without a remote. Finally, it had to fit on any standard household door. These predetermined goals gave rise to several design constraints. Power had to be supplied to the device since it was intended to be attached to a door and be remote-operated. It was determined that a power cord would be impractical in most cases; therefore, a battery was chosen. Also, the door latch mechanics proved to be a major challenge during the design process. Physically turning the knob would have required a motor with considerable torque; therefore, it was decided that door latch itself would simply be pulled back.

The device opens the latch by converting rotational motion into a linear translation of the door latch. This is achieved by having a motor turn a threaded rod on which a bar is mounted. The bar goes forward and backward as the rod spins to pull the latch open and closed. A small piece of aluminum was attached to the latch mechanism for the bar to grab onto and pull the latch back. The threaded rod is linked to the bar through gears in a one to one ratio. At each end of the threaded rod is a bearing mounted to the case to allow for smooth rotational motion. The motor is rated for 20-volts although only 12-volts are supplied to the motor due to the size of the battery.

A circuit was then designed to accomplish the desired rotation of the motor. The circuit includes a 12-volt battery, the remote control receiver, two relays, two limit switches, and the motor. The purpose of the circuit is to start the motor rotating when the remote button is pressed. As the bar goes along the threaded rod, it hits a limit switch when the latch is fully open. This then triggers a relay to switch the direction of the motor and close the latch. When the bar reaches its home position, another limit switch is pushed, causing the other relay to turn off the circuit.

The parts are all encased in a 15- by 7-inch wood case, which protrudes 2 3/4 inches from the door. The top of the case is made of Lucite and is cut into two sections. One section gives access to the battery, while the other is for the mechanical components of the device. Both sections are hinged to allow for access to the parts, though the component section is only accessible with the doorknob off. The battery compartment of the case includes two Velcro straps to secure the battery. The case is attached to the door by five wood screws.

Due to the extended distance, the unit protruding from the door, the main arm, the locking mechanism, and the screw holes had to be extended. This was done by fabricating an extension for the main arm that slid over the original arm and by welding an extension to the locking mechanism. Extenders were fabricated for the screw holes that screwed into the original holes, which had a threaded opening on the other end.

The total cost of this project was $232.

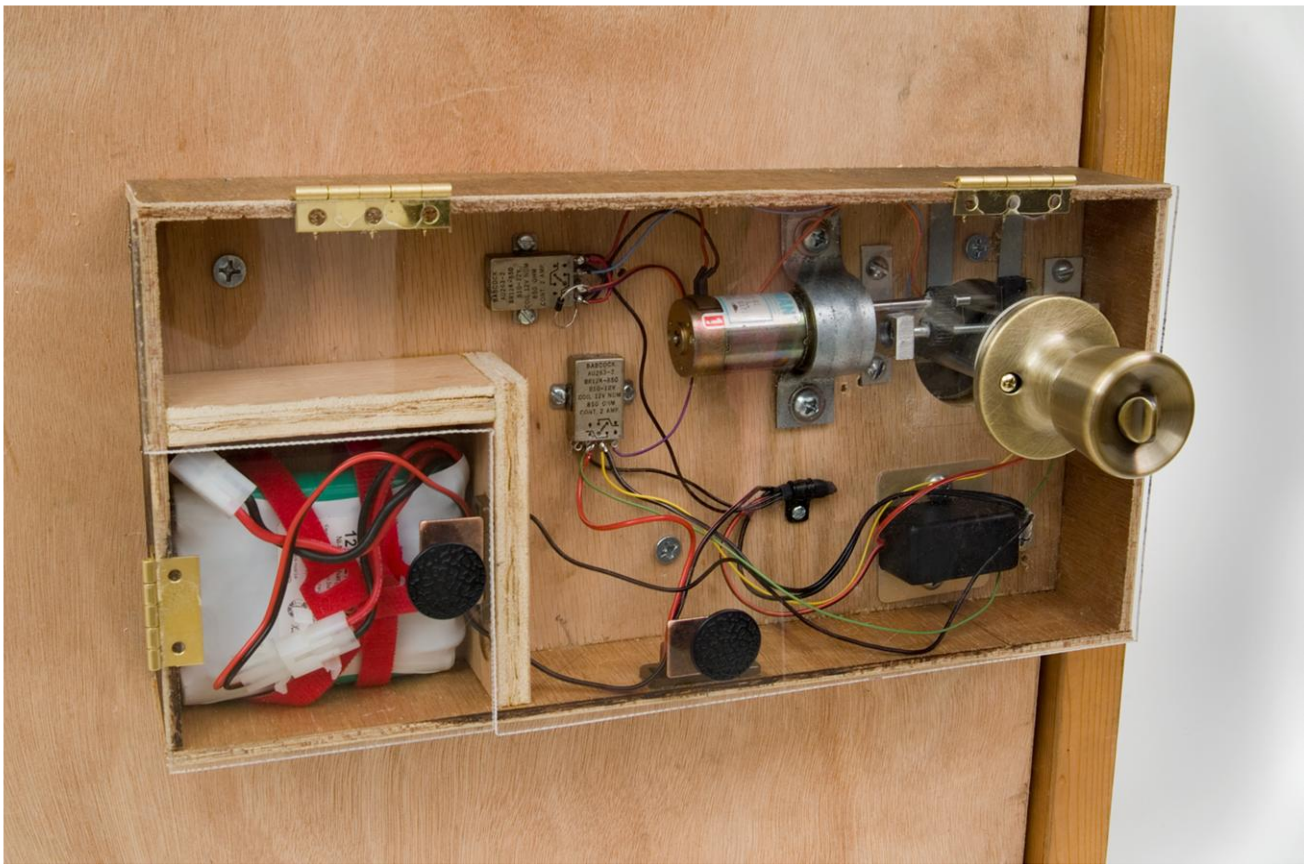

Fig. 11.47. Remote-Controlled Automatic Doorknob Opener.

ROLLABLE CHAIR BASE ATTACHMENT TO AID IN SITTING AT A TABLE

Designers: Thomas Heneghan and Patrick Pettengill
Supervising Professor: Dr. Joseph C. Mollendorf
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INTRODUCTION

When using a traditional four-legged chair, it can be difficult to pull or slide oneself toward a desk or table. Rather than sliding across the floor on the legs of the chair, the adjustable chair base attachment allows the user to roll on four caster wheels, making forward and backward movement much easier. By use of a mounted brake lever, keeping the chair where it is placed is also easily accomplished. The brake lever location on the chair's frame allows easy use of this device (see Fig. 11.48).

SUMMARY OF IMPACT

With the simple adjustment of the base, the frame can be mounted to just about any traditional four-legged chair to aid in mobility of those who are unable to pull themselves toward a table or desk using their own strength. This can also be used by people with a broken bone or those in a cast; they would not have to take all the weight off the chair's legs to move it, which can be especially difficult on rough surfaces and carpeting.

TECHNICAL DESCRIPTION

The adjustable chair base can be used with or without the use of the braking system, depending on the ground pitch and the user's preference. The brake lever is used to operate the brakes, which are standard on the caster wheels used. These brakes are designed to keep the chair stationary or free-rolling when needed. When used on level surfaces, the brakes can be used as needed by preference of user. The design of the braking mechanism on the wheel side gives the user the option of installing different wheels onto the frame for use on different surfaces, like hardwood floors. In the case that the wheels were changed, the braking system would remain in operation as long as the new wheels possess pre-installed brakes from the manufacturer.

Fig. 11.48. Brake Lever Location on Chair.

Fig. 11.50 shows a detailed view of the brakes located on the wheel side; as shown, this system utilizes the original brake lever.

The chair base is adjustable to fit chairs ranging from 16” to 20” deep and ranging up to a maximum width of 20”. The main frame is made from one eighth inch thick angle iron for strength and rigidity. The frame is capable of handling up to 500 lbs and could be capable of handling more weight with the use of stronger caster wheels.

The brake lever assembly can be mounted easily with a few screws onto the underside of the chair seat itself. The brakes are operated by a standard bicycle brake cable for ease of use and possible replacement. When the chair is set on top of the frame, it is held down by tightening a tie-down strap over the leg supports and to both sides of the frame. The strap is used to add additional safety by securing the chair to the base without installing more screws into the chair.

The total cost for this project was about $81.

Fig. 11.49. Rollable Chair Base Attachment.

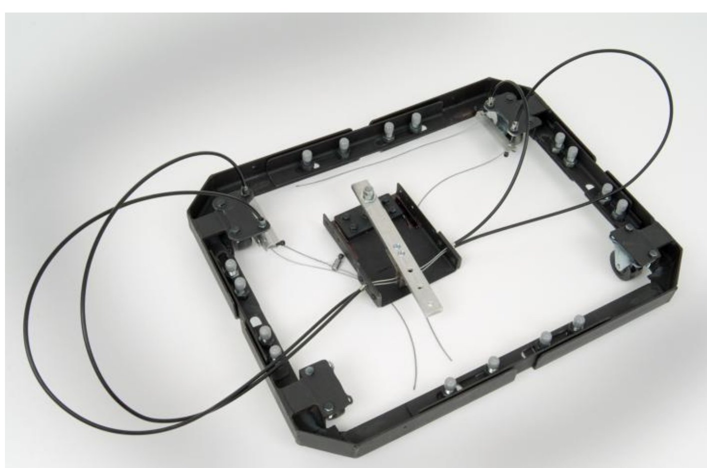

Fig. 11.50. Rollable Chair Base with Braking System.

SPACE-SAVING ADJUSTABLE CRUTCHES

Designer: Josh Hollenbeck
Supervising Professor: Dr. Joseph C. Mollendorf
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INTRODUCTION

When someone injures a leg, he or she will often require a crutch to aid his or her mobility. Most crutches have limited adjustability, making one set usable by a small range of people. Also, many users complain about how uncomfortable their crutches are. This crutch addresses both of these problems since it is highly adjustable and has comfort gel on the underarm rest.

SUMMARY OF IMPACT

This device functions like any basic crutch and provides mobility for someone with an injured leg. The key difference between this crutch and any other one is its adjustability (see Fig. 11.51). The crutch works for anyone ranging from a height of about four feet to about six feet. This adjustability will allow hospitals and home medical suppliers to stock one size of crutch for almost any user instead of many different sizes, thus saving space in storage. The adjustability also allows for easy storage when not in use. This crutch is beneficial to a family as well. If one person in the family injures his or her leg, they can simply purchase this crutch and retain it in case another family member, regardless of his or her height, requires the aid of a crutch at a later time.

TECHNICAL DESCRIPTION

The adjustable crutch combines the technology of a standard aluminum crutch with that of an adjustable cane. The majority of the construction is very similar to a standard crutch; the difference lies above the handle, where the adjustable cane technology is implemented. The sliding adjustable tubes are attached, using rivets, to the existing tubing of the crutch, making the crutch highly adjustable. Holes are drilled along the crutch to allow for adjustment of the handle height. A small piece of angled metal is attached at the bottom of the crutch to act as a foot pedal for easy adjusting (see Fig. 11.52).

Fig. 11.51. Full Range of Adjustable Crutches.

Comfort gel is added to the underarm rest (see Fig. 11.53) for user convenience. This crutch will fit users in the height range of 51.2” to 73.3”.

The total cost of this product was about $63.

Fig. 11.52. Foot Pedal for Adjustments.

Fig. 11.53. Comfort Gel for Underarm Support.

ADJUSTABLE AND PORTABLE WHEELCHAIR SCISSOR LIFT

Designer: Dennis J. Hoover
Supervising Professor: Joseph C. Mollendorf
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INTRODUCTION

This device was designed to help people who use wheelchairs get into places that may not have been accessible in the past.

SUMMARY OF IMPACT

This device helps people using wheelchairs get into buildings or up large ledges that do not have the necessary features to allow for easy access.

TECHNICAL DESCRIPTION

The scissor lift is made to be portable and as light as possible for a quick and easy fix in order to get someone up or over an obstacle. The lift is operated by a half-inch drill, which enables this device to be used anywhere as long as a drill of this size is on hand. The lift has a square shaped frame with sides measuring roughly four feet long and only four inches high when the ramp is off to one side. There are scissor supports on both sides of the top platform and the bottom platform, where the same ends are fixed. The other ends are on rails that allow the scissor lift to slide around the base, pushing the platform up. The platform is propelled upwards with a scissor-car jack that is placed in the center of the unit. When the hooked bar is placed, this jack can be attached to the half inch drill.

The final cost of this project was $30.

Fig. 11.54. Adjustable and Portable Wheelchair Scissor Lift.

Fig. 11.55. Wheelchair Lift with Elevated Platform.

AUTOMATIC LOWERING AND RAISING CAR ROOF RACK SYSTEM

Designer: Nathan Hurley
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INTRODUCTION

The Automatic Lowering and Raising Car Roof Rack System allows people who are short or people with upper body injuries to access a roof rack on a large vehicle. A motor connected to the roof rack is easily turned on with a push of a button, which can be placed anywhere inside of the vehicle. The rack is then lowered to the side of the vehicle for easy access (see Fig. 11.57).

SUMMARY OF IMPACT

Vehicles only have a certain capacity; many times luggage or other large items need to be placed on the top of the vehicle. People who are short or people with upper body injuries may not be able to access this luggage space. With the automatic lowering and raising ability, this space is easily accessible by almost anyone, even children.

TECHNICAL DESCRIPTION

The automatic rack began with a critique of a standard ski rack on a large SUV. The only way to reach the rack was by standing on the rear tire; this was not safe or even possible for many people.

Fig. 11.56. Automatic Lowering and Raising Car Roof Rack System.

The whole system is based around a garage door opener. This is the muscle of the system. The motor is a 1/2 horsepower, chain-driven system. The chain can be lengthened and shortened to fit any size vehicle. It has plenty of power to lift any amount of luggage that would typically be put on the top of a vehicle. A smaller, more condense motor could be used in place of this motor.

The chain is connected to the rack system, which is constructed of half-inch and three-quarter-inch steel tubing. Four horizontal sections are connected with two vertical sections each. These vertical sections are cut in half and connected with cotter pins to allow a bending motion as the system is lowered down the side of the vehicle. On the end of each horizontal piece are garage door wheels. These allow the rack system to easily roll up and down the top and side of the vehicle. These wheels can be padded to protect against vehicle damage during use.

The final part is the track system. The track system is very similar to that used with a garage door. These tracks are used to allow proper movement. They are just large enough for the wheels to fit in. They have three walls, a top, bottom, and side, to make sure that the rack system does not fall off the vehicle. The curved part of the track system uses only a one-wall design because this part would only be necessary when the vehicle is not moving. For this reason, it is unnecessary to add additional weight and wind resistance to the design.

With all three sections connected to the vehicle's roof, the motor can be attached to the battery of the car and the remote button can be placed anywhere in the inside of the vehicle.

The total cost of the automatic roof rack was approximately $200.

Fig. 11.57. Device Configuration While Loading.

SELF-PROPELLED TRAVEL LUGGAGE

Designer: Ryan Jarvis
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INTRODUCTION

The purpose of this project was to create a self-powered luggage device that makes traveling easier. This device is ideal in an airport where long, open, flat hallways require people to physically move their luggage relatively long distances. This device is intended for people who have disabilities who travel on a regular basis, and would like an easy way to transport their checked luggage. It can also be scaled down to accommodate carry-on luggage, although that was not the goal for this prototype.

SUMMARY OF IMPACT

The device proved to be a very effective. The speed can be adjusted from very slow to a fast-paced jog by twisting the throttle. It takes very little practice to become proficient at using the throttle mechanism.

TECHNICAL DESCRIPTION

The heart of the Self-Propelled Travel Luggage (see Fig. 11.58) is the electrical system, which consists of a 24-volt DC motor, 24-volt speed control, battery power supply, and twist throttle (see Fig. 11.59). This system was obtained by using parts from an electric scooter.

The system operates at 24 volts and uses two 12-volt batteries wired in series to produce the required voltage. When installation is completed, the throttle can be twisted to deliver variable power to the motor. The amount of power transmitted is dependent upon the throttle rotation angle.

The reason for the twist throttle being located on the right side is due to the angular velocity created as the cart moves forward. By changing the mounting from the left to right side, the throttle does not continue to twist as the luggage cart moves forward. If the throttle was kept on the left side of the cart, it would continue to gain speed and quickly get out of control.

Fig. 11.58. Frame and Electrical Components.

Fig. 11.59. Twist Throttle.

The device is rear-wheel drive and the motor delivers power to the driveshaft through a #25-chain and sprocket. The gear ratio (one to four) greatly reduces the amount of top speed the cart can accomplish. This makes carrying large loads easier since there is stronger low velocity acceleration.

There are several improvements that would need to be made in order to commercialize this device. These include modifications to the electrical system and overall setup that would make use easier and more practical. An improvement to the electrical system would be the introduction of a speed control, which has the capability to reverse. This could be used as a brake and also to navigate in tight corners and elevators.

A simple battery charger could be added for a small price. This would consist of a charger to be permanently connected to the battery packs. It could then plug into an outlet through a retractable cord. This part was not added in order to keep the cost of the project to a minimum.

To make the luggage practical for travel, the handle would also need to collapse upon itself. There are many systems available on the market to accomplish this task; the best solution would be a twist-locking mechanism. This feature would also make the product more versatile.

Another improvement would be wagon-style turning, which is when the front axle turns on a pivot at its center. Wagon-style turning would be a great way to navigate this cart in tight corridors or elevators. This would allow the front end to be turned more readily. In this case, the front wheels could be motorized. This would greatly enhance the maneuverability of the luggage when combined with a speed control which is capable of traveling in reverse.

Safety concerns are numerous for a product of this nature. If this is put in unfamiliar hands, it could quickly become a fast moving projectile. It does not take long to learn the standard operating procedures of this cart. If it were to be used as intended, it would remain safe.

The total cost was approximately $200.

Fig. 11.60. Self-Propelled Travel Luggage in Use.

FLYWHEEL ENERGY STORAGE ATTACHMENT FOR MANUAL WHEELCHAIRS

Designers: Jarrett Kaczmarski and Jeremy Kruger
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INTRODUCTION

The operation of a manually powered wheelchair is inefficient in nature. Nearly constant energy input is required to keep the wheelchair in constant motion. The addition of the flywheel to the wheelchair's drive wheels acts as an energy storage device, being charged while the operator is manually spinning the wheelchair and discharged when the energy input is discontinued. The flywheel design has two gears, one connected directly to the flywheel and the other to a free-spinning gear with an internal bearing. This feature allows the operator to switch between the flywheel mode and the free gear side depending on his or her preference, which allows this device to function as a conventional wheelchair.

SUMMARY OF IMPACT

The attachment of a flywheel to a manually powered wheelchair reduces long-term fatigue of the operator. Once the flywheel is charged and engaged, all the operator has to do is sit back and enjoy the ride. It is useful for assisting wheelchair users climbing ramps and going down long hallways. The addition of the free-spinning gear allows the wheelchair to act in its conventional manner. The free gear setting might be used in a crowded situation, or where long straight paths are not possible.

TECHNICAL DESCRIPTION

The flywheel attachment device consists of two main axles (see Fig. 11.61). The first is the drive axle, which is connected to the large rear wheels of the wheelchair; the second is the flywheel axle, which sits in the enclosure mounted on bearings. The wheelchair wheels are connected to the drive axle by a connector plate with a welded internal thread collar for mating to the drive axle. Each connector plate is pre-drilled for the different spoke arrangements of various style wheels. The drive axle is a three-piece system, with two pieces connecting to the wheelchair wheels and then threading into the drive gear axle. Connecting the drive gear to the drive axle is a machined hub, which fits inside the gear and allows for the drive axle to pass the center with a keyway for proper positioning and torque transfer. An eight-inch 52-tooth gear was used to provide a sufficient gear ratio.

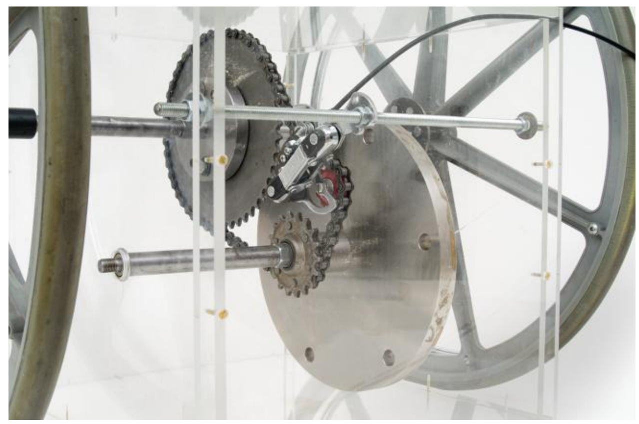

Fig. 11.61. Gear and Flywheel Assembly.

Fig. 11.62. Derailleur and Chain System.

The flywheel axle is a two-piece construction with each outer side of the shaft resting in bearings mounted in the enclosure. The flywheel sits on the left shaft with the use of a keyway. Attached to the flywheel is a two and a half-inch extension that the flywheel gear mounts to, its position being fixed with the use of a machined step on one side and a collar on the other side. The flywheel gear is a two inch 14-tooth bicycle gear, providing a four to one gear ratio from the drive gear to the flywheel. The free gear is mounted on the smaller portion of the left shaft. The free gear slides over the threads with a locking nut to fix its axial position. The shaft can be adjusted axially by threading the right shaft further on or off the left shaft. The free gear is a three inch 18-tooth gear with an internal bearing. This provides a two and a half to one gear advantage from the drive gear; this is unnecessary since it is not spinning against any resistance. Instead, this gear size was chosen to mate well with the flywheel gear.

A basic spring-loaded derailleur by XUNDAH (see Fig. 11.62) was used for the gear changing. This was mounted on a third shaft running across the entire enclosure. The derailleur is mounted so its gears are aligned with the flywheel gear. A #41 chain was used to connect the entire system. The derailleur was operated by a six-speed bicycle shifter, connected by a tension cable between both components.

The final cost of this project was $197.

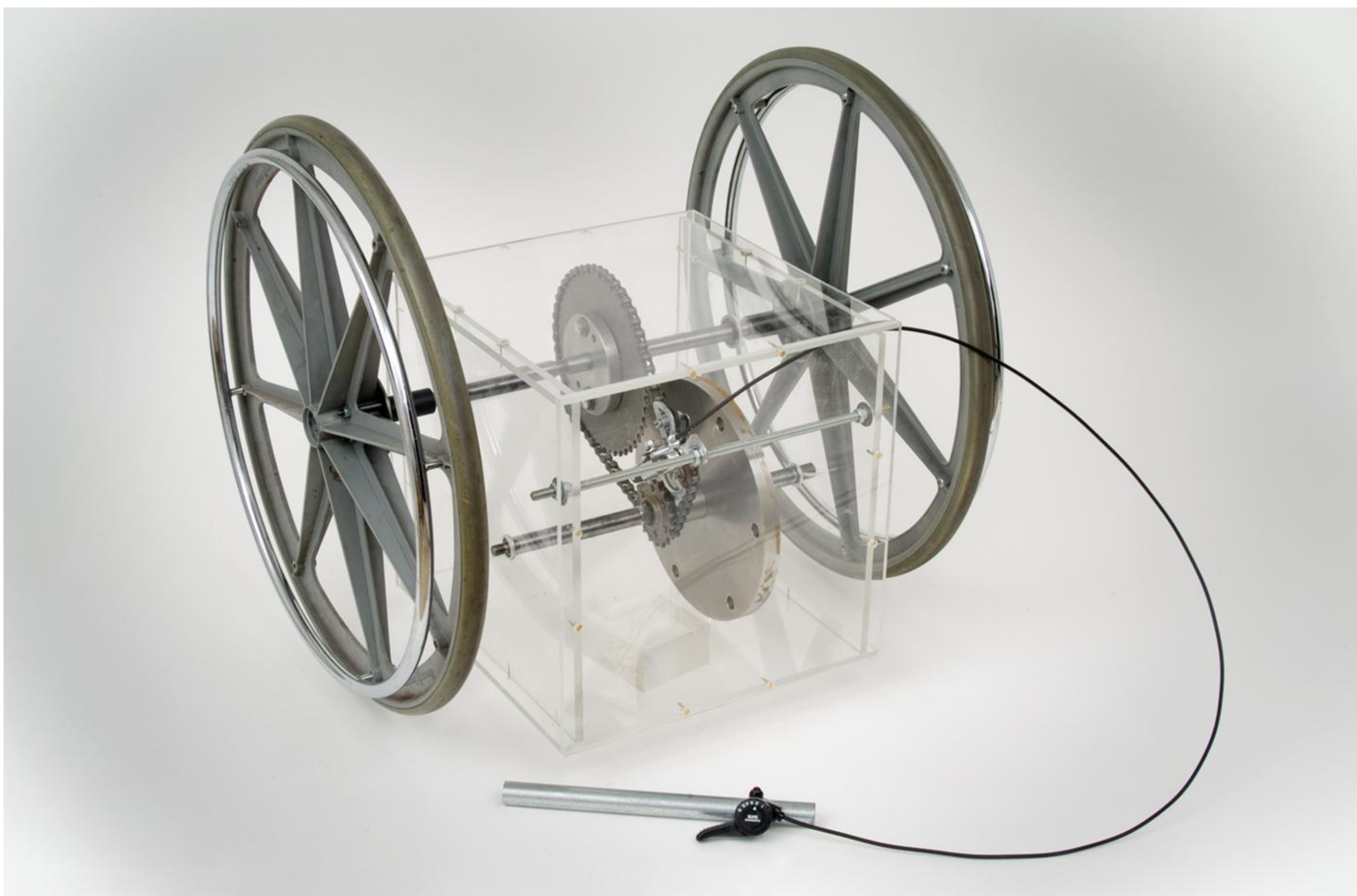

Fig. 11.63. Flywheel Energy Storage Attachment for Manual Wheelchairs.

RETRACTABLE STABILITY MECHANISM CRUTCH WITH LED NAVIGATION

Designer: Kevin Kita
Client: Scott Goheen
Supervising Professor: Dr. Joseph C. Mollendorf
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INTRODUCTION

People who use forearm crutches find that these types of crutches are not very stable. Due to the fact that they need to use both hands to work the crutches, it is difficult for them to hold a flashlight if they need to move around at night.

SUMMARY OF IMPACT

With the addition of the four extra leg supports, the crutches become very stable and can stand by themselves (see Fig. 11.64). LED lights were added to each crutch to allow the user to see at night and move around without any assistance from another person (see Fig. 11.65).

TECHNICAL DESCRIPTION

A pair of height-adjustable crutches was used to attach the LED light navigation system and extra leg supports. The LED lights were attached to the crutch with a screw and bolt. The lights were located just below the handle so that the user can turn them on and off by using his or her pinky finger.

The two circular parts for each leg support system were made from a three inch diameter piece of aluminum stock. It was milled on a lathe to have the bottom portion be 2 9/16" in diameter and 11/16" thick. The top portion was milled to be 3 5/16" thick and have a diameter of 1 3/8". The piece was then bored out to a diameter of 7/8", leaving a wall thickness of one quarter inch. A 3/16" groove was then milled into the circular part. The groove is cut by starting at one inch down from the top of the part and cutting a vertical groove 5/16" toward the top of the part. A slot was then cut to allow the square bracket and leg supports to be moved into position for use and moved out of position when not in use.

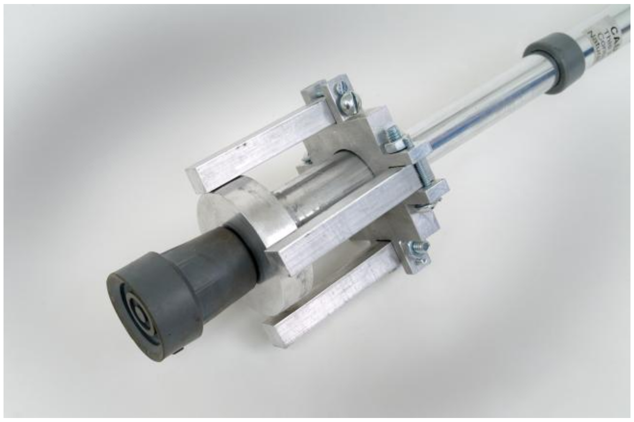

Fig. 11.64. Additional Leg Supports.

Fig. 11.65. LED Light Attached to Crutch.

The two square brackets needed to hold the supports and mount to the circular parts were machined from a four inch by half inch by 12" flat bar. Each bracket was made 4" x 4" square, and has a hole bored through the middle with a 1 3/8" diameter. The four sides each have a slot cut into them that holds the support legs. Each slot is located ¾" from either corner and has a wall thickness of a ¼″; the width of the gap is ½″. For each slot, two holes were bored to hold the leg supports. One hole is a ¼″ diameter located ½″from the end, and the other hole is a 1/8″ diameter located 3/16″ from the end. The 3/16″ hole holds a screw that keeps the leg supports from fanning out away from the crutch leg. A 3/16 hole is then counter-bored into the bracket and a 10-32 threaded screw is inserted. This screw sits in the slot that is cut into the circular part and holds the square bracket and legs onto the circular part.

The eight leg supports were cut from half inch by 4′ long square bar stock. Each leg was cut to 3 7/16″ and has a ¼″ diameter hole located ¼″ down from the top edge of the leg. These legs are then attached to the square brackets using ¼″ bolts.

The entire unit is then assembled and bolted to the crutches. The rubber end cap is removed, and the unit is placed on the shaft of the crutch. The end cap is then replaced, and the unit rests on the top of the end cap and is bolted into place.

The cost of this project was $69.

Fig. 11.66. Retractable Stability Mechanism Crutch with LED Navigation.

RANGE FINDER FOR PEOPLE WITH VISUAL IMPAIRMENTS

Designer: Brian J. Koch
Co-designer: Roger Krupski
Supervising Professor: Dr. Joseph C. Mollendorf
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INTRODUCTION

Navigation and obstacle avoidance can be difficult for people with visual impairments. The goal of this project was to allow the user to identify obstacles and paths in the surrounding environment with a simple, easy-to-use device. A handheld system was chosen for two reasons: to reduce the amount of stress on the person's body when using it for long periods of time, and because it is likely that people who have been visually impaired for a long time will be comfortable using a handheld device for detecting the environment, similar to a cane. This handheld component (see Fig. 11.67) uses a flashlight casing as the enclosure for comfort and for reduced weight.

SUMMARY OF IMPACT

By using a flashlight casing, and keeping only the needed components inside, the part of this device that is handheld can be used for long periods of time without straining the user's hand. It also provides the advantage of being able to quickly scan multiple directions with little effort and can easily be stowed inside a coat pocket when not in use. The belt-mounted enclosure safely contains all other components and allows the user to easily switch the device on and off. Finally, the transducer used provides a narrow enough beam that information regarding the environment can be obtained quickly and reliably.

TECHNICAL DESCRIPTION

The Polaroid Electrostatic transducer is mounted by fitting it into a hole through the flashlight's plastic lens. The diameter of the hole is slightly larger than the diameter of the front of the transducer (1.513"). A small amount of glue was used on the lip of the transducer, which has a diameter of 1.69" and is 0.159" behind the front of the transducer. This allows the front portion of the transducer to protrude from the lens while holding it in place. Once the transducer was secured to the lens, it was placed inside the cap, which was fitted to hold the lens.

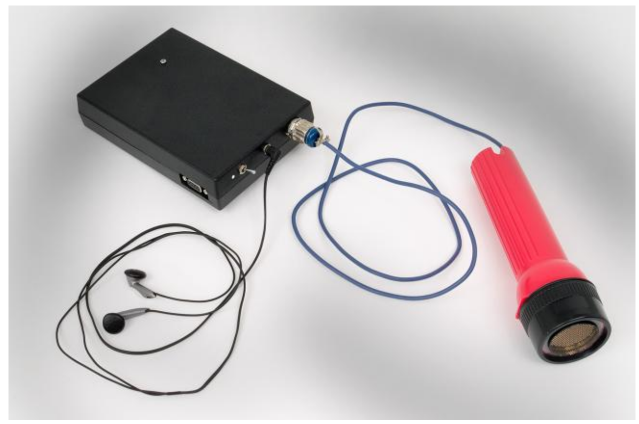

Fig. 11.67. Range Finder for People with Visual Impairments.

The Polaroid 6500 series sonar ranging module is secured in the front part of the flashlight case using the tapering of the flashlight's front and a slot, which held the actual parts of the flashlight. Additionally, the module is surrounded by non-conductive foam for protection. The module had its edges, not containing circuitry, trimmed to fit the slot and had a 500uF capacitor attached to account for the power drain each time it pings. The wires in the cable that carry power to the module and a signal from the module to the controller, were then attached and run out the back of the case. Once the transducer was connected to the module, the cap was filled with the non-conductive foam and placed onto the flashlight; this applies pressure to the back of the transducer to help secure it in the cap and prevents contact with the module. At the end of the cable, a plug was attached so that the handheld component can be disconnected.

The controller is the CME-11E9-EVBU board made by Axiom Manufacturing. This board was mounted within a purchased 4.88" x 6.88" x 1.5" enclosure that had been slightly modified. Once the board was secured, a volume control, a toggle switch, a connection to the module, and a connection to the power source were attached. The power source for the prototype is four AAA lithium batteries, which allow the system to run for 19 hours before they have to be replaced. A potential way to improve the system would be to use either AA batteries or use rechargeable batteries and have a plug setup so they can be charged without removing them from the enclosure.

The code for the range finder is programmed into the controller and adjusted to give the desired range and ping rate. This gives it a minimum range of about 1 1/2 feet; under this range, the tone will not change. The maximum range is set at 13 feet; the device will generate no tones at distances longer than this. The code can be adjusted to increase or decrease these ranges. A lower range will make the tones more sensitive to change; however, it will also decrease the area that can be sensed. The present settings were determined by repeated testing of the device to obtain enough sensitivity to identify significant changes in the distance while giving a reasonable amount of range. The final component is the headphones, which emit a tone based on distance. The pitch of the tone is determined by the controller board, and any stereo headphones can be used with this device.

The total cost of this device was approximately $195.

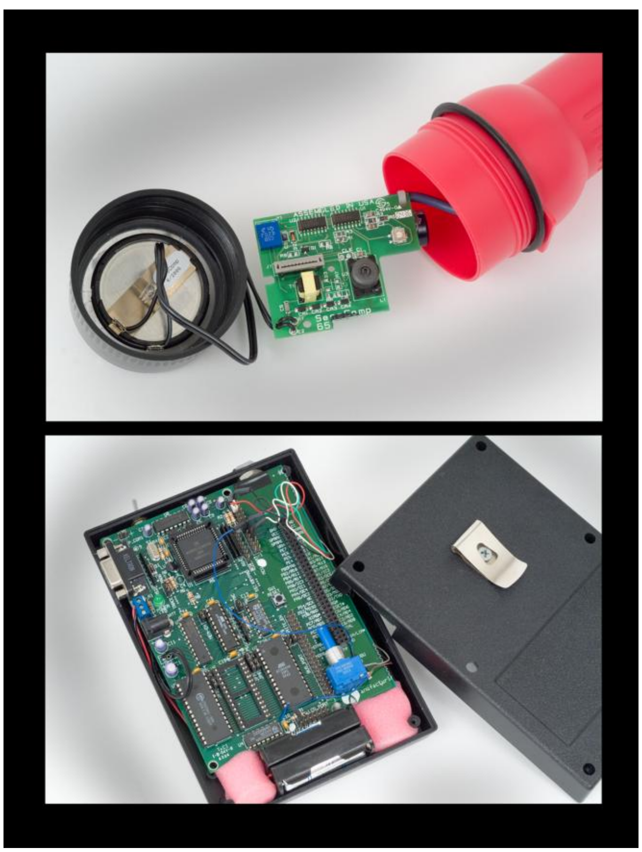

Fig. 11.68. Internal Components of Range Finder.

Fig. 11.69. Range Finder in Use.

RETRACTABLE STEP ACCESS FOR SCOOTERS

Designer: Jacqueline Kuczmanski
Client Coordinator: Renae Gullo
Supervising Professor: Dr. Joseph C. Mollendorf
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INTRODUCTION

Although motorized scooters have adjustable settings, they still may not meet the needs of some people with dwarfism. The client in this case is approximately 2 ½' tall (30"). It is difficult for her to get onto the seat, which is approximately 1 ½' from the ground. The Retractable Step Access for Scooters was designed as an accessory that can be attached to the seat of motorized scooters. The lever-operated steps extend and retract to assist the client in getting on and off the scooter seat.

SUMMARY OF IMPACT

Prior to the Retractable Step Access, the client got up onto the scooter seat by climbing. Therefore, the Retractable Step Access increases the client's comfort and enhances safety while she gets on and off the scooter seat. In addition, its ease of use increases the client's independence.

TECHNICAL DESCRIPTION

The Retractable Step Access is designed as an accessory for a Sonic Pride Mobility Scooter (see Fig. 11.70). The motorized scooter disassembles into three components: 1) the rear wheels; 2) the platform with steering device; and 3) the seat. In this design, the Retractable Step Access attaches to the seat component of the motorized scooter. The seat component of the Sonic Pride consists of the plastic seat fastened to a steel support plate.

The Retractable Step Access base is a steel plate that fits between the plastic seat and the steel support plate of the Sonic Pride Scooter. Angle iron was welded to the base steel plate to provide for mounting locations and support (see Fig. 11.71). The actual steps are made of 6063 aluminum plates, supported by 6063 angled aluminum. For safety, the steps are covered with adhesive tread, which has a yellow strip to easily indicate its location. The steps

Fig. 11.70. Retractable Steps Installed on Scooter.

connect to the angle iron of the base with one inch steel flat bars that were cut and shaped into linkage arms; these linkage arms provide the means to extend and retract the steps.

The steps retract and extend by the use of a lever. The lever is constructed from half inch metal tubing. The tube construction provides the necessary strength to eliminate bending when a force is applied to bring the steps out of a locked position.

The steps lock in two positions: extension and retraction. To lock the steps in the extended position, the lever fits between two small cylinders that are welded to the steel base. The lever is held between these cylinders by an applied spring force. To remove the steps from their locked position, the lever must be pushed outwards; this action compresses the spring. As long as this force is applied (spring is compressed), the steps extend and retract freely. To lock the steps in the retracted position, the lever is pushed in front of the cylinders; the lever rests upon the front cylinder.

The total cost of this project was approximately $105.

Fig. 11.71. Retractable Step Access for Scooter.

Fig. 11.72. Retractable Steps in Extended Position.

WALKING STICK STOOL COMBINATION

Designer: Rachel LoSecco
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INTRODUCTION

Walking for extended periods of time can become tiresome for many people. A device was designed for those who walk with a walking stick and need an immediate, temporary place to rest. The walking stick stool combination allows the client who uses a walking stick to unfold the legs and raise the seat, thus converting the walking stick into a temporary stool.

SUMMARY OF IMPACT

The walking stick stool allows the client to rest while walking and when other seating is not available.

TECHNICAL DESCRIPTION

The walking stick stool combination consists of a one inch aluminum shaft with two assemblies and two parts welded to it. At the top of the shaft is a foam ergonomic handle. Just below the handle, there is a square-shaped aluminum part, which is called a stopper, welded to the shaft. This is to keep the seat from folding inward when weight is applied. Below the stopper, there is another aluminum part that slides up and down the shaft; this is referred to as the slider. Attached to the slider are the four aluminum arms for the seat part of the stool. At the other end of the arms, a nylon cloth seat is attached. This nylon cloth came from a children's camping chair that required some modification. It was attached to the arms using washers, fender washers, and screws. There is a hole in the center so the foam handle can come through it when in walking stick mode.

The legs are located on the shaft below the slider. This portion of the device came from an old tripod. These legs are permanently attached using a spring pin that is chained to the collar that holds the legs. For stability purposes, when in stool mode, there is an aluminum plate welded to the bottom of the shaft. When in walking stick mode, the slider is down, and the legs are folded inward; both are held in place with Velcro.

Fig. 11.73. Device Configuration While Acting as a Stool.

When changing to stool mode, the client should first undo the Velcro and manually open the legs. Then the client should remove the Velcro from the seat part, slide the slider into the stool position, and insert the spring pin. The spring pin is attached to the slider with a chain. The client may then rest on the stool. With this design, the client must use at least one leg to provide balance. At this time, the device is made for people who are five feet seven inches in height and 150 pounds or less in weight.

More adjustable and stable versions of this device are possible.

The total cost of this device was $64.

Fig. 11.74. Device Configuration While Acting as a Cane.

ADJUSTABLE SHOWER HEAD FOR PEOPLE WITH DISABILITIES

Designers: Thomas Nicholas and Surinder Singh
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INTRODUCTION

People with disabilities are often not able to use a normal shower or bathtub system. Shower chairs and benches are designed to give the client support, but little has been done to aid someone with limited mobility of their extremities. This device was designed to bring the shower head and cleaning products closer to the client while showering.

SUMMARY OF IMPACT

This adjustable shower system allows clients to have a greater sense of independence as they will be able to adequately cleanse themselves without the assistance of others. It provides the client with a complete shower and also enhances the client's safety. This device was designed to be used in conjunction with a shower chair or bench.

TECHNICAL DESCRIPTION

The device's main component is the spring-roller system that is used to raise and lower the shower head and personal cleansing dispenser. The spring-rollers used in the prototype were taken from two sets of household miniature blinds and customized to fit the design specifications. The spring-rollers are to be operated in the same manner as the miniature blinds.

The hand-held shower head is connected to an 80" flexible brass hose, which connects to a three-way diverter valve. The diverter valve connects directly to the existing wall-mounted shower flange. The third flow direction allows for the connection of a normal shower head so that others can also use the shower.

The cleansing dispenser has two components for shampoo and shower gel. Also included with this device is a foot-wash basin. The basin was designed with a slightly sloped bottom for drainage and sponges which help clean the patient's feet. Each of these components increases the patient's ability to adequately cleanse themselves.

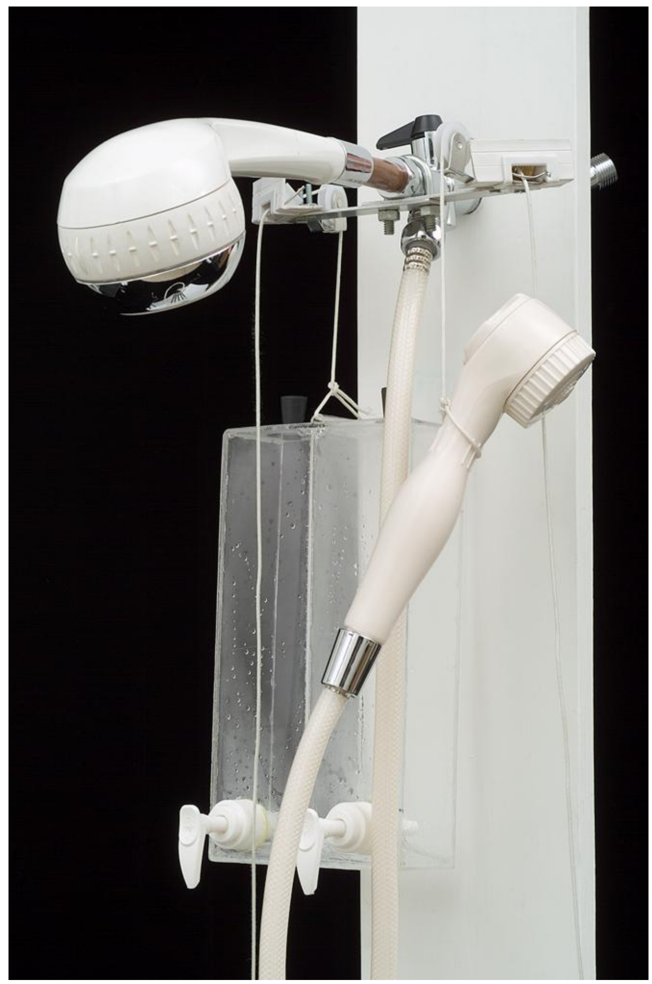

Fig. 11.75. Adjustable Shower Head and Dispenser.

The final cost of this project was $110.

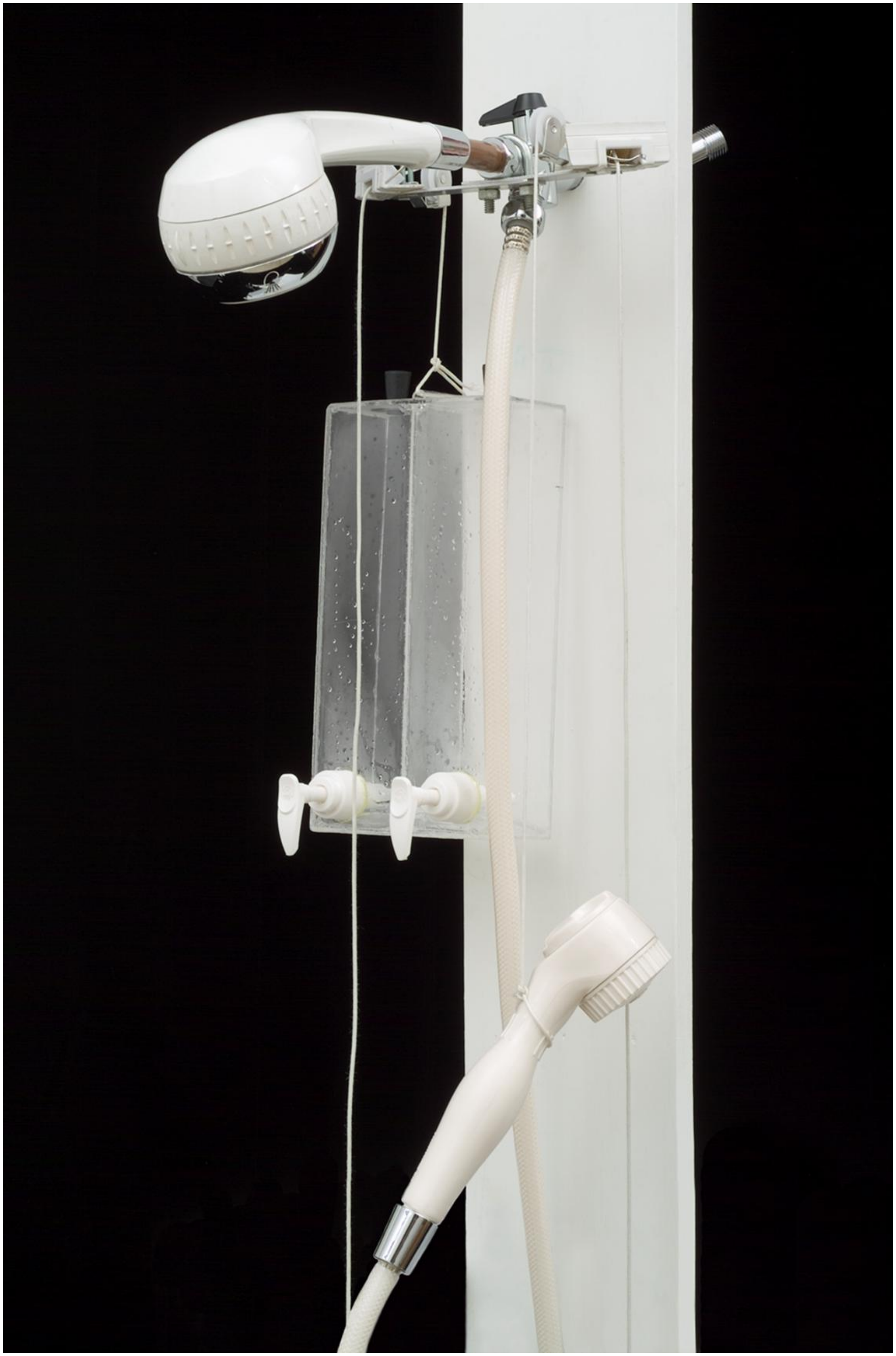

Fig. 11.76. Device with Shower Head Lowered.

REDESIGN OF A QUAD-CANE BASE: TERRAIN ADAPTIVE AND SHOCK ABSORBING WALKING CANE

Designer: William Ofori-Atta
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INTRODUCTION

Current quad canes do not adapt to the surface of contact or absorb shock. This new design will reduce falls on terrains such as cracked pavement, gravel, and uneven surfaces. Since the feet of quad-canes are rigid, the cane is unbalanced on uneven surfaces. This causes slips and falls, which can result in injuries to users.

SUMMARY OF IMPACT

This new design will enable the cane to be flexible on uneven surfaces and also absorb shock. This will reduce the number of falls caused by slips on rough and uneven surfaces.

TECHNICAL DESCRIPTION

To make the quad-cane terrain adaptive, the base of the cane was redesigned (see Fig. 11.78). The materials used for the new base included four square aluminum plates, measuring three by three inches, with a one inch radius located at the right corner of the base. The base also includes four one inch hollow aluminum studs and a square steel plate with holes drilled at the four corners. The feet utilize four 12-14-lb compression springs with a one inch inside diameter and a height of three inches; each spring was inserted into non-slip rubber cane tips. For the base spring, a 50-70-lb compression spring, with a height of three inches and an inside diameter of two inches was used.

The four aluminum plates had a stud welded to their centers and were then bolted to the steel plate with three inches of space between two sets of plates. The steel spring is encased in two steel tubes to limit the degree of movement to 15 degrees. It was then welded to the center steel piece. A regular cane shaft with a height adjustable button was then welded to the top of the encased spring. This base spring will serve as a shock absorber for the device.

Fig. 11.77. Terrain Adaptive and Shock Absorbing Walking Cane.

The four compression springs are tight-fitted on the studs at the bottom of the aluminum plates. On uneven surfaces, as the user’s weight is shifted while using the cane, the springs will deflect and adapt to the surface of contact.

The cost of parts and materials was about $55.

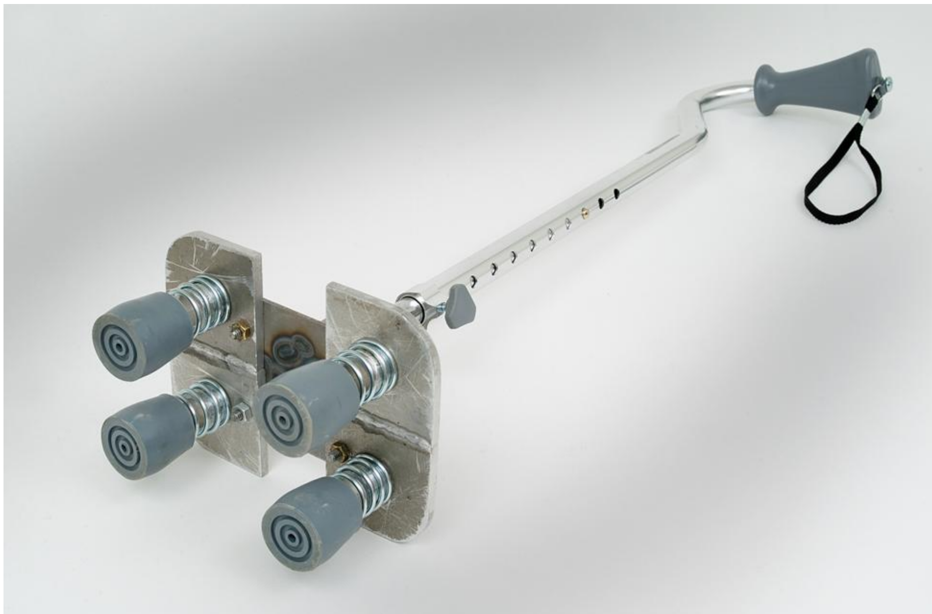

Fig. 11.78. Modified Base of Walking Cane.

Fig. 11.79. Terrain Adaptive and Shock Absorbing Walking Cane on Rough Surface.

THERAPEUTIC DEVICE TO IMPROVE BALANCE FOR THE ELDERLY

Designer: Mary Russell
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INTRODUCTION

As an individual grows older, his or her lower extremities weaken, increasing the chance of a severe injury. The use of a therapeutic device may not only decrease fall risk but also decrease the cost of fall injuries.

SUMMARY OF IMPACT

Many products on the market assist individuals with walking and moving short distances. However, very few of these products help to improve balance therapeutically. This design is unique in that it targets elderly individuals who want to avoid using walkers in their everyday lives.

TECHNICAL DESCRIPTION

The device consists of a 1.5″ thick plywood platform (see Fig. 11.80) that measures 3′ x 4′ and provides a safe and supportive surface. Attached to the top of the platform are three separate sections of PVC pipe. The front section of the PVC pipe consists of a T-design with three legs and dimensions of 36″ x 37″, while the two U-shape side pieces have two legs each with dimensions of 23.75″ x 37.5″. At the end of these legs, a PVC adapter is threaded into a metal flange. This flange is then screwed into the platform using one and a quarter inch wood screws.

In the middle of the platform, the individual stands on two balance discs, one for each foot, which are 14″ in diameter with a thickness of two inches (see Fig. 11.81). This allows the individual to improve his or her balance, and the PVC pieces available if support is needed.

Using superglue, the four strain gauges are mounted, 90 degrees apart from each other in the center of each individual leg. These strain gauges have been wired to obtain bending loads. A data acquisition system was connected to the strain gauges for measuring the output when a force is applied to any of the PVC sections. Once received, the data is converted into a Microsoft Excel document and manipulated as necessary. This allows a physical therapist to evaluate which side of the body is weaker and needs more concentrated therapy.

The main component of this data acquisition system is a Motorola 68HC11 Microcontroller (MCU). The MCU provides digital data inputs, digital data outputs, and analog data inputs. These inputs and outputs can be manipulated with software running in the MCU chip.

The MCU circuit board also contains support hardware, which includes spring switches for operator input, 16 character LCD display for operator visual information, a solid-state piezo beeper module for operator audible information, a standard serial port operating at 9600 baud for program development, a debugging system for the final product, data output to be recorded on a PC, MAC or other computer, a strain gauge conditioner to amplify force information from the balance and present data to the MCU as a DC signal ranging from zero to five volts, and a battery pack to provide portable operation.

The total cost of the project was $212.

Fig. 11.80. Therapeutic Device to Improve Balance for Elderly, in Use.

WIRELESS INFRARED TRANSMITTING FIRE ALARM WITH VIBRATING BAND RECEIVER

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INTRODUCTION

The fire alarm is a common safety feature readily available in many public locations. It is a customary invention with some differences among models that typically involve a bell and a light that responds to heat or smoke exposure. A modified fire alarm (see Fig. 11.82) was designed for people with impaired hearing. Since this device uses more than a blinking light to warn people of a fire, people with poor hearing will now be able to sleep or relax with more comfort.

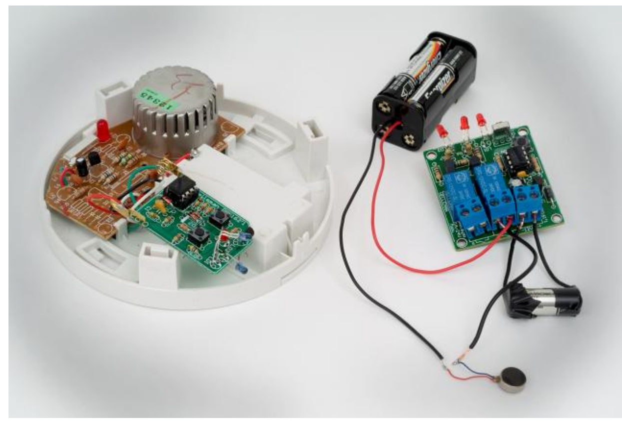

Fig. 11.82. Modified Fire Alarm.

SUMMARY OF IMPACT

The device helps people with disabilities sleep more safely. Similar products on the market vibrate a bed or pillow to wake the user. This product allows the user to sleep or rest anywhere, as long as he or she is wearing the device.

TECHNICAL DESCRIPTION

The initial system requirements for this project consisted of a comfortable and durable band, transmitter with a strong enough range, and reasonable budget. The project consisted of wireless infrared transmitter and receiver, standard fire alarm, and vibrating DC motor. The transmitter and receiver were built from kits ordered from ApogeeKits, specifically the MK161 and MK162. They were infrared, small, and required some intensive assembly.

The transmitter was modified and mounted onto the fire alarm in place of the bell. By wiring the transmitter directly through the fire alarm, no supplemental battery source was required. The fire alarm/transmitter sends a signal in bursts of three and runs off of a nine volt battery.

The second part of the product is the receiving kit (see Fig. 11.83). As the three bursts of IR transmission are received, the kit responds accordingly. The kit is built with two separate circuit dry switch loops. It runs off a 12-volt battery for maximum life. The dry switch loops have no current flowing through them from the receiver itself; they are simply switches that close and allow flow when the transmitter fires. Wired through one of these closed loop circuits is a DC Samsung a670 vibrating phone motor. This motor is small, yet powerful enough to be noticed by the user. It is wired to collection of four one and a half volt batteries (AAs). When the loop is closed, the six volts flow through the motor and the motor begins to vibrate.

This entire assembly is placed into an arm band typically used for an I-pod. It has a clear front to allow for minimum IR interference, as well as an adjustable strap for maximum comfort. It has a Velcro case to make it easy for the user to change the battery.

The total cost of all the equipment combined was $85.

Fig. 11.83. Armband Receiving Kit.

ADJUSTABLE TEMPERATURE PRESET DOUBLE-KNOB FAUCET ATTACHMENT

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INTRODUCTION

Currently, new houses come equipped with easy-to-use bathroom and kitchen sinks that allow a person to control water temperature and flow rates in various ways. Many home owners with older faucets still find themselves twisting and fiddling with the faucet knobs to get the desired flow rate and temperature. This may sound like a simple task, but it can prove to be a nuisance for a person with a disability such as arthritis. This design is intended to alleviate the nuisance of fidgeting with knobs in order to achieve a desired water flow temperature.

SUMMARY OF IMPACT

This attachment allows users to set the water flow temperature that best suits the task they do most frequently in the bathroom or kitchen sink. The simple design and low number of components helps make the attachment more affordable. The attachment easily installs onto a standard double-knob faucet tap, allowing the user to control both taps at the same time. This attachment gives any homeowner the option of having an easy-to-use faucet in their home without the cost of a brand new, high-priced faucet.

TECHNICAL DESCRIPTION

This design uses a simple three-bar mechanism that allows the attachment to turn both taps in unison with the push of a handle. A key feature of this design is the adjustable bar located on the cold water tap (see Fig. 11.85 and Fig. 11.86). The adjustable bar is located on the cold water tap because the pressure on the cold water tap is usually higher than the pressure on the hot water tap. This pressure difference may be due to the restricted flow of the hot water through the water heater. This causes the water mixture to be cold when both taps are opened all the way. This attachment allows the user to regulate the hot and cold water ratio by adjusting the length of the bar on the cold water tap.

Fig. 11.84. Adjustable Temperature Preset Double Knob Faucet Attachment.

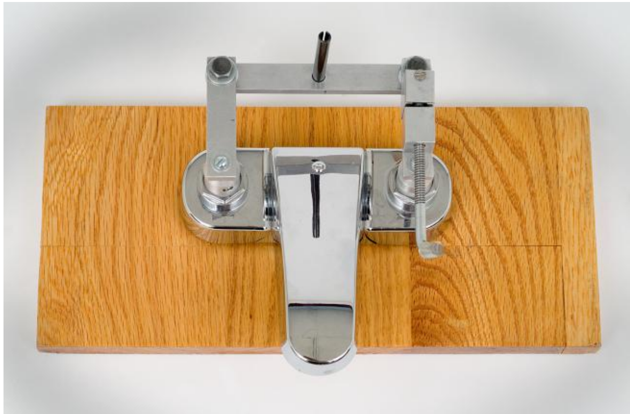

Fig. 11.85. Device with Both Taps Set Equally.

Extending the length on the cold water tap decreases the cold water flow rate with respect to the hot water flow rate. This gives the user a warmer water mixture if desired. Once the user finds a comfortable water flow temperature during use, they can attain that same temperature at any other times through the push of a handle. The adjustable bar on the cold water tap extends to about three times the length of the bar attached to the hot water tap. This allows the user to get a mixture of water that is fairly warm.

The final cost of this project was $32.

Fig. 11.86. Device with Adjusted Cold Water Tap.

Fig. 11.87. Device Configuration When Faucet is Turned On.

HYDRAULIC HEIGHT-ADJUSTABLE KITCHEN ASSIST CHAIR

Student Designer: Mark Szymanski
Client: Theresa Daruszka
Supervising Professor: Dr. Joseph C. Mollendorf
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INTRODUCTION

This device was designed to assist people with weak legs in performing everyday kitchen tasks. Preparing food can take a long time, and it is hard for people with weak legs to stand for extended periods of time. This device provides a place for a person to sit while preparing a meal. The person is able to sit at a normal table height, or they can raise the chair so they can reach high countertops without getting up from the chair.

SUMMARY OF IMPACT

The Hydraulic Height-Adjustable Kitchen Assist Chair (see Fig. 11.88) is a rolling chair that allows a person to maneuver around the kitchen with great freedom. As an alternative to a wheelchair, this chair is not bulky and is height adjustable so that a person can comfortably reach countertops of various heights. The hydraulic hand pump (see Fig. 11.89) allows the person to raise and lower the chair without getting up from it. It also provides a mode for exercise to help strengthen the person's upper body.

Fig. 11.88. Hydraulic Height-Adjustable Kitchen Assist Chair.

Fig. 11.89. Hydraulic Hand Pump Assembly.

TECHNICAL DESCRIPTION

The Kitchen Assist Chair was designed to be highly maneuverable and compact enough so it can be used in kitchens of all sizes. For this reason, a computer chair was chosen to be converted into the assisting chair. The computer chair rolls easily and can fit in relatively small areas. The base of the chair has five legs arranged in a star shape. There is one caster on each leg of the base. Each leg measures 12" from the centerline of the base.

A hydraulic foot pump has been installed between the seat and the chair base. This pump allows a person to raise or lower the seat without getting up from the chair. The pump has seven and a half inches of travel, as the seat of the chair can rise from

24" to 31.5" from the ground. Since the chair was designed to serve a person with weak legs, the hydraulic pump was converted from a foot pump to a hand pump. The hand pump is operated by gripping the handle near the back of the chair and pushing it forward. The hand pump is made out of half inch Chrome Allium tubing, selected because of the material's rigidity and strength. Two angled brackets were used to increase the strength of the hand pump at the 90 degree bend. The hand pump was designed so that it can be easily operated at the lowest and highest positions of the chair, while not being in the way of the person sitting in the chair as he or she performs kitchen tasks. The handle is angled backwards so that it will not prevent the chair from sliding comfortably underneath a table. Finally, a cushioned grip was added to the hand pump for comfort.

Two adapters have been constructed from 6061 aluminum to connect the three components of the chair. The first adapter connects the hydraulic pump and the seat. The second adapter is pressed onto the shaft of the pump, and then the seat is pressed onto the outside of the adapter. The second adapter connects the base of the chair and the hydraulic pump. This adapter also houses a ball bearing that allows the pump and seat section of the chair to rotate 360 degrees.

The cost of the project was approximately $170.

Fig. 11.90. Kitchen Assist Chair in Use.

Fig. 11.91. Full Stroke of the Pump Handle Shown, as Compared to Fig. 11.90.

WALKER WITH SKI ATTACHMENT AND BRAKES

Designer: Anthony Tasner
Supervising Professor: Dr. Joseph C. Mollendorf
Mechanical and Aerospace Engineering Department
State University of New York at Buffalo
Buffalo, NY 14260-4400

INTRODUCTION

A device was designed to help individuals who use a walker travel through snowy or icy conditions with more ease than the conventional wheel and stud walker.

SUMMARY OF IMPACT

The simplicity of the design makes it a practical and user-friendly device. This walker (see Fig. 11.92) may be easily operated by anyone who already uses a walker during his or her everyday life.

TECHNICAL DESCRIPTION

The Walker with Ski Attachment and Brakes was developed by modifying a pre-existing walker. A conventional walker design was slightly modified to allow for skis and a braking system to be attached in a way that still allows use of the walker as it was originally designed.

Traditional snow skis were shortened and holes were drilled and chamfered to allow the skis to be attached to the posts of the walker. The front posts are attached to the ski using a Delrin bracket, which was machined to allow the front posts to swivel from front to back to allow the braking system to work. Two stainless steel bolts hold each Delrin bracket to the ski through the bottom of the ski.

The rear posts of the walker (see Fig. 11.93) have a machined aluminum brake peg. Also attached to the rear post is a brake plunger used on traditional walkers. This brake plunger works by pushing down on the back of the walker, which produces downward movement of the rear post. A hole was drilled through the back of the ski to allow the brake peg to go through the ski when someone pushes down on the back of the walker. When the brake plunger is fully compressed, the brake peg will come through the ski and into contact with the snow or ice (see Fig. 11.94); this will halt forward movement of the walker. When the walker needs to be slowed down or stopped, all the user has to do is push down on the back of the walker.

Fig. 11.92. Walker with Ski Attachment and Brakes in Use.

The total cost of the project was $20.

Fig. 11.93. Walker Braking System.

Fig. 11.94. Braking System Configuration When Walker is Pushed Downward.

PILL CAPSULE OPENER

Designer: Kristin A. Terragnoli
Client Coordinator: Tammy M. Milillo
Supervising Professor: Dr. Joseph C. Mollendorf
Mechanical and Aerospace Engineering Department
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Buffalo, NY 14260-4400

INTRODUCTION

There are large numbers of patients taking prescribed medication who cannot swallow traditional pill tablets for certain reasons. Some medicines come in a powder form administered via a plastic pill capsule that dissolves faster and results in more efficient drug release and effect. The Pill Capsule Opener provides a way to separate the two halves of a capsule and pour out the contents in a controlled fashion for oral consumption by spoon.

SUMMARY OF IMPACT

This device was designed for a student with cerebral palsy who lacks the muscle control required to swallow pills as well as the motor skills required to separate the tiny pill capsule and successfully empty the contents. Before the fabrication of this device, the patient had to rely on health care aides or other assistants to prepare the medication for her consumption. This device offers invaluable independence by allowing many people with handicaps to self-administer their encapsulated medication. It assists those with limited strength or dexterity and enables those who cannot swallow pills to enjoy the benefits of pill capsules as opposed to traditional pill tablets.

TECHNICAL DESCRIPTION

The design consists of a 5 ¾″ x 8 ¾″ base supporting a 6″ x 3″ x 4 1/4″ raised platform into which a 2″ diameter hole was drilled to accommodate either a 3 1/2 or 5-ounce Dixie® cup (see Fig. 11.95). A hinge unit was glued to the left of the hole. This hinge unit consists of symmetrical 2 ¼ inch by 2 inch pieces of wood with holes drilled to precisely fit a 1.45″ (Size 7) laboratory stopper made from styrene butadiene rubber. This stopper has a 1/5″ hole in the center where a pill capsule with an approximate diameter of 3/16″ (roughly 6-mm) can be inserted (see Fig. 11.96). The two pieces are connected by two 5/8″ x ¾″ brass hinges. The pill is placed into the lower half and the upper half can be lowered onto

Fig. 11.95. Pill Capsule Opener.

Fig. 11.96. Pill Capsule Opener with Pill Capsule in Place.

the pill via the hinges. The capsule is separated when the upper half is lifted upwards; the top of the capsule remains stuck in the upper half and the bottom of the capsule containing the medication remains stuck in the lower (see Fig. 11.97). This unit is attached using two 2 1/2″ by 2″ pieces of wood, which are both glued to the platform. The unit is connected to the rightmost piece with two more brass hinges; the left piece provides stability when in the horizontal position. After rotating backward 180 degrees via the rear hinge and separating the pill capsule, the rear hinges will lock and the unit can then be rotated 180 degrees to the right (see Fig. 11.98). This enables the medication to fall from the bottom half into the cup positioned in place; this eliminates any mess and ensures that 100 percent of the medicine dose is administered. The cup can then be removed and the contents eaten. Accessibility features include 3/8 inch wooden dowels for leverage and ease of use. An attached 5/32 inch Allen key is used to force the empty capsule halves back out of the stopper holes. This device also makes use of removable/replaceable rubber stoppers and a removable "tray" below the bottom stopper for stability when force is applied from the top.

The total cost of this project was $98.

Fig. 11.97. Device Configuration after Pill Capsule Has Been Split.

Fig. 11.98. Pill Contents Being Poured into Positioned Cup.

COLLAPSIBLE AND TRUNK-LOADING SHOPPING CART

Designer: Daniel Wanderman
Supervising Professor: Dr. Joseph C. Mollendorf
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INTRODUCTION

A shopping cart (see Fig. 11.99) was designed to load completely into the trunk of an automobile with ease in order to eliminate the task of having to transfer individual contents (e.g.: bags of groceries) from the cart to the trunk.

SUMMARY OF IMPACT

This type of cart can be used by anyone, but will be most beneficial to those who have difficulty in bending down to lift heavy objects, or those who have trouble gripping individual shopping bags, such as people with arthritis, to transfer bags from the cart to the trunk.

TECHNICAL DESCRIPTION

The collapsible and trunk-loading shopping cart has legs that retract, allowing the cart to fit with ease into the trunk or cargo hold of an automobile. The cart was designed to be pushed up against the back of a car (with an open trunk) and simply slide into the trunk with minimal effort.

The cart was also designed with ergonomics in mind; the handle is located at a comfortable height of 40″ from the ground when it is fully extended. The storage area of the cart is roughly 8,000 cubic inches; this volume is comparable to most shopping carts found at grocery stores. The entire cart measures 24″ in width, making it the perfect size to navigate through grocery store aisles and check-out lanes.

After shopping is completed, the cart is brought to the back of a car with an open trunk (see Fig. 11.101). The cart is then pushed up against the bumper, and a set of small casters catch the lip of the trunk to support it. When pushed a bit further, the front legs start to fold back, leaving the cart supported by both the trunk and the cart's rear legs, which are still on the ground (see Fig. 11.102). Once the front legs are fully folded and the cart is pushed as far in as it can go, the user must release the rear legs and push them forward on a guiding track (see Fig. 11.103). This will fully retract the rear legs of the shopping cart. At this point, the cart is fully lodged inside the trunk (see Fig. 11.104), which can then be closed. Once at the destination, the cart can be unloaded in

Fig. 11.99. Collapsible and Trunk-Loading Shopping Cart.

Fig. 11.100. Shopping Cart in Collapsed Configuration.

a similar (reverse) fashion to the loading process and taken directly to its target location. Although the actual cart can be made from another material, the prototype was made from Aluminum with bronze bearings in order to keep it as light as possible.

The total cost of this project was $325.

Fig. 11.101. Shopping Cart at Start of Loading Process.

Fig. 11.102. Front Legs Collapse toward Rear as Cart is Pushed into Trunk

Fig. 11.103. Operator Slides Shopping Cart Rear Legs Forward.

Fig. 11.104. Shopping Cart in Collapsed Position within Trunk.

MECHANICAL WINDOW OPENER FOR DOUBLE HUNG WINDOWS

Designer: David B. Watson
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INTRODUCTION

The freedom to easily open and close windows is a luxury not always afforded to people with physical disabilities. This product addresses the issues of reduced ability to operate windows due to physical impairment. People with reduced motor control may experience difficulty operating windows and may injure themselves attempting to open windows. This device allows them the ability to open and close windows with the push of a button.

SUMMARY OF IMPACT

This device returns the freedom of window control to individuals who have lost the ability to safely and easily open their own windows. The mechanical window opener helps to save time and effort and prevents potential injury. This device may be used for public and private spaces of any kind where mechanically controlled windows are desired. Facilities such as nursing homes or extended care facilities could install this device to allow guests the ease of opening and closing their own windows without having to call for assistance. Staff and maintenance workers would also be able to operate an abundance of windows with minimal physical exertion. The window opener is designed as an aftermarket product, which allows the user to mount the unit directly to his or her preinstalled windows.

Fig. 11.105. Mechanical Window Opener for Double Hung Windows.

TECHNICAL DESCRIPTION

The case of the unit (see Fig. 11.106) is constructed out of one quarter inch thick polycarbonate acrylic and is sectioned internally to hold and secure the mechanical components. The face of the case unscrews to allow the unit to be mounted. The entire unit mounts to the window frame (indoors) via two lag screws. The window can now be permanently unlocked because the unit will act as a locking mechanism when not in operation. An angle bracket is fixed to the window and then connected to the unit's connecting bar, which will be responsible for moving the window. The connecting bar is a machined 'L'-shaped bar that connects the unit to the window. The connecting bar is what lifts the window when the motor is operated. A power converter is included with the unit and must be plugged into a standard wall outlet and connected to the port on the bottom of the unit. The user can then operate the window by manually pressing the 'UP' or 'DOWN' buttons on the face of the device (see Fig. 11.107). When the unit is energized, the internal motor turns the lead screw on which the connecting bar is threaded. The lead screw is composed of a ½" diameter course-threaded rod. Both ends of the lead screw are machined and fit inside a fixed bearing at either end. The gear-motor is connected to one end of the lead screw and is responsible for turning the screw when the device is activated. The connecting bar travels up or down the lead screw depending on the motor direction and carries the window with it. The connecting rod also travels along a guide bar that is fixed inside the case. The guide bar helps to reduce the amount of torque required to move the window by preventing the connecting bar from turning during operation. A linear bearing is installed to reduce drag along the guide bar. The window can be stopped at any position along the travel distance but will automatically stop when it reaches the installed limit switches. The next evolution of the window opener is to include a remote control device to further assist in the safe and easy operation of pre-installed windows.

The cost of this project was approximately $180.

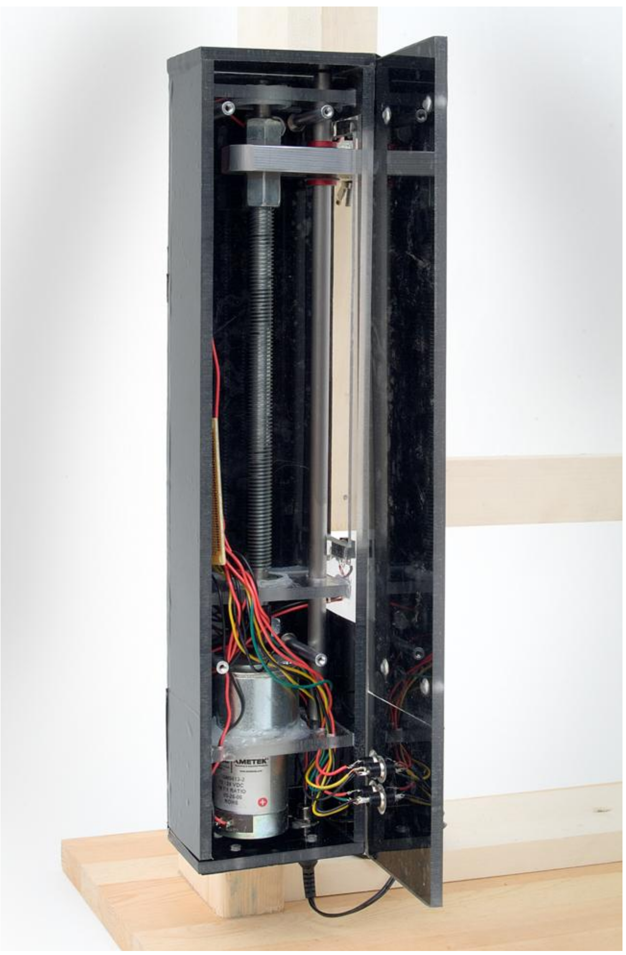

Fig. 11.106. Casing and Internal Components.

Fig. 11.107. Switches Used for Operation.

CHAPTER 12
TULANE UNIVERSITY

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VOICE MONITORING DEVICE FOR CHILDREN WITH AUTISM

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INTRODUCTION

Some children with autism have difficulty maintaining their voice at an appropriate level, often speaking too loudly or too softly. This causes difficulties in the classroom, particularly when reading aloud. The goal of this project was to create a device to enable students to monitor their voice levels while they are reading to the class. The device consists of a book light intended to provide real-time visual feedback by illuminating the book the student is reading in accordance with voice level. If the student reads too loudly, the page is illuminated in red. If the student reads at an appropriate level, the page is illuminated in blue. If the student reads too softly, the page is barely illuminated. Additionally, a column of red, blue, and white LEDs was included in the design to allow the teacher to see what the student sees without looking over the student's shoulder. A microphone acts as the voice level sensor. A custom stand integrates these items together into a standalone system.

SUMMARY OF IMPACT

This device impacts the entire classroom atmosphere. Since the students get immediate feedback regarding their voice levels, they are continually aware of their volume. This system of feedback is much less intrusive and distractive than the traditional correction method of the teacher asking students to adjust their voice level. As the students learn to control their voice levels, the classroom becomes quieter and more conducive to learning. The students enjoy this method of feedback and are observed to read for longer periods of time than before.

The teacher was excited about the project from the beginning. She believes that it might take a while for the children to become used to the device, specifically the color arrangement, but that it will help the children learn where their voice levels should be.

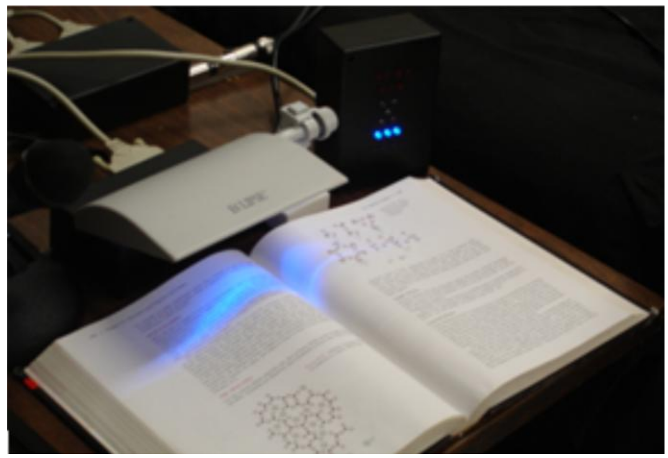

Fig. 12.1. Speech Therapy Device.

TECHNICAL DESCRIPTION

The device consists of: 1) an input; 2) a circuit; and 3) two outputs. The input is the microphone into which the students speak. The sound, in the form of a voltage, enters into the circuit. The circuit consists of: 1) a voltage follower with gain to amplify the sound signal; 2) an AC to DC rectifier; 3) an inverting op-amp with gain; and 4) an LED driver. The LED driver lights different LEDs based on the amplitude of he input signal. A potentiometer permits the teacher to control the threshold levels. This circuitry fits onto a single circuit board and is encased in a strong plastic box. Fig. 12.2 shows a diagram of the circuit.

The two visual feedback mechanisms are a book light and a column. The book light is a small plastic black box with two rows of directional LEDs coming out of the top, a row of blue LEDs, and a row of red LEDs. The LEDs shine directly upwards onto a mirror. The parabolic mirror then diffuses and redirects the light onto the page the student is reading. The column is also made of a plastic box. It consists of: 1) seven rows of LEDs; 2) two blue rows on the bottom; 3) three white rows in the middle; and 4) two red rows on the top.

The main circuitry box is connected to the two outputs through printer cables. These printer cables allowed the outputs to be disconnected and reconnected to the box easily and without any wire exposure. Also, the 10’ wires are long enough to allow the teacher to move the main circuitry box or column away from the book light and student if desired. The entire apparatus can be attached via Velcro to a stand, allowing the teacher to easily move the device.

The cost of the device was about $212.

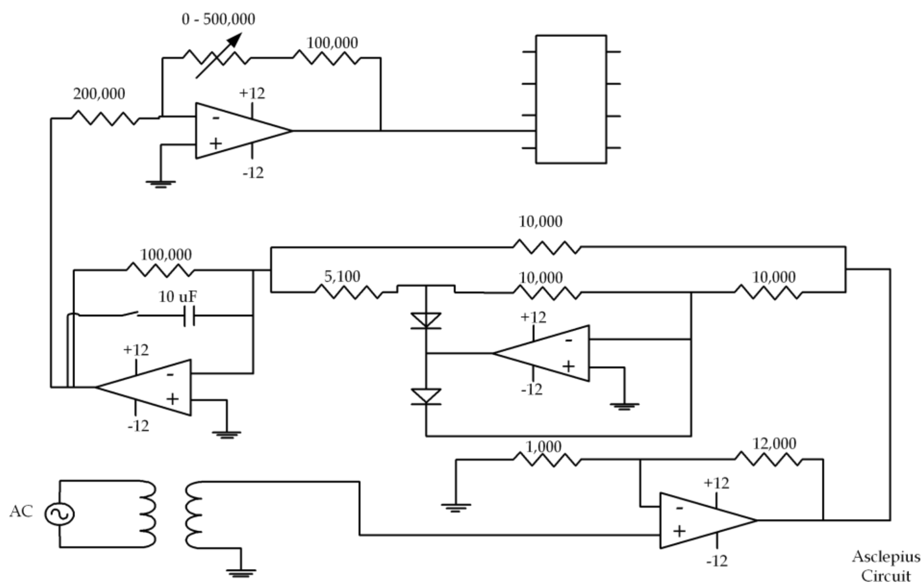

Fig. 12.2. Circuit Schematic.

COMMUNICATION DEVICE FOR A PERSON WITH ANOXIC BRAIN INJURY

Designers: Matt Riser, Sam DeStefano, Robbie Whitman, and Jeremy McShane
Client Coordinators: Holly Cohen, MPT, and Jill Jones, LOTR
Supervising Professor: David A. Rice
Department of Biomedical Engineering
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INTRODUCTION

A 26-year-old female with anoxic encephalopathy is unable to speak and receives most of her nutrition through a feeding tube. Her mobility and fine motor skills are being treated in physical therapy. She would benefit from a more efficient means of verbal communication. Previously, the client would communicate by pointing to letters on a board to spell words. This process takes a long time and can be hard to follow. In response to this need, a computer-based communication system was designed. The system allows for more effective communication through the use of basic phrases and words on a portable simplified keyboard. The keyboard was configured to be identical to the communication board that she used previously. The device uses text-to-speech software to allow the client to "type" what she would like to say. The software then "speaks" the text. The keyboard has been reconfigured with larger keys and quick keys tagged with symbols to represent commonly used phrases, greatly facilitating its use.

SUMMARY OF IMPACT

The communication system allows for expanded communication, clearly benefitting the client and inspiring her to initiate conversation with others because a "voice" can be associated with her thoughts. With the system, the client can give complete responses, as opposed to short responses associated with her previous means of communication. The ability to engage in more meaningful communication may carry therapeutic benefit as well.

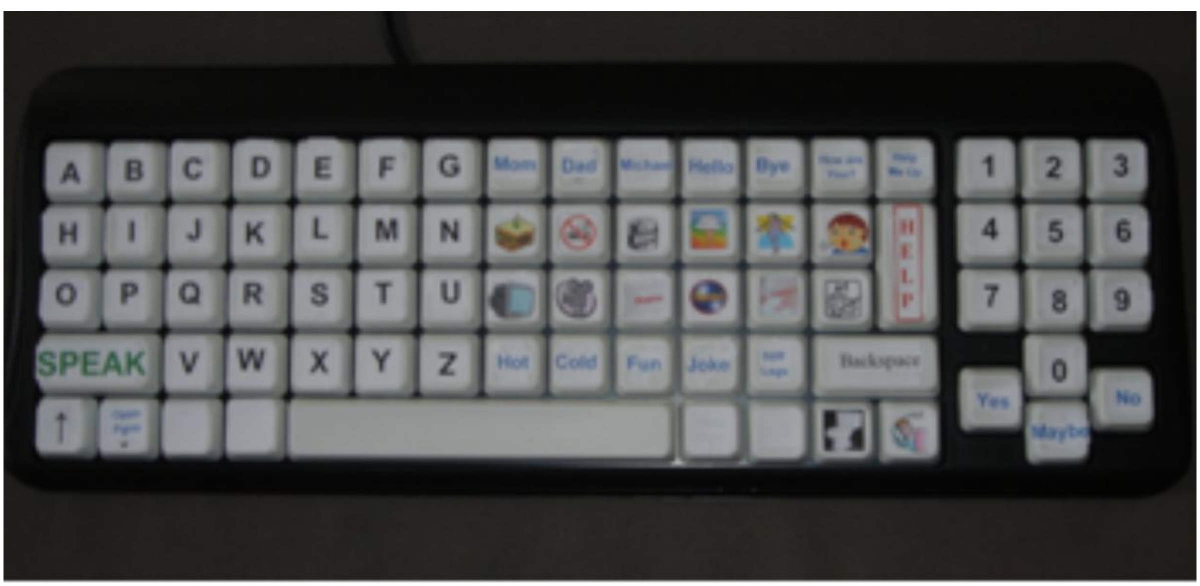

Fig. 12.3. Remapped Keyboard.

TECHNICAL DESCRIPTION

The system (see Fig. 12.4) includes a number of prefabricated devices: 1) a Compaq Presario Laptop; 2) an EZ keys Googol board keyboard; 3) Verbose Text-To-Speech software; 4) a Laptop carrying case; and 5) an infrared joystick mouse. The keyboard was remapped with specific phrases that were suggested by the client. It also contains a full alphabet on the left side with a numeric keypad on the right side. Each key was re-programmed to give a different and more cogent output (see Fig. 12.3). All keys are capable of being used to: 1) execute a function; 2) produce a phrase; 3) produce a letter; or 4) remain nonfunctional. Each key is laminated to extend the service life and to protect the associated icons located on top of each key.

The joystick mouse has a stiff joystick style without the rotational directions. The left and right clicks are located at the top of the stick while the bottom has an infrared scanner that moves the icon on the screen. Both the keyboard and the joystick are connected to the laptop through high speed USB ports. The text-to-speech software allows the client to type anything on the screen, after which the program will "say" it. The software incorporates a hot key that will open the program with a single keystroke. Text is highlighted upon being "spoken," which allows the user to continue writing without having to delete the previous text. One key executes the play of a word or phrase. The application can be exited to enable use of the laptop in regular mode.

The laptop works as the main framework for the device. It connects all aspects of the device and enables mobility. The laptop weighs about six pounds and the entire system weighs about 10 pounds. Power usage specifications can be modified on the laptop to save power and extend battery life.

The final part of the system is the case to carry all the parts. It is an efficient, durable portable case with thick rubber surrounding the entire laptop. The laptop is locked in with Velcro on the top and bottom and is also fastened in with four adjustable plastic corner holders. All cords can be run into the back of the case so that they need not be disconnected. The case also has a compartment to hold accessories. The case comes with a carrying strap.

The device is portable and lightweight. The operating system has been reconfigured for a quick system boot and a direct connection to the program so that the client may use the system spontaneously.

The approximate cost of this project was $800.

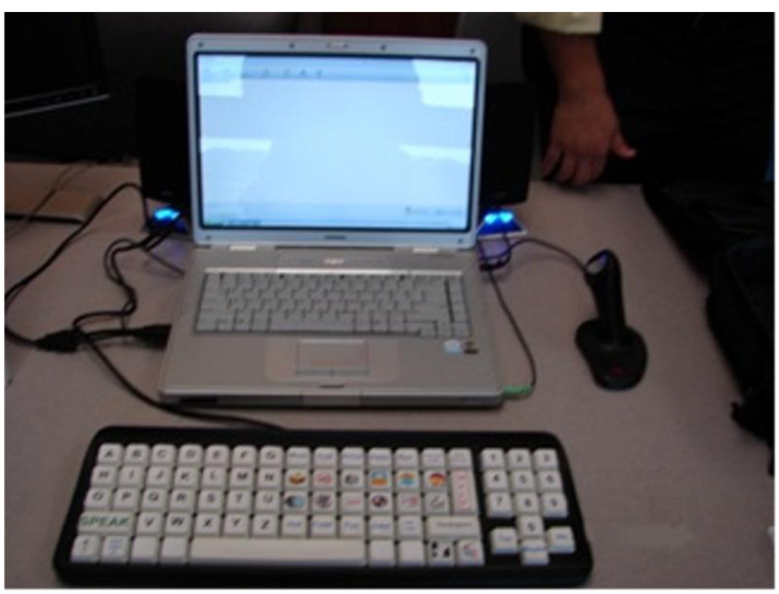

Fig. 12.4. Front View of Entire System.

WORKSTATION FOR A PROFESSIONAL WITH A LIMITED MOBILITY

Designers: Jenae Guinn, Adam Herder and Brett Weiner
Client Coordinators: Morteza M. Mehrebadi, PhD, Donald P. Gaver, PhD
Supervising Professor: David A. Rice
Department of Biomedical Engineering
Tulane University
New Orleans, LA 70118

INTRODUCTION

The client is uses a wheelchair and has limited mobility. He works from home, but has a difficult time accessing and utilizing standard desks. The client requested an L-shaped workstation that would facilitate working from home. The unit had to: 1) fit into a specific room of his house; 2) not obstruct access to nearby windows and doors; and 3) have a suitable working height so that the desktop would clear the client's wheelchair. The device had to be custom-built because existing L-shaped desks were too large and thus blocked the window, door, or both. The workstation consists of a desk and a moveable CPU stand with an adjustable shelf.

SUMMARY OF IMPACT

The workstation provides the client with the means to conveniently and comfortably work from home. He can use the desk to hold his printer, computer peripherals, and other necessary office supplies. The separate CPU stand frees up valuable workspace on the desktop and is mobile for convenient positioning. The adjustable shelf allows the stand to be used to hold other devices in the event that the client purchases a different model

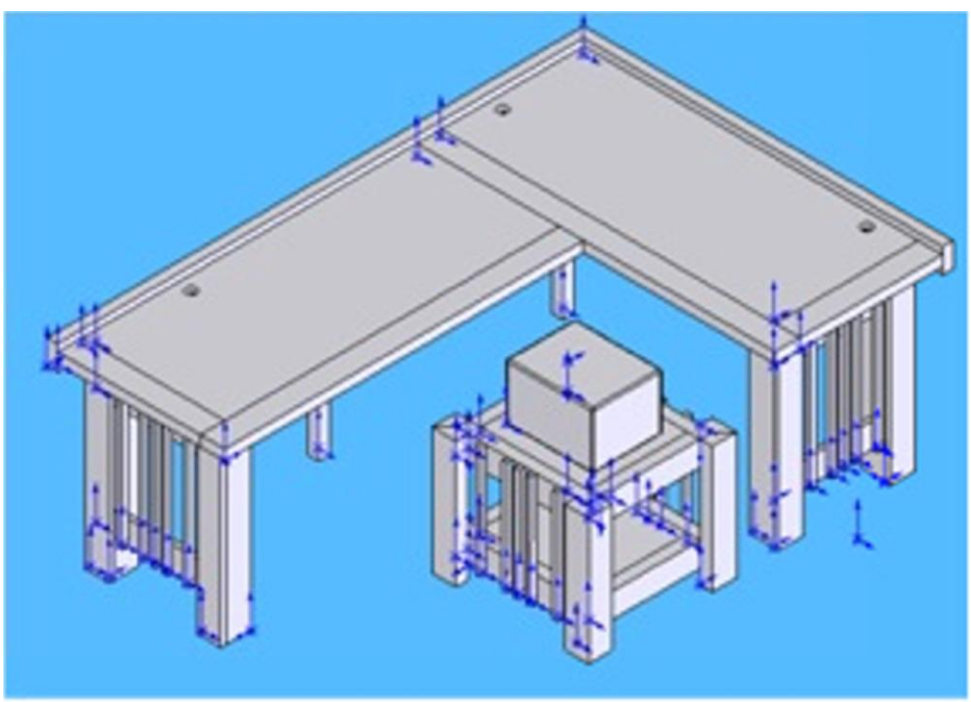

Fig. 12.5. Schematic of Desk and CPU Stand.

computer.

When the client used the workstation for the first time after installation in his home, he was pleased with the outcome. The physical dimensions of the desk were ideal for him and his office space. The aesthetic desires were met and, as a result, he has a piece of furniture that blends harmoniously with his interior design. He is no longer reliant on small, temporary folding tables as a work surface to hold his papers; this creates more space in his home and allows for better access.

TECHNICAL DESCRIPTION

At the client's request, the workstation was made from wood and designed in the manner of prairie or mission style architecture. To maintain the aesthetic of natural material, birch plywood was used for the large surfaces and oak for the legs and decorative edging. A natural polyurethane satin finish was applied to preserve the wood and produce an aesthetic finish.

The workstation was designed using SolidWorks design software. Analyses were performed with the COSMOSWorks add-in. Material properties of oak were found in the Forest Products Laboratory wood handbook ("Wood as an engineering material." Gen. Tech. Rep. FPL-GTR-113. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory, 463 p.). Material properties for birch plywood were unavailable, so a loading experiment was performed to determine Young's modulus. A section of birch plywood was simply supported and a known force was applied. Maximum deflection was measured, and the elastic modulus was determined from the equation dmax = -PL3/48EI. Due to the alternating laminate layers, the material properties of birch plywood were approximated as isotropic.

With this information, an L-shaped desk was designed that is structurally sound without support from a leg at the inside corner, facilitating client maneuverability underneath the desk. The desk measures 28″ from the floor to the bottom surface of the desktop, 75.5″ long, and 52.25″ wide. The CPU stand measures 14.25″ x 17″, and is 20″ tall, including casters.

The cost of the project was approximately $390.

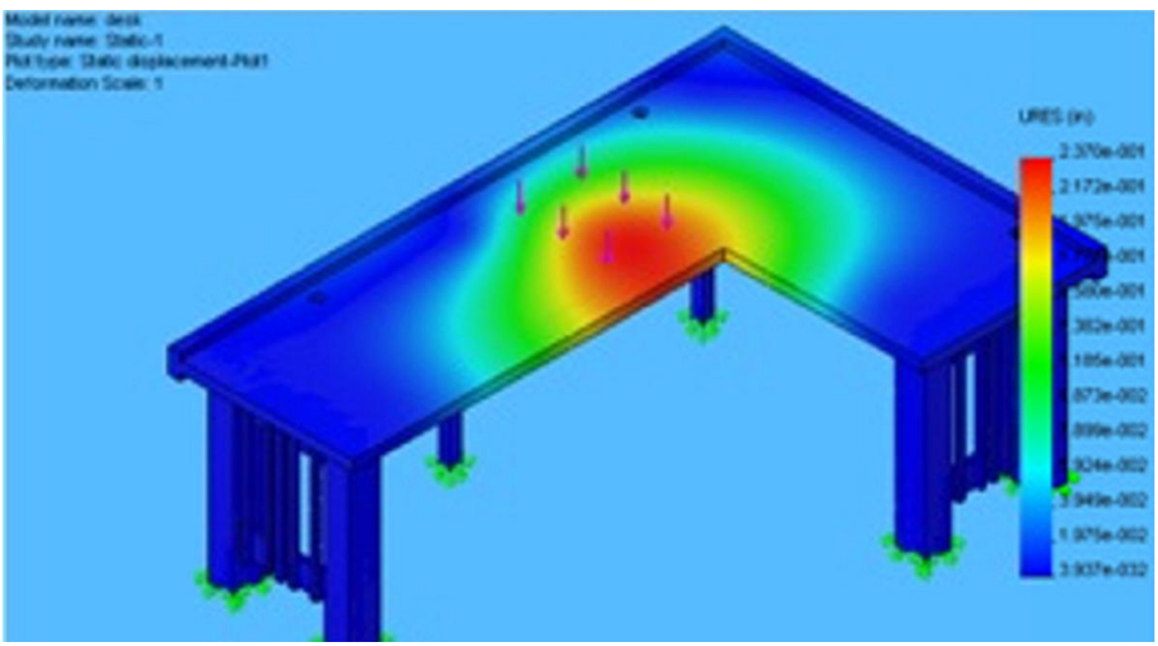

Fig. 12.6. Mechanical Analysis of Custom Workstation.

PAINTING EASELY

Designers: Emily Florine, Caroline Haas, Cole Johnson, Sara Thorson
Client Coordinator: Ronald C. Anderson, PhD, Annette Oertling, PhD
Supervising Professor: David A. Rice
Department of Biomedical Engineering
Tulane University,
New Orleans, LA 70118

INTRODUCTION

A portable and easy-to-use easel was designed and constructed for a client with osteogenesis imperfecta, a disease characterized in part by brittle bones. She has limited mobility, small stature, and paints while lying down. She is an avid artist and requested that an easel be built to move the canvas for her. The device allows the client to paint large canvases independently. The design consists of a motorized base on which is mounted a vertical frame. The vertical frame contains the canvas mount and the motor systems to move the canvas horizontally and vertically. The canvas mount also allows the tilting of the canvas. The vertical frame collapses on top of the base and rolls on the rear wheels for portability.

SUMMARY OF IMPACT

The client has short stature and limited ability to reach all areas of large canvases. Before receiving the easel, the client needed an assistant to move the canvas for her. The easel moves the canvas horizontally and vertically. The easel also allows the canvas to be tilted toward and away from the artist. This easel allows the client to paint independently in any location to which the easel can be transported.

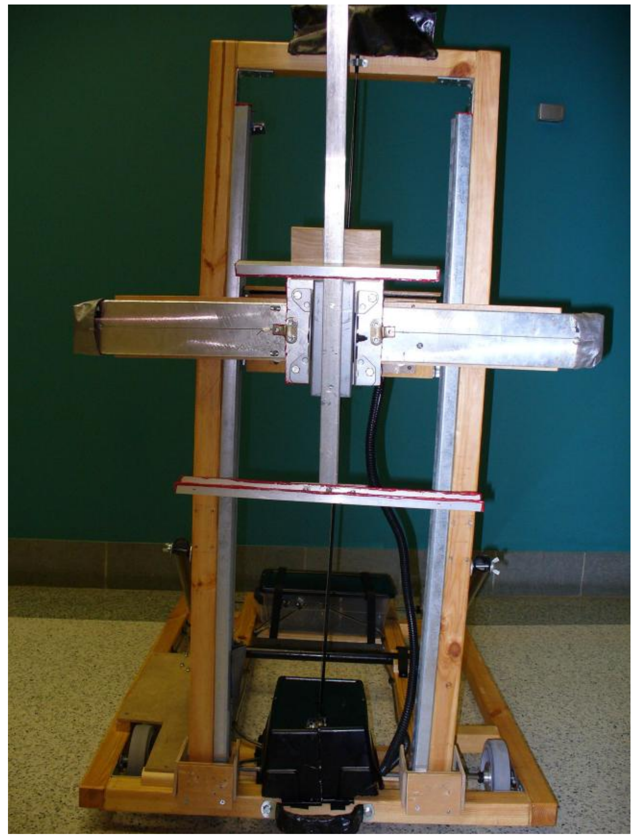

Fig. 12.7. Easel Front View, No Canvas.

TECHNICAL DESCRIPTION

The goal of this project was to create a remote controlled motorized easel that: 1) allows for movement of the canvas in four degrees of motion: tilt, x, y, and z directions; 2) is portable; 3) is safe; 4) is easy to use; and 5) can support canvas sizes between 10" x 10" and 36" x 36".

The motion of the canvas in the x, y, and z directions is accomplished by the activation of three motors, one controlling each direction of motion. The motors are reversible to allow motion in the positive and negative directions along each axis. The motors are activated by remote control. There are six buttons to control the three motors, with one button for each direction. The motors are all run from one 12-V DC battery. The motors cause motion via pulley and cable constructs. For the x and y directions, the pulleys wind and unwind aircraft cable to pull the canvas in the appropriate direction. The canvas slides along rails that attach to the wooden frame to guide the movement. For the z direction, the pulley turns a timing belt to rotate the axle attached to the base of the easel. Tilt is controlled by manual adjustment.

The easel collapses so that the vertical portion of the frame, which holds the easel, folds down onto the base. The easel collapses onto itself to a transport and storage height of approximately 10 inches. The easel can be pulled to the desired location by rolling it on its rear wheels (see Fig. 12.8).

A charger is provided with the battery. The charger is a trickle charger so the battery cannot be overcharged. If used unplugged, the battery will last for 16 hours. It requires 16 hours to completely charge a drained battery.

Safety features incorporated into the design include: 1) limit switches to prevent the canvas from moving off of the slides in the vertical or horizontal directions; 2) a limit switch to prevent activation of any motor when the easel is not set in its upright and locked position; 3) strain relief on all electrical wires; and 4) covering of all electrical wires, pulleys, motors, and pinch points.

The total cost of the easel was $885.

Fig. 12.8. Easel Collapsed Side View.

POLE TRANSFER AID

Designers: William Heim, Cindy Lumby, Kara Tellio and Dena Wiltz
Client Coordinators: Holly Cohen, MPT and Sharon Crane, LOTR
Supervising Professor: David A. Rice
Department of Biomedical Engineering
Tulane University
New Orleans, LA 70118

INTRODUCTION

The client is a 12-year-old girl with cerebral palsy. She has a marked lack in trunk strength but her arm and upper body strength are sufficient to enable her to pull herself along a rail. She also has some leg strength. A pole transfer aid was developed to allow more independence for moving between the client's bed and wheelchair (see Fig 12.9).

The pole stretches from the floor to the ceiling for maximum stability. It is anchored to the floor by a flange and to the ceiling by an adjustable telescope-like flange. The telescope-like flange corrects for any height variations between the floor and ceiling. The flanges are attached using screws. There are two circular rings on the pole. The rings allow the client to pull herself as she swings her body. The lower ring is placed at a position where she can grasp it from a sitting position in her wheelchair. The higher ring is placed at a comfortable position for grasping while standing. Each ring is connected to a center rectangular pole using horizontal connecting spokes. The rings are connected together using vertical poles that serve to support the client as she rotates herself. The connecting poles are attached to the center pole using collars attached with Allen screws. The collars allow the rings to be height adjustable. Sport tape covers the area of the pole that she grips.

SUMMARY OF IMPACT

This system allows the client a sense of independence. She is able to autonomously move herself from her wheelchair to bed and vice-versa. In addition, it allows her to use the strength she has and to exercise her muscles. The device is height-adjustable and easily modifiable such that custom alterations can be made. The physical therapist indicated the device is sufficient for independent transfers and will give the client enough stability with the multiple gripping surfaces. She noted that the vertical bars in the design will allow for easier hand repositioning. She also noted that the tennis grips were a good addition because they are cleanable, replaceable, and form a secure gripping surface.

Fig. 12.9. Transfer Pole.

TECHNICAL DESCRIPTION

The pole transfer aid consists of a height-adjustable ring system, a top flange, and a center pole with an attached bottom flange. The rings and horizontal supports are steel; the collars, flanges, and center pole are galvanized steel. The device is designed to be anchored to the floor and ceiling by the flanges with 14” x 1.5" wood screws; five wood screws screw into the bottom flange and floor and four wood screws screw into the top flange and ceiling. The ring system is adjustable to the individual's height. Each ring is laterally connected to a collar by three spokes. Each collar is attached to the center pole via two Allen screws, which allow for height adjustability. Two vertical poles connect the two rings to each other. The rings and vertical poles are covered with polyurethane foam core grips. The top flange is attached to the center pole by two set screws.

The total weight of the pole transfer aid is 44 lbs with final dimensions of 18" x 18" x 9' (length x width x height). Its exterior was treated with Rustoleum to resist rusting.

Overall production is simple and can be done with limited and nonspecialized equipment and readily accessible materials. The pole transfer aid is an economical solution to the problem posed and meets all requirements of strength and durability.

The pole transfer aid cost about $500.

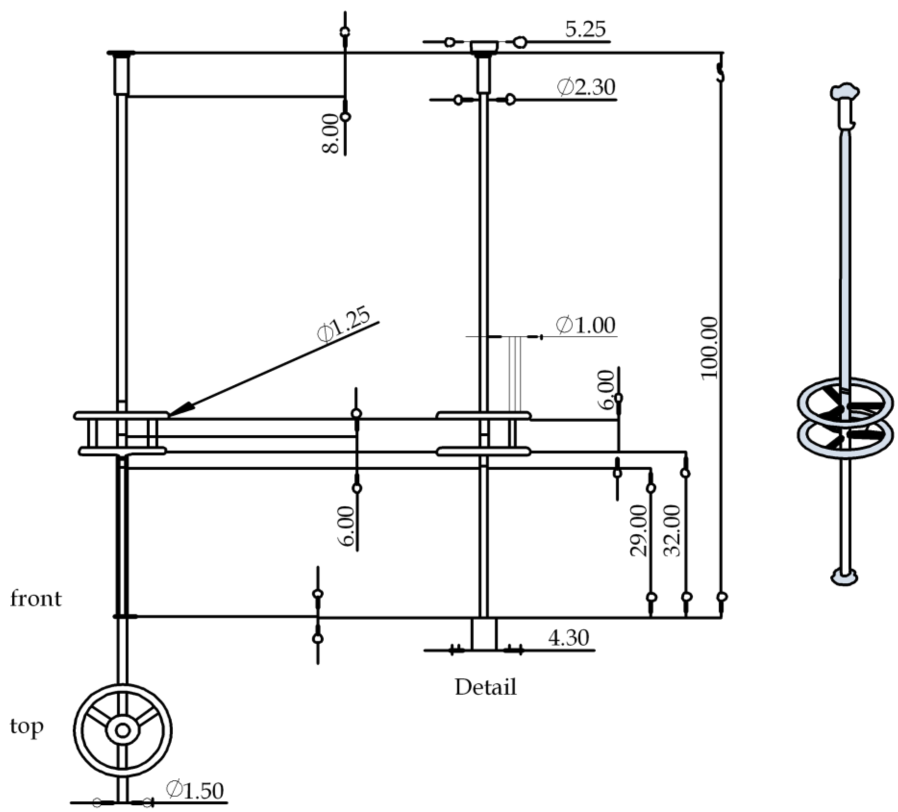

Fig. 12.10. Dimensions of Transfer Pole.

KIDS' INTERACTIVE SENSORY SYSTEM

Designers: Kimberly Bordeaux, Sarah Flanders, Elliot Hardy, and Helen Witt
Client Coordinators: Elaine Joseph, Ed.D. and Debbie Pavur, Newcomb Nursery, New Orleans, LA
Supervising Professor: David A. Rice
Department of Biomedical Engineering
Tulane University
New Orleans, LA 70118

INTRODUCTION

The Kids' Interactive Sensory System (KISS) was developed for a children's facility for which staff members requested a sensory development tool. Those who are potentially able to benefit from additional sensory experiences include children who have been diagnosed with autism, pervasive developmental delay, ADD or ADHD, and sensory integration or processing difficulties. The Kids' Interactive Sensory System provides tactile stimulation to aid children's development.

Snap Wall® pieces have a sturdy design that ensure a safe structure and allow for simple incorporation of tactile features. Plywood backing holds the tactile pieces in place but is easily removed for cleaning or replacement. A no-slip backing adds to the safety features of the design. The seven panels can be connected both vertically and horizontally to allow for comparison of the varying tactile surfaces and easy storage. Additionally, the large surface area allows for indoor motor activity with a large group of children, encouraging peer interaction.

SUMMARY OF IMPACT

Stepping between pieces with vertical differences encourages bodily awareness and careful placement without compromising safety. The facility director is pleased with the overall design, textile materials, and potential for use in the classroom. She was able to find an easily accessible storage location, which will encourage use of the device. Additionally, she mentioned that while there are many sensory development tools currently on the market, none meet the needs of an indoor motor system. KISS allows the children to play on a rainy day without resorting to bringing outdoor toys into the playroom. Finally, she looks forward to encouraging her teachers to use it for all age levels, but recognizes that it will most like benefit the one- and two-year-old groups in daycare. The one-year-old group finds exploration of the individual surfaces to be the most entertaining, while the two-year-old group enjoys stretching from surface to surface to compare the different tactile sensations.

Fig. 12.11. Kids' Interactive Sensory System in one Possible Configuration.

Fig. 12.12. Kids' Interactive Sensory System in another Possible Configuration.

TECHNICAL DESCRIPTION

Galvanized steel wall anchors (molly bolts) are inserted into each of the four corners of one side of each of the seven Snap Wall® pieces. Round edged plywood backing, 22" x 22" x 0.5", was stained with a waterproof polyurethane coating to add durability. After aligning the backing with the plastic pieces, holes were drilled and countersunk to fit flathead screws. Textile pieces attach to the plywood with a combination of staples, adhesive caulk, and epoxy to ensure sturdy adherence and allow for simple replacement or touch-up. The plywood is backed with a no-slip stair grip to minimize motion of the pieces when laid flat on the floor, the most likely configuration, as shown in Fig. 12.13.

Each of the seven panels have a different textile attached to them: 1) panel 1 is a cotton pillowcase that has been quilted, and several of the sections have rice sewn into them to provide contrasting textures within the panel; 2) panel 2 is pieces of various patterned felt covering a soft foam layer; 3) panel 3 is the reverse side of a rubber bathmat with suction cups; 4) panel 4 is a clear plastic bathmat with raised circular nodules; 5) panel 5 is a faux leather material covering a soft foam layer; 6) panel 6 is the top side of a rubber bathmat with soft rubbery extensions; and 7) panel 7 is a doormat with stiff plastic extensions. The system can be assembled as: 1) a mat on the floor; 2) a cube; and 3) a vertical wall.

The total cost of parts and materials was about $720.

Fig. 12.13. Different Textiles and Bright Colors Appeal to Children.

BULL-RIDING TRUNK TRAINER

Designers: Anna Brahm, Nicole Lehrer, Amy Levelle, and Justin Lipner
Client Coordinators: Holly Cohen, MPT and Lauren Best Shapiro, LOTR
Supervising Professor: David A. Rice
Department of Biomedical Engineering
Tulane University,
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INTRODUCTION

A nine-year-old boy with cerebral palsy has weak trunk tone, making it difficult for him to maintain his upper body in an upright position. The hypertonicity of the client's legs causes adduction, which leads to scissoring of his legs while walking. The device developed in response to this problem is a trunk tone trainer. The trainer simulates the movements of a mechanical bull. With the control of a supervising adult, the device moves the user around in an unpredictable way. The weight and imbalance of the user is the source of the system's movement. The "bull" swings back and forth and side to side. This forces the user to adjust his trunk position and utilize his balance to avoid falling. His legs are abducted throughout the riding session. The bull is narrow enough for the user to straddle but wide enough for him to stretch his legs apart. It has appropriate padding and a pommel in the front for him to grip. This system provides a fun and useful way for the client to get the exercise and muscle development that he needs.

SUMMARY OF IMPACT

The bull provides a fun means of social interaction among the client, friends, and family. He readily interacts with other individuals to demonstrate the bull. Straddling the bull has become easier for him over the short period of time it has been installed in the home. Most importantly, it provides a convenient way for the client to stretch and engage in exercises from the convenience of his home, as opposed to isolating his physical therapy to the therapy center, or in the presence of a physical therapist. The client's parents may increase the challenge of his riding as they deem appropriate.

TECHNICAL DESCRIPTION

The two major components of the trainer are the frame and the bull. The timber frame is 10 feet long, six feet wide, and eight feet high. The bull is a padded 12" PVC pipe suspended by four ropes. The ropes attach to the pipe at four points. These ropes run through pulleys and attach to the bottom of the frame. The frame, ropes, and bull form a four-bar mechanism that ensures a rolling motion while the bull moves. This forces the client to grip and engage his trunk muscles to remain mounted. The ropes are pulled manually to simulate the movement of the mechanical bull. The bull is narrow enough for the client to straddle but wide enough for him to stretch his legs apart. The bull is equipped with straps that hold him securely to the saddle but still allow independent trunk movement. The saddle also has handlebars for further grip points. A 6" deep pit of garden mulch lines the ground below the bull to offer padding in the case of a fall. Also, the posts are padded to eliminate hard surfaces.

Fig. 12.14. View of "Bull" and Enclosure.

The cost of the device was approximately $460.

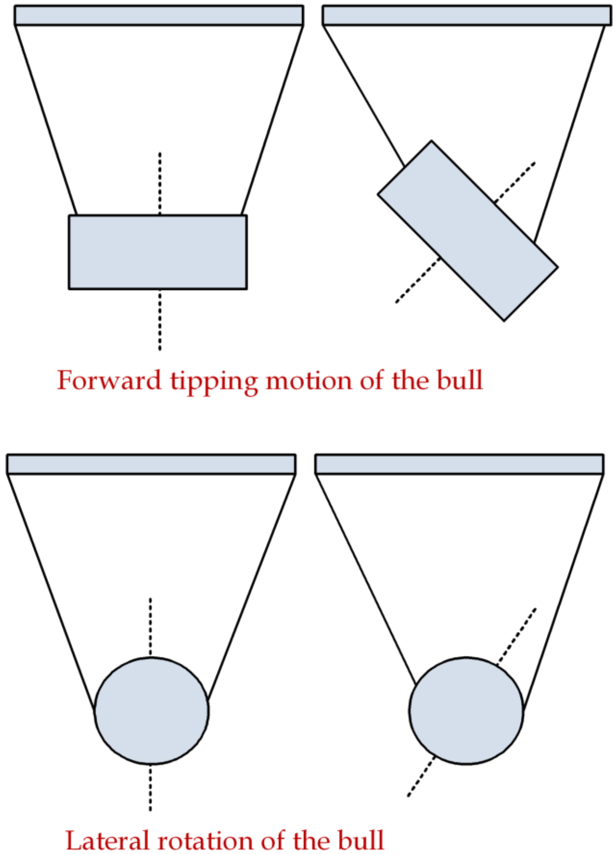

Fig. 12.15. Forward Tipping of Bull Exercises Lower Back Muscles and Lateral and Medial Abdominal Muscles; Lateral Rotation Exercises External and Internal Obliques.

SCHOOL DESK WITH MOTORIZED SLANTBOARD

Designers: Samy Abdelghani, Justin Cooper, Elizabeth Doughty, Grace Ledet
Client Coordinator: Valerie Faneca, LOTR, Jefferson Parish School District, LA
Supervising Professor: David A. Rice
Department of Biomedical Engineering
Tulane University,
New Orleans, LA 70118

INTRODUCTION

A school desk (see Fig. 12.16) was constructed for a kindergartener with arthrogryposis. The student lacks use of her arms, uses a mouthstick and wheelchair, and requires the use of adaptations and assistive technology to participate in academic and motor activities.

The main body of the desk is made of wood and features a motorized slantboard with a magnetic surface that allows the client to completely control its angle. The slantboard is controlled with two buttons that are located on the desktop. The desk also features height adjustable legs with locking caster wheels that allow it to be mobile. The slantboard is battery-powered to eliminate the necessity for any connection to an external power supply. The slantboard allows papers to be held with magnets; and has a ledge at its base that prevents any books placed on the surface from falling when the slantboard is tilted. In addition to its novel features, the desk has all the amenities of a normal school desk. It has a large, flat workspace for schoolwork and two storage units for school supplies. Rubber edging has been added around the edge of the desk and slantboard to eliminate any sharp edges that could prove unsafe in a classroom. The desk is similar in appearance to other desks used by the class.

SUMMARY OF IMPACT

This desk promotes successful integration within the classroom setting, adjustability to growth, ease of movement and access in the educational environment. The design meets all of the specifications discussed in the planning process.

TECHNICAL DESCRIPTION

The desk has three major parts: 1) the frame; 2) the legs; and 3) the slantboard. The frame of the desk was made from wood constructed using biscuit joints and wood glue. The legs were made from telescoping aluminum tubes that lock in place, making the desk height adjustable, without sacrificing strength. Locking caster wheels were attached to the bottoms of the legs. The legs were then attached to the desk using metal brackets that were covered with decorative wooden housings. The slantboard was made from half-inch plywood with a steel surface. This allows for a stable writing surface that is easy to clean and magnet-friendly.

The slantboard was attached to the frame of the desk using piano hinges. It was also attached to a linear actuator that allows it to be controlled by the pushbuttons. The actuator was connected to the frame of the desk and the slantboard with two pin hinges. The linear actuator has a 6” stroke to lift the hinged slantboard. The actuator is powered with two 6-volt batteries and draws at most 4 amps. The actuator can lift with a force of 110-lbs and can hold a load of 550 lbs in static equilibrium. Two momentary SPDT switches are used in conjunction with two 4PDT relays to switch the polarity of the voltage applied to the motor. Pushing one of the switches causes the actuator to extend and raise the slantboard; the other switch lowers the slantboard.

Lockout logic is applied to cancel the action of the motor and prevent the battery from short circuiting in the event the user presses both switches simultaneously. Additionally, the slantboard has a key switch with a removable key that prevents the slantboard from being used without the key in place. This feature allows teachers and aids the ability to monitor the use of the desk and prevent other students from misusing the slantboard. The linear actuator has internal limiting switches that stop the linear actuator at its maximum and minimum heights.

The desk is lightweight, mobile and strong. It can be easily pushed by one person and can hold the weight of a grown student. All surfaces of the desk have been stained and sealed so that it matches the desks that are currently used in the classroom. The size of the desk is about the same as two average school desks side by side. This allows the desk to be arranged easily by others.

The final cost of the desk was approximately $500.

Fig. 12.16. Front and Side Views of Desk.

MOTORIZED GLIDING CHAIR

Designers: Cameron Charbonnet, Rachael Dula, Dave Siet, and Preston Smith
Client Coordinator: Carrie Cassimere, MSW, The Chartwell Center, New Orleans, LA
Supervising Professor: David A. Rice
Department of Biomedical Engineering
Tulane University
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INTRODUCTION

Many children with autism have difficulty regulating their activity level and emotional state. A device was needed for calming autistic children in an elementary school classroom. The children misbehave at times and have problems settling down and maintaining focus. This in turn becomes a disruption for the entire classroom. A motorized gliding chair was requested to provide a calming device to be used without disrupting other members of the classroom (see Fig. 12.17 and Fig. 12.18). The goals for the chair were to: 1) provide even, natural motion; 2) run smoothly when propelled; 3) swing at its natural frequency; and 4) be aesthetically pleasing to the children.

SUMMARY OF IMPACT

The specialized chair tested well with the students. The repetitive movement, which can either be controlled automatically or manually, is useful in promoting an appropriate motion magnitude. The chair seems nonthreatening to the students. The instructors use the chair to help the classroom run more smoothly and without disruption and to help the students learn self-regulation.

TECHNICAL DESCRIPTION

The chair's motion is particularly important because the child needs to feel pressure at the forward and backward apex of the glide. The selected chair had joints that provided the desired motion. To drive the chair, a 1/17 horsepower gearmotor was selected after tests with a stronger 1/8 horsepower motor. The stronger motor did not produce fluid motion when forces like those a child produces were applied. The stronger motor also made more noise, which could create a distraction in the classroom setting.

An eccentric 5 lb weight with a 6" offset attaches to the motor. This provides the driving force. The approach requires that the frequency of the motor's rotation match the frequency of the chair's natural gliding motion. This is accomplished by running the motor with a variable DC controller that can slow down the speed to around 1.1-Hz. This method provides a safer mode of driving force and easier maintenance and repair than the other alternatives considered. This method also reacts well to disturbances during rocking. The housing of the chair itself provides a natural barrier so that children will not be exposed to the motor or weight. The ottoman, also fitted for gliding, needed rigid but adjustable attachment to the chair. It was decided that this was the safest strategy for movement while also providing consistent and smooth motion.

Fig. 12.17. Motorized Gliding Chair.

The teachers designated a specific isolated area for the chair to be placed. After safety testing and implementation, the chair became available to students who are over-stimulated and it did not cause a distraction to others in the classroom.

Total cost of the chair was approximately $500.

Fig. 12.18. Chair Demo and Motor Control Switch.

CUSTOM WORKSTATION

Designers: Stephanie Fiebrink, David Lipps, David Simon, and David Welch
Client Coordinators: Ronald Anderson, PhD and Darryl Overby, PhD
Supervising Professor: David A. Rice
Department of Biomedical Engineering
Tulane University,
New Orleans, LA 70118

INTRODUCTION

A custom workstation was designed for a woman who has polio. She has only limited use of her left arm and uses a wheelchair. It is difficult for her to use a regular desk because she is limited in her ability to reach and regular desks do not accommodate to the shape of her powerchair. She needed a workstation so that she can be self-sufficient. She requested: 1) support for a keyboard and mouse accessible from her chair; 2) tissue storage at a reachable location; 3) file storage accessible from the top of the desk; 4) a place for her respirator and hose; 5) storage space; and6) other accessible organization units.

SUMMARY OF IMPACT

This project improved the client's work life. She no longer has to rely on her business partner to do simple things for her, from getting her a tissue to getting her files. She now has easy access to a keyboard and mouse as well as her files. She is able to store ordinary desk items such as pens and a checkbook, accessing them as necessary.

TECHNICAL DESCRIPTION

This workstation (see Fig. 12.19) is composed of three units, arranged in an L-shape. The first unit, the main portion of the workstation, is at an appropriate height for the client to fit her wheelchair under the desk. There is a cutout in the left corner for her wheelchair joystick to maneuver under the front of the desk. The second and third pieces are located to the left of the first unit. A shelf is located under each of these pieces, one specifically for the client's respirator. There are nylon clips attached to the side of the unit to keep the hose in place. Both the second and third pieces also contain a section of the top that slides back to expose hanging file storage. On top of each sliding piece is an organizer tray with removable dividers. All three pieces are equipped with adjustable feet to customize the height of each piece according to the client's desires.

The total cost of this project was $338.

Fig. 12.19. Custom-Built Workstation.

PUTT-PUTT PUTTER

Designers: Brandy Alvarez, Bryan Bell, and Selma Hokenek
Client Coordinator: Erich Sollenberger, BSW, MED, Grace King High School, Metairie, LA
Supervising Professor: David A. Rice
Department of Biomedical Engineering
Tulane University,
New Orleans, LA 70118

INTRODUCTION

An instructor at a local high school coordinated the construction of a special putt-putt course designed to be used by students who have disabilities and use wheelchairs. He requested that a putter be designed and constructed to enable the students of the high school to putt a ball at the push of a button. With the device, the students can aim the ball with the aid of pushbutton controlled laser attachments, and can putt the ball with another pushbutton. Alternate jacks allow for other control mechanisms to be used, such as sip-and-puff switches. The device is designed to rewind automatically after a putt, so no adjustment or further control is needed after a swing. With this device, a wheelchair user can play a round of putt-putt golf on the course with as little assistance as possible.

SUMMARY OF IMPACT

The putter was designed to provide students with a reliable mechanism with which they could play alongside their peers. A critical design point was to have the putter system itself swing, rather than to depend on wheelchair motion to strike the ball. With this device, the students can play a round of putt-putt with minimal assistance on the specialized course.

Fig. 12.20. Side View of Putter.

TECHNICAL DESCRIPTION

The putter system consists of two main pieces: the backboard and the cross bar (see Fig. 12.20). All moving parts are attached to the backboard. The putter is made of fiberglass and the shaft has been bored to allow for a ¼” shoulder screw to securely attach it to the board. This connection allows the putter to freely pivot during the swing. A second hole was bored in the shaft to allow an aircraft cable to pass through. A catch on the aircraft cable moves the putter when the cable is wound up by motor. Springs keep the aircraft cable taut at all times. As the putter is moved into a ready state, a catch system locks the putter in place. The cable is then automatically unwound to its initial state to allow for the putter to freely swing. The catch system is released by activating a solenoid attached to the catch. All moving parts are housed in a wooden frame with clear acrylic cover.

The cross bar rests on the arms of the wheelchair secured by adjustable straps. The control system and battery are located on the cross bar and are housed in respective project boxes. The battery weight balances the putter mechanism on the wheelchair. The control system consists of a master key switch for security, on or off switch with activation LED for putter power (see Fig. 12.21). A momentary contact pushbutton activates the lasers.

Two crossed lasers are used so that the proper elevation of the putter can be readily established when it is mounted onto a wheelchair. The lasers also provide a marker for aligning the putter relative to the ball. The push of the "fire" button initiates the swing as well as an automatic rewind and clock of the putter. A dashpot snubber slows the putter at the end of its stroke. Positioning the putter so that it hits the ball during this deceleration phase enables the player to control the strength of the putt.

The laser and fire controls are equipped with attachments for other control mechanisms, such as sip-and-puff or pedal switches. The system is composed of three relays, a 12-V battery with charger, and 5A fuse for protection.

The cost of the putter system was about $300.

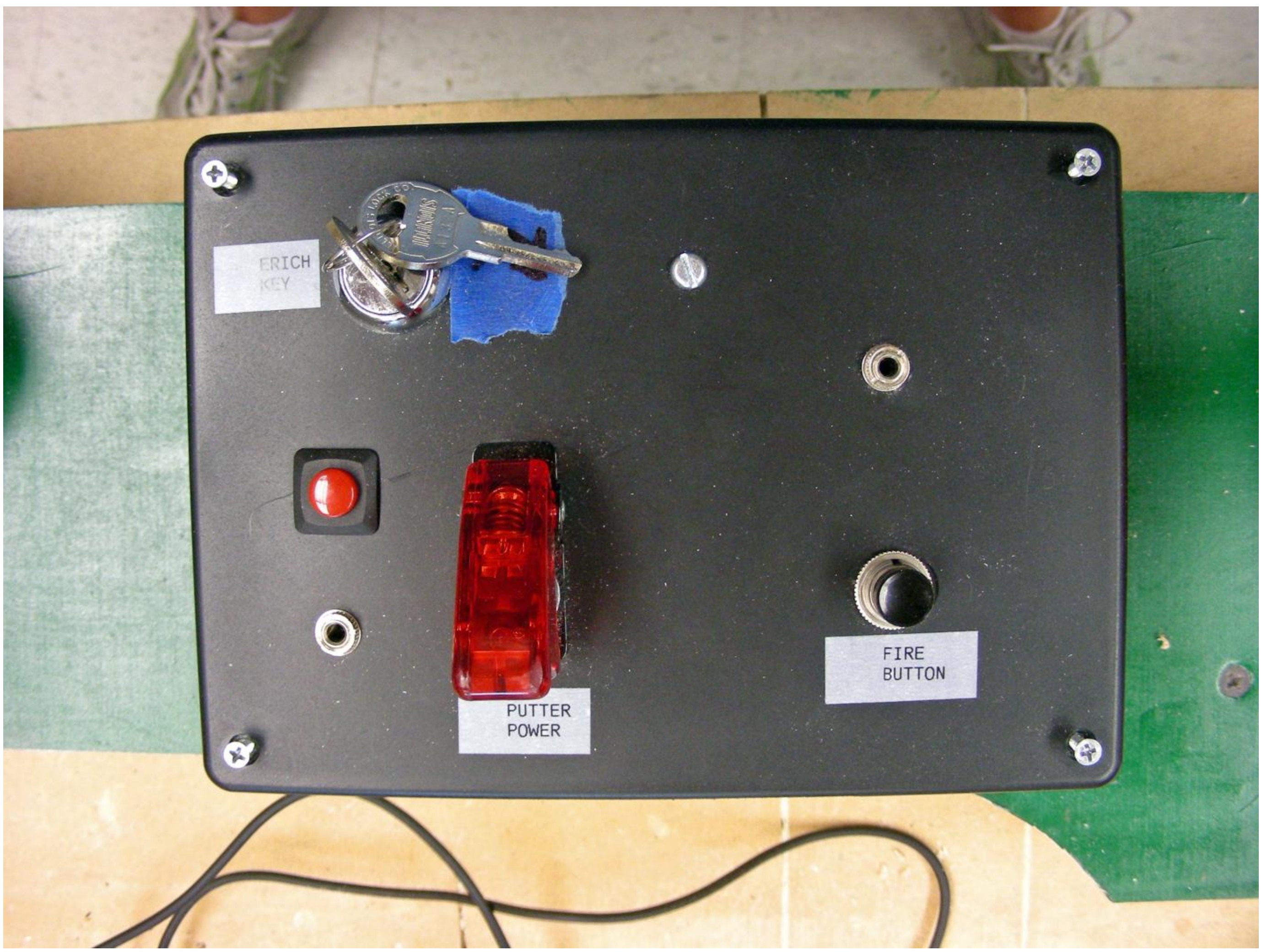

Fig. 12.21. Control Panel.

CHAPTER 13
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TEST FIXTURES FOR BIOMECHANICAL ASSESSMENT OF MURINE TIBIAE AT EARLY STAGES OF DISTRACTION OSTEOGENESIS

Designers: Meredith Reid, Andrea Rossillon, and Sarah Shadix
Client Coordinators: Shawn Gilbert, MD, Division of Orthopedic Surgery; Alan Eberhardt, PhD, Department of Biomedical Engineering
Supervising Professor: Alan Eberhardt, Department of Biomedical Engineering
University of Alabama at Birmingham, Birmingham, AL 35294

INTRODUCTION

Distraction osteogenesis (DO) is the process of fracturing a bone (osteotomy), allowing the fracture to begin to heal (latency phase), and distracting the bone with an external fixator at a set rate over a period of days or weeks (distraction). Finally, the newly-formed callus is allowed to mineralize (consolidation). DO is used to correct deformities or malformations that result from injury or disease.

Current research suggests that the development of hypoxia, specifically the elevation of hypoxia inducible factor-1α (HIF-1α) in cells, is a key feature of the angiogenic response during fracture healing. A researcher aims to investigate the effects of pharmacological activation of the HIF-1α pathway on bone healing when the Von Hippel-Lindau (VHL) complex is deleted in mice.

In order to assess the mechanical and structural properties of healing DO bones, a protocol for biomechanical assessment of murine tibiae was needed. The goal was to design appropriate fixtures for tensile and four-point bend testing of DO murine tibiae. The design constraints included the size of murine bones (15-20 mm length, two to three mm diameter, three mm callus) and the loading

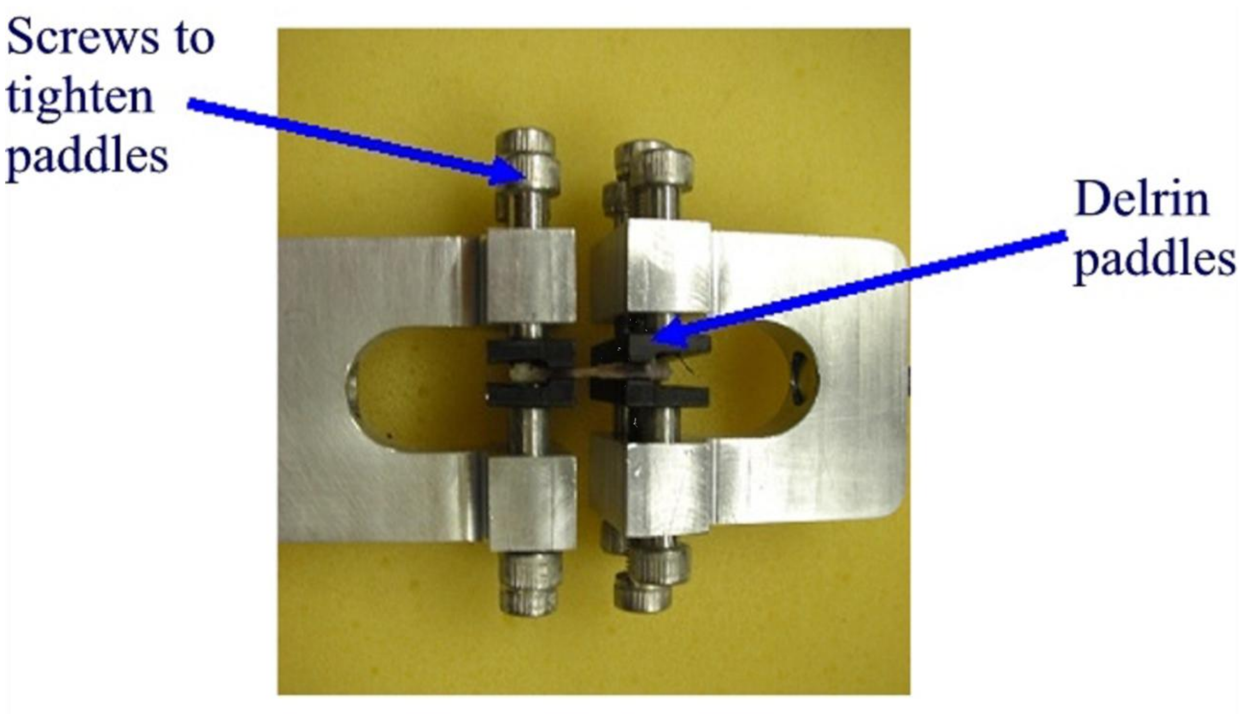

Fig. 13.1. Tensile Test Fixtures Holding a Murine Tibia.

capabilities of a Bose Testbench system (20 N maximum load, 80-100 g. maximum fixture weight). Also, a graphical user interface (GUI) and the appropriate data analysis techniques were needed to provide a convenient means for outputting structural and mechanical properties of the healing callus.

SUMMARY OF IMPACT

The completed fixtures will provide the means for testing mouse bones subject to distraction osteogenesis. The results of the effort will help researchers understand the pharmacological manipulation of the HIF-1α pathway, which is central to hypoxic response and neovascularization. The aim of the work is to improve bone healing in mice that have undergone distraction osteogenesis-a first step towards improving bone healing in children undergoing DO to correct deformations and malformations of the lower extremities.

TECHNICAL DESCRIPTION

The test fixtures were machined from 6061-T6 Aluminum. The tensile test fixtures contain adjustable paddles (see Fig. 13.1) that allow gripping of the tibia away from the healing callus along the diaphyseal region of the bone. The weight of each tensile grip is approximately 68 g. The four point bend test fixtures contain loading noses that are adjustable, both top and bottom, with an engraved scale (in mm) for span measurement (see Fig. 13.2). The entire four-point bend apparatus weighs 80 g. The GUI, programmed in MATLAB, allows the user to select a test method and structural properties are calculated directly from the imported load vs. displacement data. The material's properties (E, σ_{yield}, σ_{ult}) are calculated once the user enters additional information related to specimen geometry. The user also has the option of plotting load vs. displacement or stress vs. strain. All properties and the plots are displayed in the main GUI window.

The cost of materials and machining was $1500.

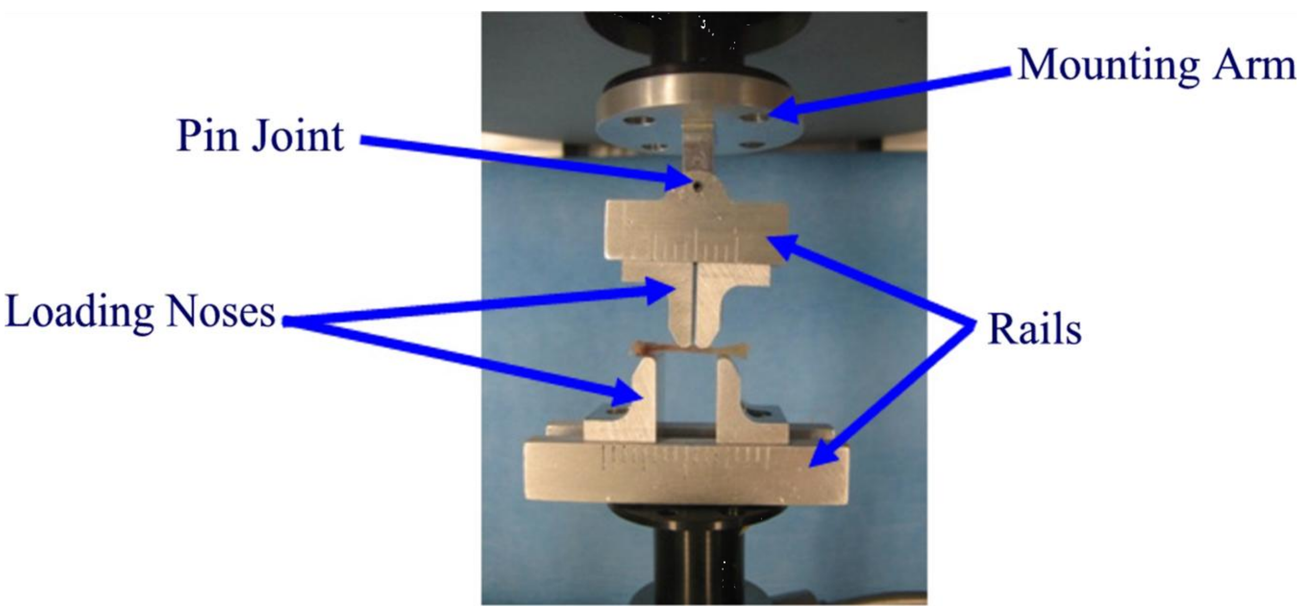

Fig. 13.2. Four-Point Bend Test Fixtures Supporting a Murine Tibia.

PERSONAL LIFTING PEDESTAL

Designers: Megan Chamlee, Rakesh Lala, and Saso Klesnik
Client Coordinators: Mr. Harlan Dutton; Alan Eberhardt, PhD, Department of Biomedical Engineering
Supervising Professor: Alan Eberhardt, Department of Biomedical Engineering
University of Alabama at Birmingham, Birmingham, AL 35294

INTRODUCTION

There are currently over one million people with amputations in the United States and approximately 133,000 hospital amputation discharges every year. Currently there are no devices specifically designed to assist people with lower-limb, above-the-knee amputations safely reach standing heights. The only similar devices currently on the market are wheelchairs that allow the user to stand. These designs, however, are not conducive to people with lower limb amputations because they require the presence of lower limbs for support.

The goal was to design a user-controlled Personal Lifting Pedestal (PLP) for the lower limb of an average-sized male (160-lb) with an above-the-knee amputation. The average male's sitting eye height is 48.5" and the average male's standing eye height is 67". Thus, the device would raise the user from a sitting position to a standing height of 5' 7" - a required rise of 15.9". Other design parameters for the PLP consisted of: 1) ease of entry/exit; 2) user friendly controls; 3) safety; and 4) stability.

SUMMARY OF IMPACT

Following amputation, many individuals seek ways by which they can regain independence in performing their daily tasks and activities. Research has shown that the ability to elevate to a standing height can have psychological, physiological, and social advantages for the amputee. The present design represents phase one of a two-phase project to develop a motorized PLP, which will permit the user to move throughout a room and raise and lower himself or herself to perform various tasks that require the user to reach standing heights, such as placing books on upper shelves, for use in a work environment.

TECHNICAL DESCRIPTION

The frame was designed out of carbon steel due to its impact resistance, strength-to-weight advantage, and weldability. The dimensions of the frame are 30"x26"x30". The frame consists of two 26" hollow bars and two 30" hollow bars along the top and bottom, each two inches by one inch in cross section. The side bars are four telescoping hollow rods (outer diameter of one inch). The frame is open in front which allows for easy entry into the PLP. The frame was painted to make it corrosion resistant. Two DL4 Desklift Actuators (Linak) are used as the lifting mechanism for the PLP. These actuators were selected because they had telescoping casings that resist bending and because they offered the appropriate stroke length and thrust. The actuators are controlled simultaneously using a remote with a memory function and height display. A DeltaTM II Bosun Chair Harness (Western Safety) was chosen for the hanging seat since it had a seat board that provides built-in suspension support and a harness for restraint.

The user climbs into the chair and fastens himself or herself in using the harness when the pedestal is in the lowest position (see Fig. 13.3, left). Using push button controls, the user actuates the system to rise to a standing height (see Fig. 13.3, right). Preliminary calculations were performed to ensure the stability of the PLP. The completed device was tested in various positions using a 160-lb male and the device was determined to be safe and functional.

The cost of materials and machining was about $1316.

Fig. 13.3. Personal Lift Pedestal for People with Lower Limb Amputations.

CYCLE ASSIST: JAVIER MODEL 1.0

Designers: Nick Cutchens, Ross Lumsden, and Soli Zadeh
Client Coordinators: Mr. Javier Flores; Brian Mueller, UAB HSF Ortho/Pros. Division
Supervising Professor: Alan Eberhardt, Department of Biomedical Engineering
University of Alabama at Birmingham, Birmingham, AL 35294

INTRODUCTION

The objective of this project was to redesign a hand-to-handlebar attachment device. A male client had a below-elbow amputation; he lost his left hand and forearm in a work-related accident. His right hand has a remaining index finger and thumb. He is an avid cyclist and was having problems with his prosthetic hand (Otto Bock®). The hand was constructed to be closed in its normal state, with a pull-cord that opens the hand. A strap system connected to the pull-cord goes around his back; when he flexes his shoulders, the hand opens. The back strap was found to be a problem for the client because it restricts his range of motion while on his bicycle. Also, the hand was found to disengage from the handlebars during strenuous activities, such as biking up a steep hill. The hand was tested using a spring scale and showed release with pull-off forces greater than 30 lb.

Design goals were to develop a lightweight device that enables the client to grip his handlebar with his prosthetic arm, allows for comfortable riding positions, and operates reliably with an automatic emergency release and without unintentional disengagement. It was also necessary to eliminate the back strap and to create a device that would withstand at least 50 lb of rider-applied tensile forces, which was the reported strength of the threaded forearm attachment.

Fig. 13.4. Revised Otto Bock® Hand, Containing Extended Thumb.

SUMMARY OF IMPACT

Prior to his accident, the client was an extremely active person, competing in triathlons and working part-time as a personal trainer. He wanted to regain his ability to ride a bicycle without restrictions. The present design will provide the client with greater freedom to take longer bike rides without pain from the original back strap. The emergency release system will ensure that, in the event of an accident, he does not remain attached to his bike, causing serious injuries.

TECHNICAL DESCRIPTION

Three design solutions were initially formulated: 1) variations on ball-in-socket attachments; 2) a gear-driven clamping device; 3) modification of the client's existing prosthetic setup. Upon evaluation of the pros and cons associated with each design, it was decided to modify the existing Otto Bock® hand setup. To address the pull off issue, the thumb of the hand was lengthened and shifted laterally so the thumb would fit between the two fingers of the hand (see Fig. 13.4). Upon testing, the extended thumb resisted pull-off by applied forces over 50-lb.

An emergency release mechanism was designed and constructed of 6061-T6 aluminum. It employed a threaded connector, which contained a pin guide that ensured the pin would disengage the connector when the emergency release cord was pulled (see Fig. 13.5, left), at the base of the modified hand. The pull-cord extends from the pin release across the handlebars and loops over the rider's good thumb (see Fig. 13.5, right). In the event that the rider is thrown from the bike, the pull-cord would automatically disengage the threaded connector, releasing the rider's prosthetic forearm from the hand, which would remain attached to the bike.

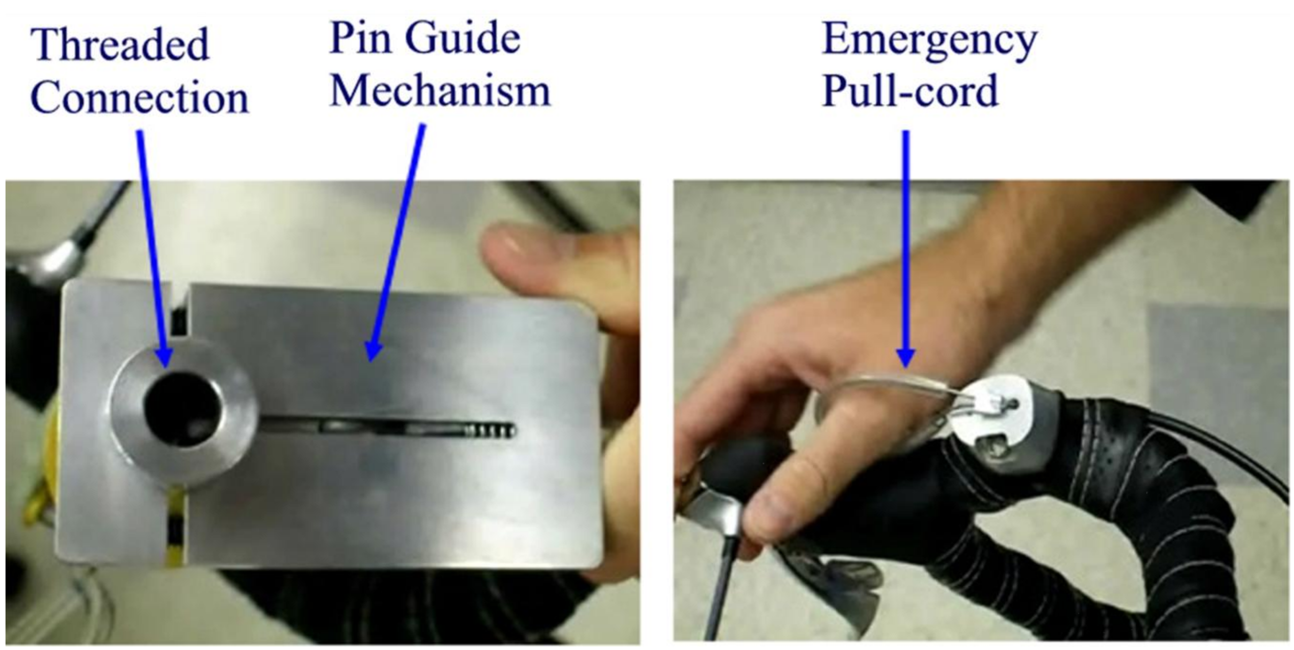

Fig. 13.5. Emergency Release Mechanism Including Pin Guide (left) and Emergency Pull-Cord (right).

CHAPTER 14
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FREELY ACCESSIBLE AND ADJUSTABLE KEYBOARD WITH MOUSE PAD

Designers: Stephen Heussler and Nolan Skop
Client Coordinator: Miriam Kurland, Hampton Elementary School
Supervising Professor: Dr. John Enderle
Biomedical Engineering Department
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INTRODUCTION

The Freely Adjustable and Accessible Keyboard and Mouse Pad was designed for an elementary school student with cerebral palsy who lacks fine motor control and is unable to use a standard keyboard and mouse. The main goals of the device were to increase the client's ease, speed, and accuracy of typing. The device (Fig. 14.1) contains fewer keys than an average keyboard, which allows more space between the keys and improved typing accuracy for the client. The keys are also more durable than those of a typical keyboard. The keyboard rises to a greater angle than a standard keyboard. Seven buttons on the keyboard replace a standard mouse. A USB port provides easy transport of the device between computers.

SUMMARY OF IMPACT

This device helps people who lack fine motor control to use a computer with less difficulty. The placement and spacing of the keys make it easier to select the right key. The mouse pad incorporated into the keyboard improves navigation of the computer.

TECHNICAL DESCRIPTION

Cherry MX switches were used for the keys to lengthen the life of the keys and increase durability. All of the switches and electrical components are mounted on a printed circuit board and the signals are wired to a control board (Fig. 14.2 and 14.3). The control board interprets the signals from the

Fig. 14.1. Top View of Keyboard

switches and sends the signals to the CPU through a USB connection.

LEDs were placed behind the mouse pad to provide backlighting. The power for the LEDs comes from the computer through the USB connection. A switch is on the front of the device that turns the LEDs on and off. Diodes were placed after each switch to eliminate ghosting. The final dimensions of the casing are 15.7" by 6.5". To prevent sliding, rubber sheeting was placed on the base.

The cost of the parts and materials was about $600.

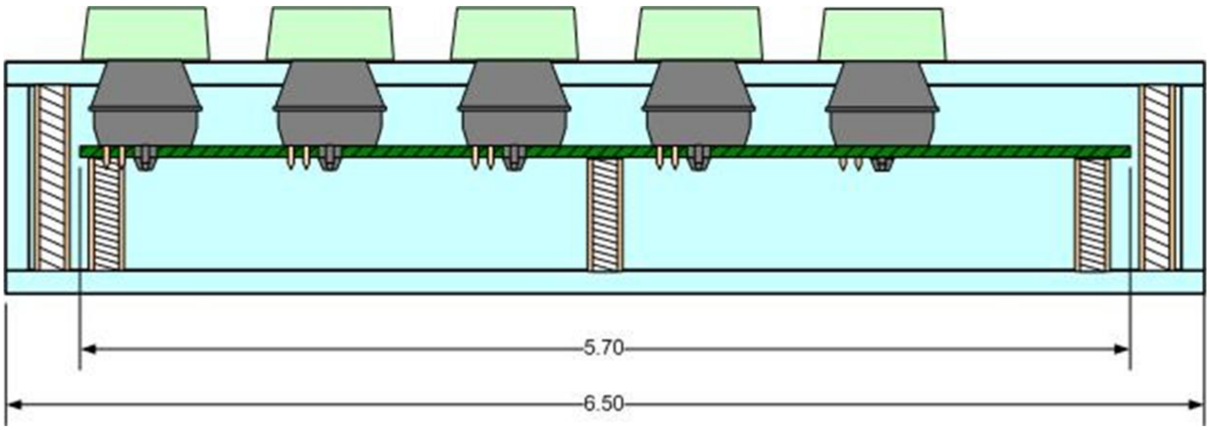

Fig. 14.2. Cross-Section of Keyboard.

Fig. 14.3. Internal View of Keyboard.

ASSISTIVE ROBOTIC ARM

Designers: Asma Ali, Megan G. Madariaga, and Danielle C. Mcgeary
Client Coordinator: Merriam Kurland, Hampton Elementary School, Hampton, CT
Supervising Professor: Dr. John D. Enderle
Department of Biomedical Engineering
University of Connecticut
Storrs, CT 06269

INTRODUCTION

The intent of this design was to create an artificial robotic arm to help an elementary school student with quadriplegic athetoid cerebral palsy to eat independently. The arm allows the client to eat lunch with his peers without the constant supervision from an aid.

SUMMARY OF IMPACT

The device provides the student, who has impaired fine motor skills, a way to eat independently. The device also provides a grip mechanism resembling the human hand. The device also closely resembles the movements of the human arm by providing a full range of motion about the x, y, and z axes.

TECHNICAL DESCRIPTION

The Assistive Robotic Arm (Fig. 14.4 and 14.5) consists of the following subunits: 1) a base; 2) upper arm; 3) lower arm; 4) wrist; 5) gripping device; 6) motors; 7) batteries; and 8) circuitry. The base houses a motor and a rotating plate, which rotate the entire device. To ensure safety, the base has a mechanical constraint that only allows for 120 degrees of rotation. The base securely mounts to the client's chair via strong clamps.

The upper arm attaches to the base. An elbow joint connects the upper arm and the lower arm. The elbow joint can move from zero to 90 degrees vertically. The 90-degree limit prevents the device from over-rotating and harming the client.

The upper and lower arms are connected by a pulley system. When in motion, the lower arm follows the motion of the shoulder joint and stays parallel to the ground. The shoulder joint rotates via a motor located at the connection of the shoulder to the base. The motor inserts through the base connection by an aluminum shaft. This shaft also connects to the pulley system. On the shaft is a long rod that limits the rotation of the entire base.

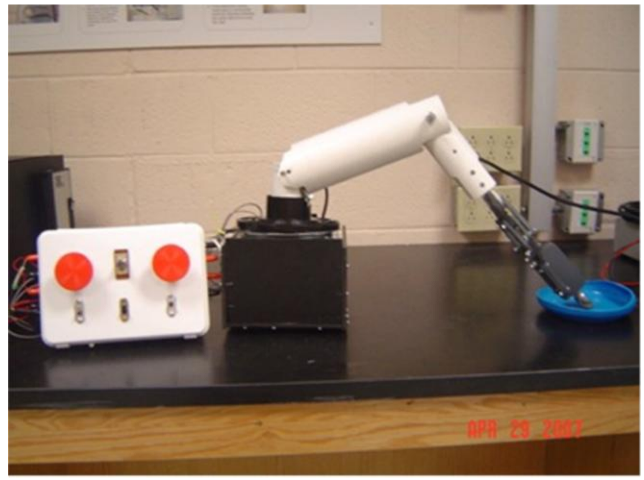

Fig. 14.4. Assistive Robotic Arm.

When both of the vertical joints are extended to 120 and 90 degrees simultaneously, a maximum extension of 25" is added to the client's reach.

The lower arm is connected to the grippers by a wrist joint. The motion of the gripping device is controlled by two gears. One of the gears is rotated via a motor.

The grippers are designed to hold a metal spoon bent at a 30 degree angle. A specialized soup spoon is the only spoon that can be attached. Slits in the grippers that fit the handle of the spoon ensure safety.

The device is controlled by a keypad. The keypad consists of six switches that are durable and simple to use. The client can orient the device to a desired position by operating the keypad. The keypad is responsible for turning on and off the voltage source from the batteries. The keypad is also responsible for controlling bidirectional movement of the arm by reversing the voltage.

The cost of the parts and materials was about $650.

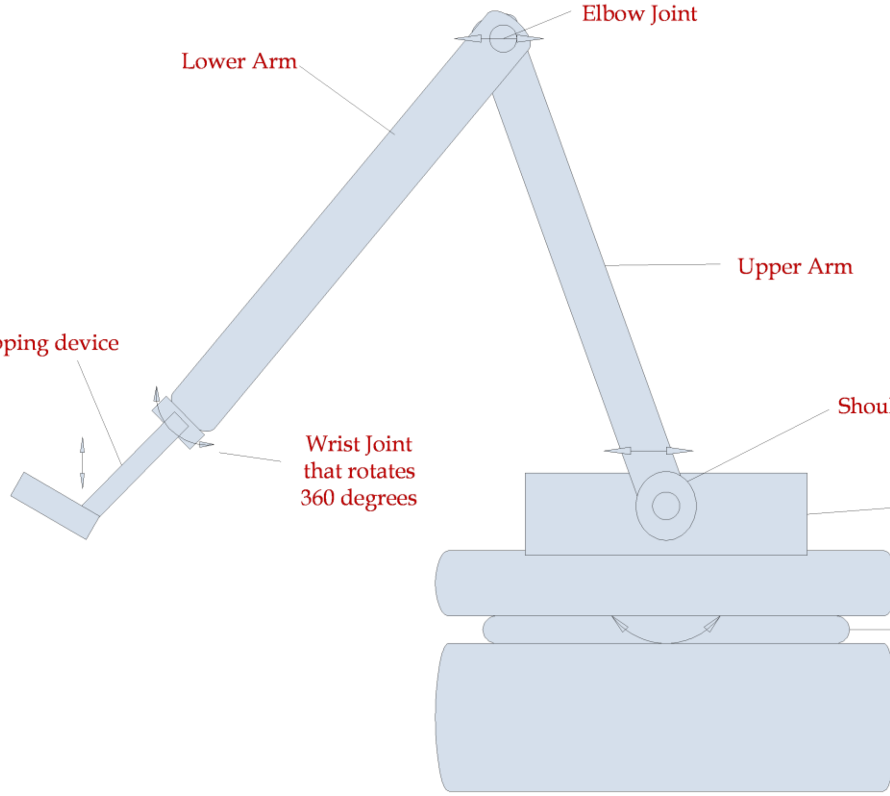

Fig. 14.5. Drawing of Arm.

HEAD AND ARM MOUNTED ART DESIGN SYSTEMS

Designers: Rebecca Lussier, Sirisha Muppidi and Nemi Kotadiya
Client Coordinator: Dr. Brooke Hallowell, Ohio University, Athens, OH
Supervising Professor: Dr. John Enderle
Biomedical Engineering Department
University of Connecticut
Storrs, CT 06269

INTRODUCTION

The Head and Arm Mounted Art Design Systems were designed for an individual to help create works of art in an art studio for people with developmental disabilities. The client has limited motor skills due to cerebral palsy and hydrocephaly. The devices are rotating cables that turn a compass that fits multiple sizes of art utensils, including pencils, crayons, markers, and paint brushes. The devices are attached either to the head or arm of the user (see Fig. 14.6 and Fig. 14.7). The systems are turned on or off by sensing purposeful blinks provided by the artist using an eye-blink controller circuit. The Head and Arm Mounted Art Design Systems allow users to draw and paint independently.

Fig. 14.6. Head Mounted Art Design System.

Fig. 14.7. Arm Mounted Art Design System.

SUMMARY OF IMPACT

The devices allow the client to draw without assistance and independently to turn the devices on and off. The adjustable design of the systems makes it possible for other artists at the studio to use the devices as well.

TECHNICAL DESCRIPTION

The main subassemblies of the Head and Arm Mounted Art Design Systems were fabricated from a rotating speedometer cable within a flexible, yet rigid, gooseneck tube. The rotating cable rotates an adjustable compass piece in order to fit multiple sizes of media. The use of aluminum for the intermediate pieces makes the devices light enough to wear.

The rotating motion of the compass on both systems is provided by a 12-volt DC reversible motor. The motor has high enough torque power to rotate anything attached at the compass end. A reversible feature is incorporated in the design of the motor and the controlling button so that the user can increase the number of his or her designs. The motor is run by rechargeable AA batteries and requires minimal wiring.

The devices use an infrared eye-blink switch. If the user purposefully blinks for a second, the circuit processes the signal and then powers the motor on (Fig. 14.8). Conversely, if the user blinks for another second, the system powers off. The infrared sensor and receiver use safe levels of infrared. The sensor is mounted to a pair of eyeglasses worn by the user while the devices are in operation. Soft switches are included in the circuit to ensure safety and so the user can control the direction of the motor. The switches are foam and fabric covered DPDT switches and use large internal plates to facilitate actuation. An overriding switch was placed in both systems so that caretakers can turn the systems on or off as well.

The cost of the parts and materials was about $1200.

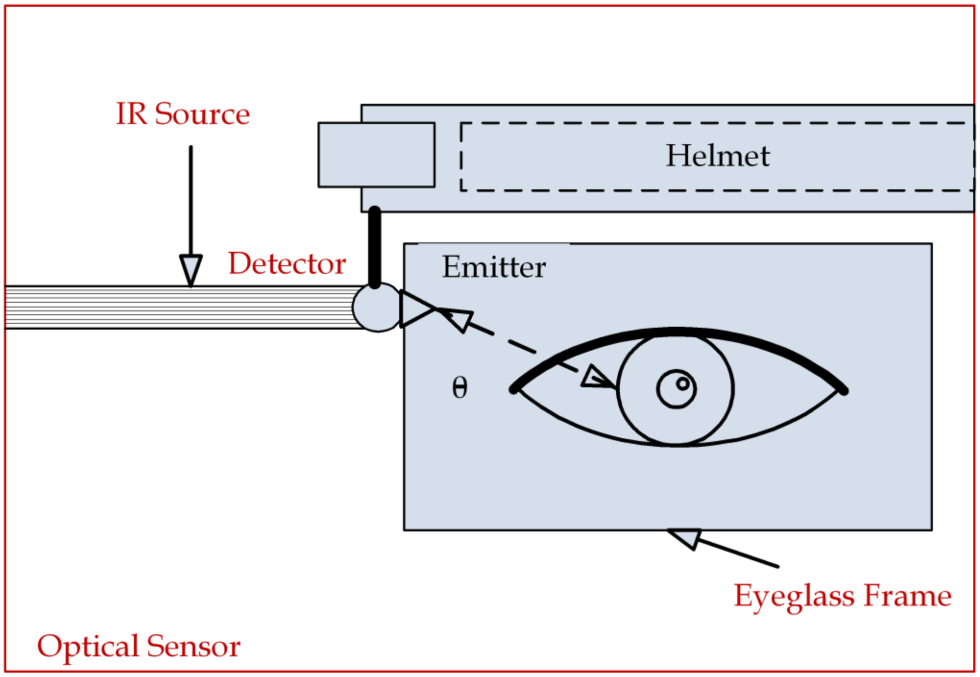

Fig. 14.8. Eye Blink Sensor.

MEDICINE REMINDER DEVICE

Designers: Sheldon Bish, Karla Sittnick, and Kenta Umetsu
Supervising Professor Dr. John Enderle and Bill Pruehsner
Client Coordinator: Dr. Brooke Hallowell, Ohio University, Athens, OH
Biomedical Engineering Department
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Storrs, CT 06269-2247

INTRODUCTION

The Medicine Reminder Device was designed for an elderly woman with multiple medical conditions who needs to take medicine twice a day. The client has an impaired ability to monitor her own medication schedule and required a way to independently take her medication. The medication reminder was designed to provide independence to the client from her caretakers and give her the capability to stay on her medication schedule. This device is a simple model Personal Digital Assistant (PDA) modified with a program to keep track of her dosing schedule, as well as keep a record of when and how often she takes her medicines.

SUMMARY OF IMPACT

The Med-Rem application used along with the Palm device provides the patient independence from family and caretakers in her daily medication routine. Med-Rem provides a dependable reminder for the patient when it is time to take her medications, which medications to take, and in what amounts. It also requires a response from the user. The caretaker is able to double-check the patient's ability to use the device as a reminder by using the Dose Count and Medication Log features. The device is aesthetic and is readily available on the market. The patient or caretaker can select games and other applications to be added to the device to increase the patient's positive association with the device.

TECHNICAL DESCRIPTION

The PDA casing is made from plastic designed to be lightweight and impact resistant (see Fig. 14.9). The casing (ABS) thickness is 1/8" to provide more impact resistance then an average thin metal sheet casing. The window screen of the casing is made from clear polycarbonate material.

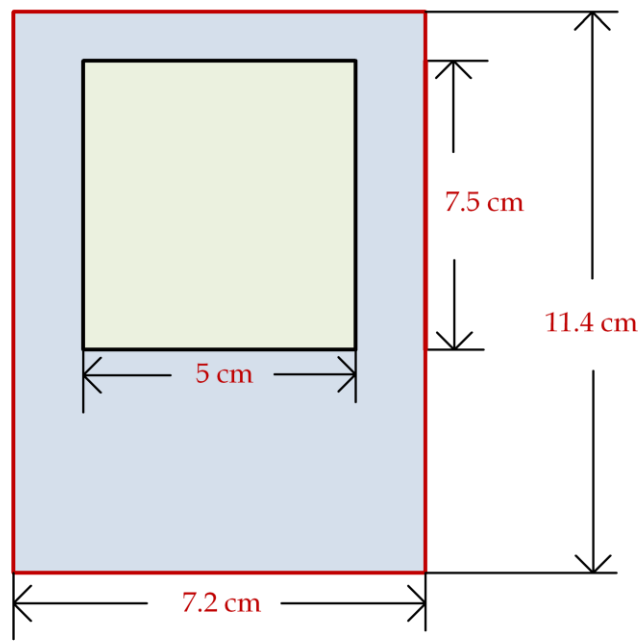

Fig. 14.9. Case Size for Medication Reminder PDA Device.

The Medication Reminder Application, "Med-Rem", allows the caretaker to store five independent medication sessions for the patient. Each medication session is capable of being set for a time chosen by the caretaker along with dosage type and amount. All medications can be added to a main medication list prior to being entered into an individual medication session. The device also has a "dose count" feature, which continuously monitors remaining medicine available for dosage. The caretaker may also view a medication log of patient interaction. The medication log is able to store an unlimited number of records, and each record is created upon patient interaction through a scheduled Medication Session. The log stores the: 1) date; 2) time; 3) medication name; 4) dosage type; 5) dosage amount; and 6) user response for each medication alert. Upon reaching a scheduled medication session, the palm: 1) turns on (if off); 2) starts the med-rem application; 3) produces a visual alert on the screen; 4) sounds an alarm (see Fig. 14.10).

The initial alert asks if the client is ready to begin her medication session. The patient is given the option to continue or snooze. The patient is allowed to snooze a total of three times and is then forced to continue with the session or skip the session entirely. If the session is skipped entirely, the user response is stored as "skip." When the patient chooses to continue with the medication session, alerts containing medication name, dosage amount, and dosage type are displayed to the user one at a time for each medication contained in the specific medication session. The device requests a response of "Yes" or "No" regarding whether or not the patient has consumed the medication. Once the last medication on the list is shown in an alert and the patient has responded, a final completion message for the medication session is displayed to communicate to the patient that the Medication Session has been completed.

The cost of the parts and materials was about $130.

Fig. 14.10. Alert Screen on Med-Rem.

SHAMPOO AND CONDITIONER IDENTIFICATION DEVICE

Designers: Sheldon Bish, Karla Sittnick and Kenta Umetsu
Client Coordinator: Dr. Brooke Hallowell
Supervising Professor: Dr. John Enderle
Biomedical Engineering Department
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INTRODUCTION

The Shampoo and Conditioner Identification Device (Fig. 14.11) was designed for an elderly woman with visual and cognitive impairments. The client requested a way to differentiate her shampoo and conditioner bottles while in the shower. The Shampoo and Conditioner Identification Device is a lightweight, waterproof, and shock-proof device that emits an auditory voice signal of "shampoo" or "conditioner" when certain colored bottles are scanned in front of the device.

SUMMARY OF IMPACT

The purpose of the device is to reduce the client's confusion and frustration and thus make the client's shower experience easier and more enjoyable. The device also ideally saves the client's family members time and energy of having to identify bottles for her. Additional design considerations for future work on such a device include a smaller and lighter device that does not hang on the shower curtain rod and more stable wiring for consistent functioning if and when the device is moved.

TECHNICAL DESCRIPTION

The casing of the Shampoo and Conditioner Identification Device was fabricated from an opaque polypropylene 12" x 12" block. The polypropylene casing has a hard, smooth surface that prevents bacteria build-up and provides chemical resistance. The window for the color sensor was made from clear polycarbonate in order to provide translucence while having high impact resistance.

The color sensor is a light to frequency sensor that is fully programmable with computer software (see Fig. 14.12). The output of the sensor is customizable for optimal compatibility with the microcontroller in the device circuit.

Fig. 14.11. Shampoo-Conditioner Identification Device.

The microcontroller contains a frequency counter program that distinguishes between the color sensor's output signals for red and blue. The microcontroller communicates with tan SP03 voice module and indicates which of the pre-programmed phrases to repeat as a signal of red or blue is detected. The audio signal from the SP03 is sent through a speaker. The audible responses are "Shampoo" and "Conditioner." An illustration of the circuit is in Fig. 14.13.

The cost of the parts and materials was about $680.

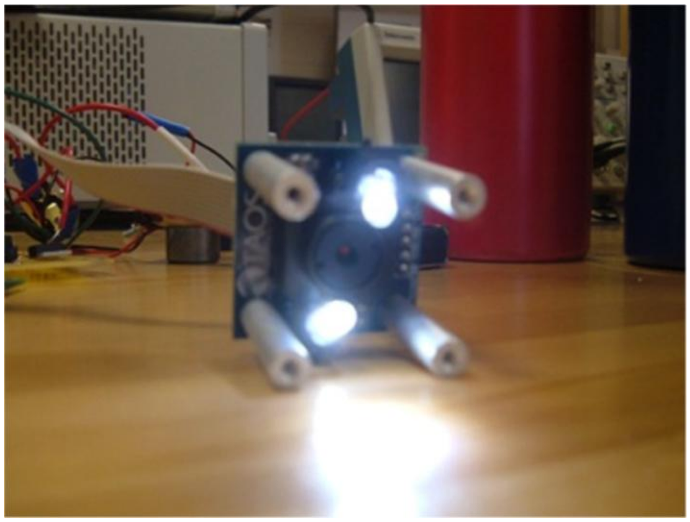

Fig. 14.12. Light to Frequency Color Sensor.

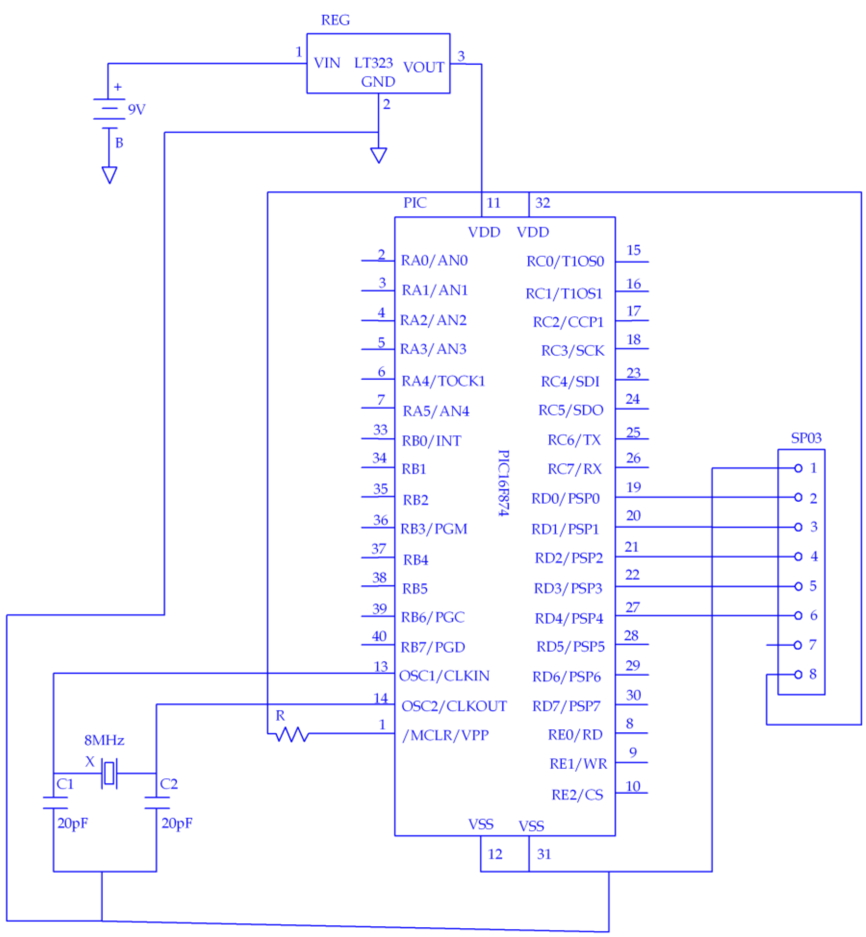

Fig. 14.13. Frequency Counting Circuit.

INTERACTIVE WHEEL OF FORTUNE GAME

Designers: Kristen M. Gingras, Meghan E. Schmidt and Yadverinder Singh
Client Coordinator: Dr. Brooke Hallowell, Ohio University, Athens, OH
Supervising Professor: Dr. John Enderle
Biomedical Engineering Department
University of Connecticut at Storrs
Storrs, CT 06269

INTRODUCTION

The Interactive Wheel of Fortune Game was designed to be used in a workshop for adults with developmental disabilities. The clients requested a form of entertainment that accommodates limited mobility and dexterity and also allows them to socialize in a fun and visually stimulating environment. The Interactive Wheel of Fortune Game includes: 1) bright colors on the exterior of the game; 2) Light Emitting Diodes (LEDs) that light up with activation of the game; 3) audio comments that are spoken at initial power of the game and when the wheel spins; and 4) two different methods to spin the wheel (a one-button push button wireless remote and a motion sensor).

SUMMARY OF IMPACT

The portability of the game allows it to be moved around the room and to other locations. The game ideally engages the adults in social interactions while ensuring safety. The clients are able to spend their time in a positive manner that allows them to enjoy themselves.

TECHNICAL DESCRIPTION

The base of the game is fabricated from high density polypropylene to prevent movement while the wheel is spinning. To provide further support, a support system was constructed for the inside of the base. The support system was made out of a wooden block. The wooden block was fastened onto the base and secured on each side using 2′ x 4′ wooden planks (see Fig. 14.15). The motor is attached to the top of the wooden block by use of an aluminum plate.

The wheel was made from polypropylene in order to ensure high strength and high heat capacity while spinning. The colors red, blue, yellow, and green were used on the wheel (Fig. 14.14) to make high contrasts. Shiny silver stickers indicate the point values on each section. Dowels are attached at the base of the wheel, and they assist in the indication of which point value the player lands on.

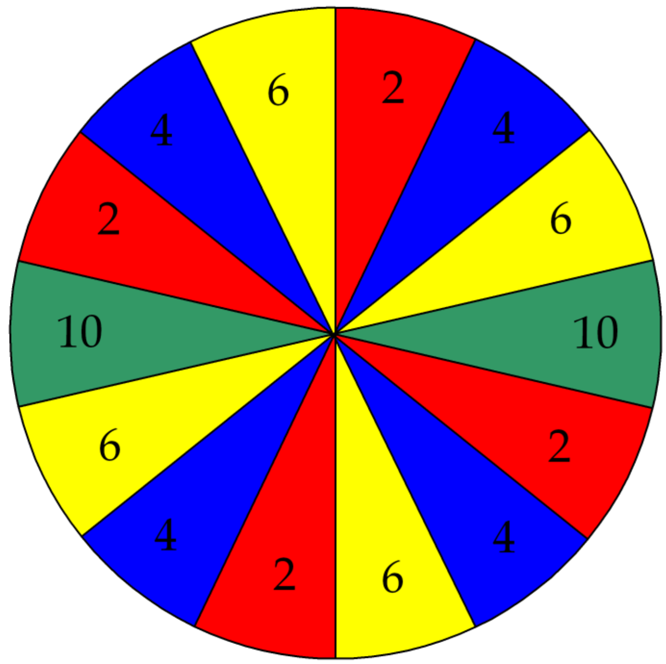

Fig. 14.14. The Wheel of Fortune Game.

A clicker system is part of the design and is on the side of the base. The clicker was fabricated from elastic tubing that has flexibility when coming into contact with the dowels. The clicker indicates the final point value. An SP03 audio response system gives audio feedback to the players. The entire device operates on six nine-volt batteries.

A wireless communication capability exists between the remote and the microcontroller for the motor. The remote activates the spinning of the wheel for those who have difficulty approaching the device. A light sensor also activates the device to turn when a user waves his or her hand in front of it.

The cost of the parts and materials was about $685.

Fig. 14.15. Support System.

MODIFIED COMMUNICATION SYSTEM ACCESSORY DEVICES

Designers: Philip Licitra and Stephanie Santos
Client Coordinator: Madeleine Kineavy
Supervising Professor: Dr. John Enderle
Biomedical Engineering Department
University of Connecticut
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INTRODUCTION

A joystick control device and a secondary viewing screen were used to operate and enhance the client's existing augmentative device, developed by DynaVox Technologies®. The client required a more durable and reliable selection device and needed an auxiliary liquid crystal display (LCD) screen for others to provide more active and personal conversations. The two devices allow the client to interact more effectively with others. The joystick: 1) has a large gripping surface; 2) is durable; 3) provides a faster and more efficient means of communication.

SUMMARY OF IMPACT

The devices improve the client's quality of life by increasing the ease and efficiency of his augmentative device and allowing the client to more naturally and quickly communicate with friends and family. The addition of the head switch to the joystick helps the client maintain better posture, and the size of the joystick grip improves his hold.

TECHNICAL DESCRIPTION

The mechanical design of the joystick reduces wear and fatigue. The joystick is designed to operate efficiently under repeated force applications of up to 250 pounds to accommodate the client's high tone and movements. The device has a one-touch selection feature, which gives the client the option to use either a hand-grip mounted button or an externally connected head switch (developed by AbleNet®). The joystick control connects to the augmentative device through a USB connection and can be used as a cursor control on any cursor-controlled device with a USB port. The head switch is connected through an integrated panel mounted mono-jack port. The mono-jack port is located on the back side of the joystick encasement. The joystick (Fig. 14.16) is mounted on the left armrest of the client's wheelchair. The joystick was mounted by permanently attaching an aluminum T-slot extrusion to the armrest of the wheelchair and sliding a linear bearing, which is permanently attached to the joystick, over the t-slot extrusion.

Fig. 14.16. Joystick in Encasement with Attached Optional Head Switch.

The seven-inch secondary viewing screen is self-contained in an ABS plastic enclosure (see Fig. 14.17). The screen is powered by a rechargeable NiMH battery pack, which provides battery life for ten hours before needing a recharge. A green LED was installed to indicate that the screen is powered. The LCD screen connects to the DynaVox® via a VGA video card in the video output port. A clearly labeled rocker switch designates whether the battery voltage is being directed to power the LCD screen or to the Universal Smart Charger, where the battery can be recharged. The central position on the rocker switch is designated as the "OFF" position.

The cost of the parts and materials was about $750.

Fig. 14.17. LCD Screen in Custom Enclosure.

CHAPTER 15
UNIVERSITY OF DENVER

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LOWER EXTREMITY ASSISTANCE PROJECT

Designers: Brooke Knisely, Ross Smith, David Muecke, Basma Al-Salem
Client Coordinator: Dr. Thomas MacKenzie, Denver Health Medical Center, Denver, CO
Supervising Professors: Dr. Kimberly E. Newman & Dr. Peter J. Laz
Department of Engineering
University of Denver,
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INTRODUCTION

The Lower Extremity Assistance Project (LEAP) was designed for a client with decreased quadriceps strength and control. Helps the client to move independently from a seated position on the side of a bed into a resting position on a bed. The LEAP design uses a pneumatic lifting mechanism to move the client's legs from a hanging vertical position to a horizontal position.

SUMMARY OF IMPACT

LEAP allows the client to move to a resting position and eliminates the client's need for assistance.

TECHNICAL DESCRIPTION

The leg lift was designed to be similar to a recliner leg lift using an air bladder.

The dimensions of the device were determined based on stability, force, and shear requirements. The device was designed to adjust using a pin mechanism for varying heights of beds and couches.

Pneumatic lift analysis was performed to specify the pressure needed to lift the client's legs . The electrical and computing components were developed to control the pneumatic pump speed and display the current operating range. Speed is controlled using a large radial switch and is shown with a seven segment display.

The cost of the parts and materials was about $775.

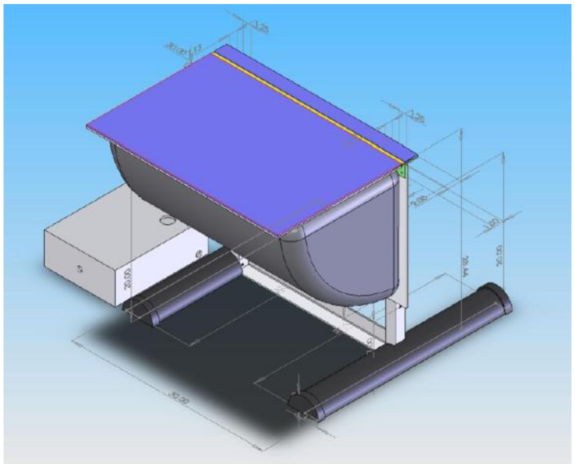

Fig. 15.1. CAD drawing of LEAP.

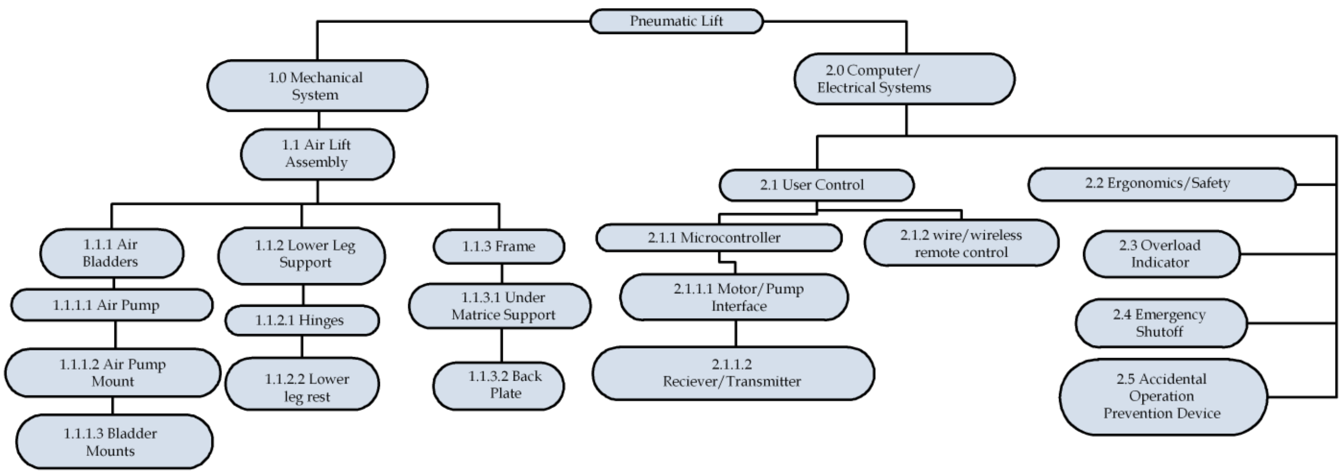

Fig. 15.2. System Block Diagram of LEAP.

RECUMBENT EXERCISE MACHINE

Designers: Kelly Gibson, Scott Carter, Brian Joyce, and Harmony Zeller
Client Coordinator: Dr. Thomas MacKenzie, Denver Health Medical Center, Denver, CO
Supervising Professors: Dr. Kimberly E. Newman and Dr. Dan Armentrout
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INTRODUCTION

The recumbent exercise system was designed to provide a cardiovascular workout for an individual who is unable to use existing exercise products. A design was used to ensure balance. Workout information is displayed for: 1) heart rate; 2) speed; and 3) duration of exercise. Resistance is manually adjustable, and the device is self-powered with low momentum. The seat is designed for comfort and it turns, enabling the user to easily access the device.

SUMMARY OF IMPACT

The device allows the client to perform cardiovascular exercise without risk of falling or injury (see Fig. 15.3). The exercise system allows for recumbent exercise with low momentum in case the client needs to stop. The device provides balance and stability for the client, and it is self-powered. The device also provides comfort and easy access.

TECHNICAL DESCRIPTION

The recumbent cycling system provides sensor information for the client's heart rate and cycling speed to monitor workout performance. The information is displayed during the workout using a microcontroller and a custom display unit. Resistance is generated using electrical current and is manually adjusted.

Static load analysis was performed to ensure the structure would support individuals weighing up to 500 lbs. The seat rotates 90 degrees for sitting and then locks in the operating position. The space between the seat and the foot peddles adjusts to accommodate heights from 5′5″ to 6′5″.

The cost of the parts and materials was about $1500.

Fig. 15.3. Exercise Machine Demonstration.

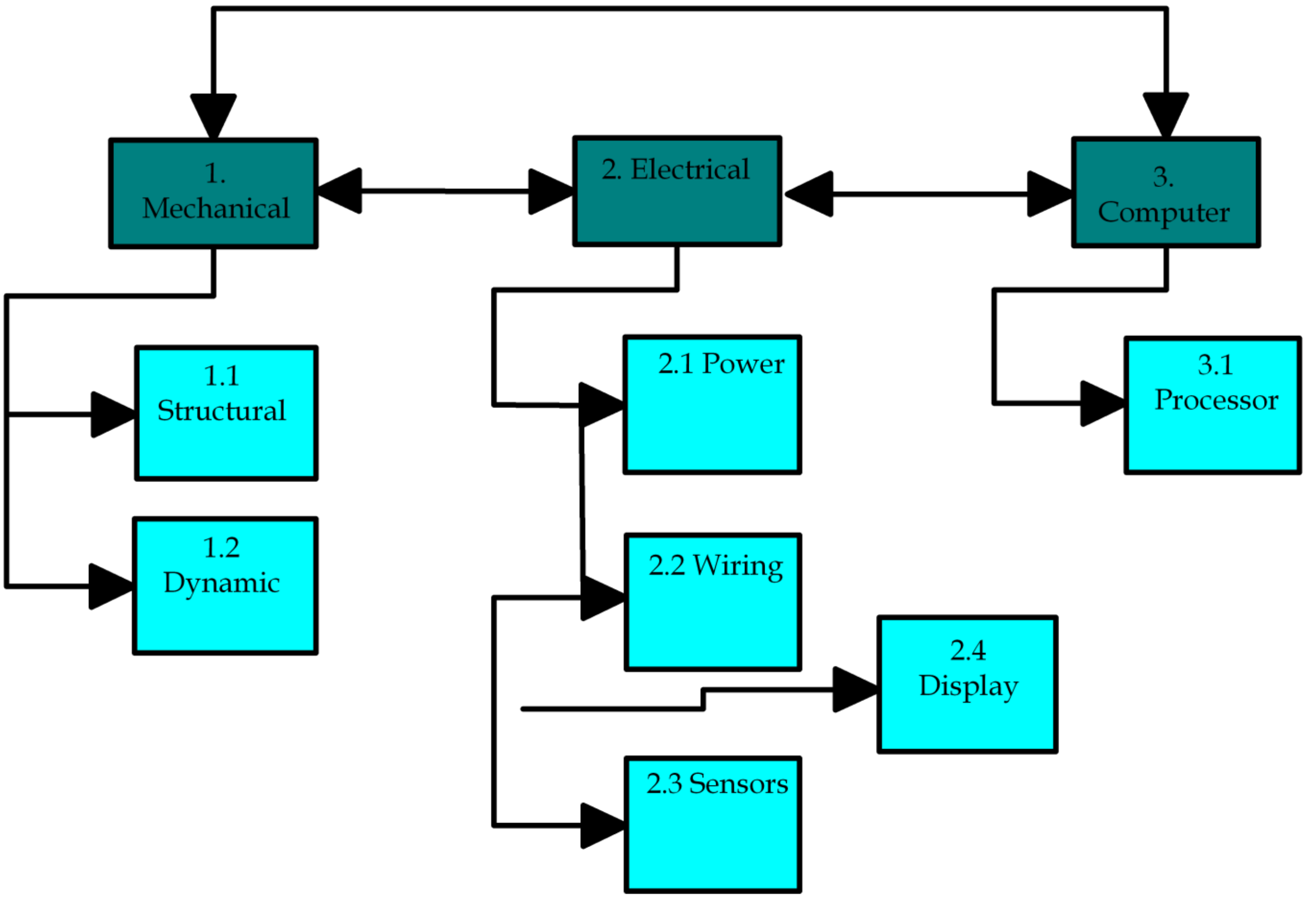

Fig. 15.4. System Level Block Diagram.

CHAPTER 16
UNIVERSITY OF MASSACHUSETTS AT LOWELL

Department of Electrical and Computer Engineering
University of Massachusetts Lowell,
Lowell, MA 01854

Principal Investigator:

Dr. Donn Clark (978) 934-3341

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DISCRETE TRIAL TEACHING GAME

Designer: Brian T. Lavoie
Client: Ferryway School in Malden, MA
Supervising Professors: Charles Maffeo and Alan Rux
Department of Electrical and Computer Engineering
University of Massachusetts at Lowell
Lowell, MA 01854-5104

INTRODUCTION

The Discrete Trial Teaching Game (DTTG) (Fig. 16.1) was designed to help students with autism learn by using light and sound. DTTG presents the students with three stimulus flashcards. The teacher selects the correct flashcards. The game then compares the teacher's choice to the student's choice and displays green or red LEDs around the correct or incorrect choice. DTTG plays melodies for correct and incorrect choices and dispenses candy as positive reinforcement for correct choices.

SUMMARY OF IMPACT

The device helps students maintain focus and interest during lessons. The device is fun for the students, provides positive reinforcement, and reduces steps required by the teacher during lessons.

TECHNICAL DESCRIPTION

The device entails five interactive stages: 1) input; 2) logic circuitry; 3) the ISD 2560 chip-recorder; 4) the LED display; and 5) the candy dispenser.

The inputs for the teacher are four push-button switches. One switch is for resetting the game between each trial, and three switches are for selecting one of the three stimuli as the correct choice. The student has three inputs. These inputs utilize the Parallax QT113 touch sensors, which are connected to copper pads under the flashcards. The student places his or her finger over his or her choice and this activates the touch sensor.

The logic circuitry of the game is programmed onto a complex programmable logic device (CPLD), which comes with a programming board and software made by Xilinx. The input is seven switches. Outputs consist of single correct and incorrect choice indicators, 24 bicolor LEDs, enabling and addressing the ISD2560 chip-recorder, and an activation of the candy dispenser for correct choices.

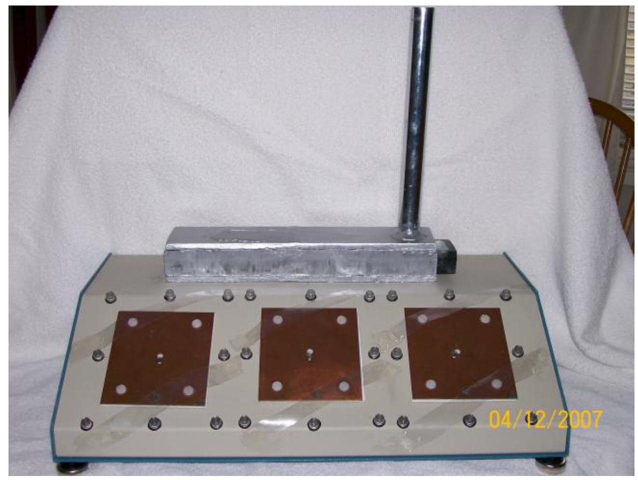

Fig. 16.1. Discrete Trial Teaching Game.

The LEDs are bicolor red or green with a common cathode. Eight LEDs are around each cardholder.

The ISD2560 chip-recorder (Fig. 16.2) utilizes addressing to play back a maximum of 60 seconds of sound over 600 address spaces, which provides 0.1 seconds of recording per address space. The chip stores six unique sounds in different addresses.

After a correct choice, candy is loaded into a drawer from a tube mounted on the device. After the student takes the candy, the game is reset, and the candy drawer is pushed back in position to load another piece of candy (Fig. 16.3).

The total cost of the device was about $287.

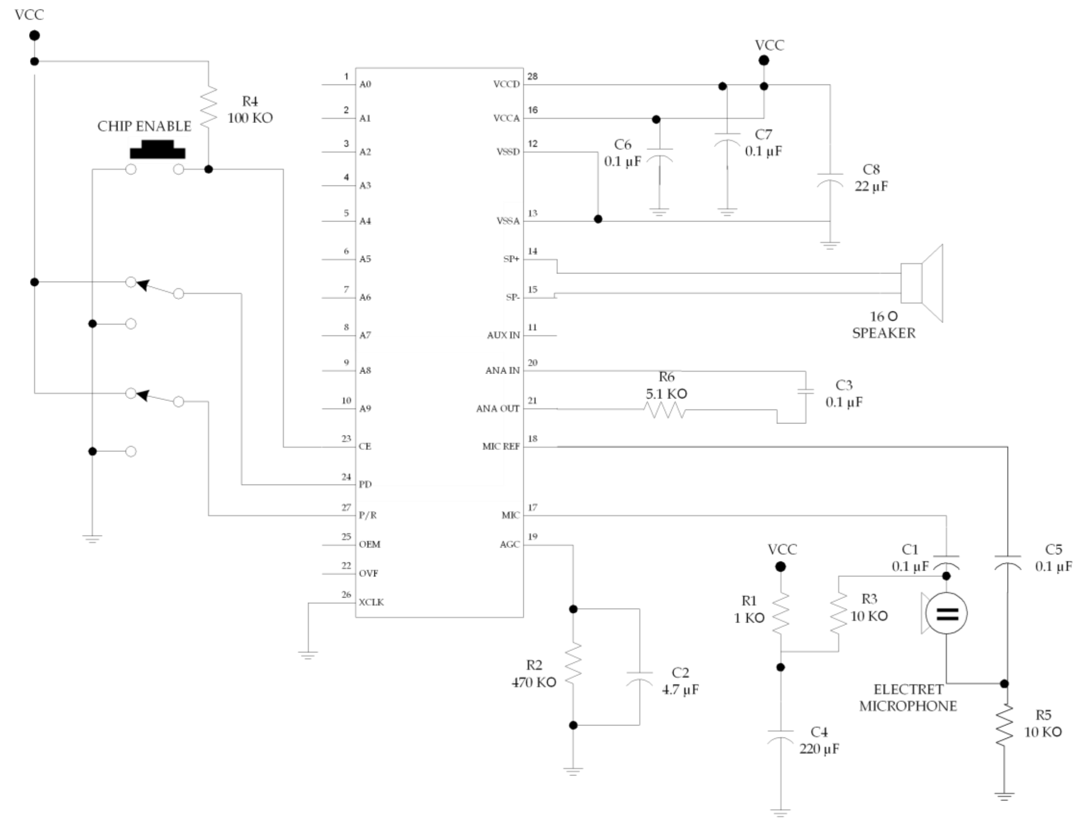

Fig. 16.2. Schematic Utilized by the ISD2560 Chip-Recorder.

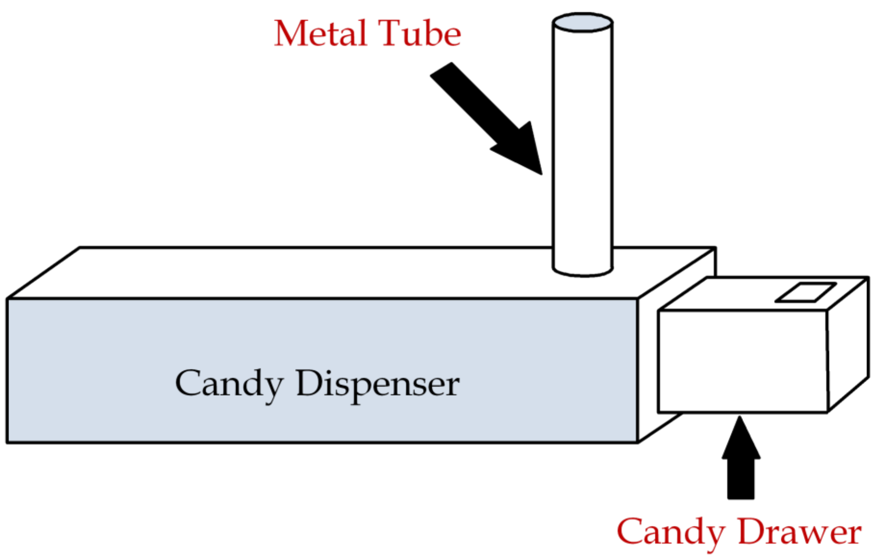

Fig. 16.3. Diagram of Candy Dispenser.

MATCHING CARD GAME

Designer: Christine Brunelle
Client Coordinator: Karen Mercurio, Brookside Elementary School, Dracut MA
Supervising Professor: Alan Rux
Electrical and Computer Engineering Department
University of Massachusetts at Lowell
Lowell, MA 01854

INTRODUCTION

The Matching Card Game (Fig. 16.4) is a learning tool for kindergarten students with cognitive and physical disabilities. The device has ten slots with pictures behind them. The slots accept cards with the same pictures. When a card is inserted into a slot, the box determines whether the right card was inserted based on holes or notches that are in the card and outputs a signal based on the answer. If the correct card is put into the correct slot, a green light turns on and a musical tune plays; if a wrong card is put into the wrong slot, a red light turns on and a buzzing sound plays. The pictures on the cards can be modified by the teacher, who requested a system that does not require constant supervision. The Matching Card Game is an independent learning tool that allows students to be left alone while learning.

SUMMARY OF IMPACT

The device increases the number of children that the teacher can attend to at one time and allows students to learn without constant supervision. The game gives the students independence and a sense of accomplishment. The game's ability to be modified for higher level classes increases the ways in which it may be used.

TECHNICAL DESCRIPTION

The game has four main parts: 1) optical switches; 2) multiplexers; 3) a microcontroller; and 4) light emitting diodes (LEDs). Four optical switches are placed in each slot to allow for a binary number up to ten. Each card has notches or holes in a particular order, corresponding to the correct slot for that card. When a card is inserted, the outputs from the optical switches go to the multiplexers and are fed into the microcontroller. The microcontroller determines whether the input is correct for the slot being read from. It then outputs accordingly and then switches over to the next slot. The microcontroller operates the multiplexers to read slots one through ten sequentially and constantly check the status of the slot.

The components were put into a box made of ABS plastic. The optical switches (H21A1, 40 total) were chosen because they were slotted. The multiplexers (74150, 4 total) are 16-1 bit converters so that the microcontroller (Basic Stamp BS2p40, 1 total) can scroll between slots and have a parallel input. At the request of the teacher, large green LEDs were used instead of red LEDs.

The cost of the parts and materials was about $300.

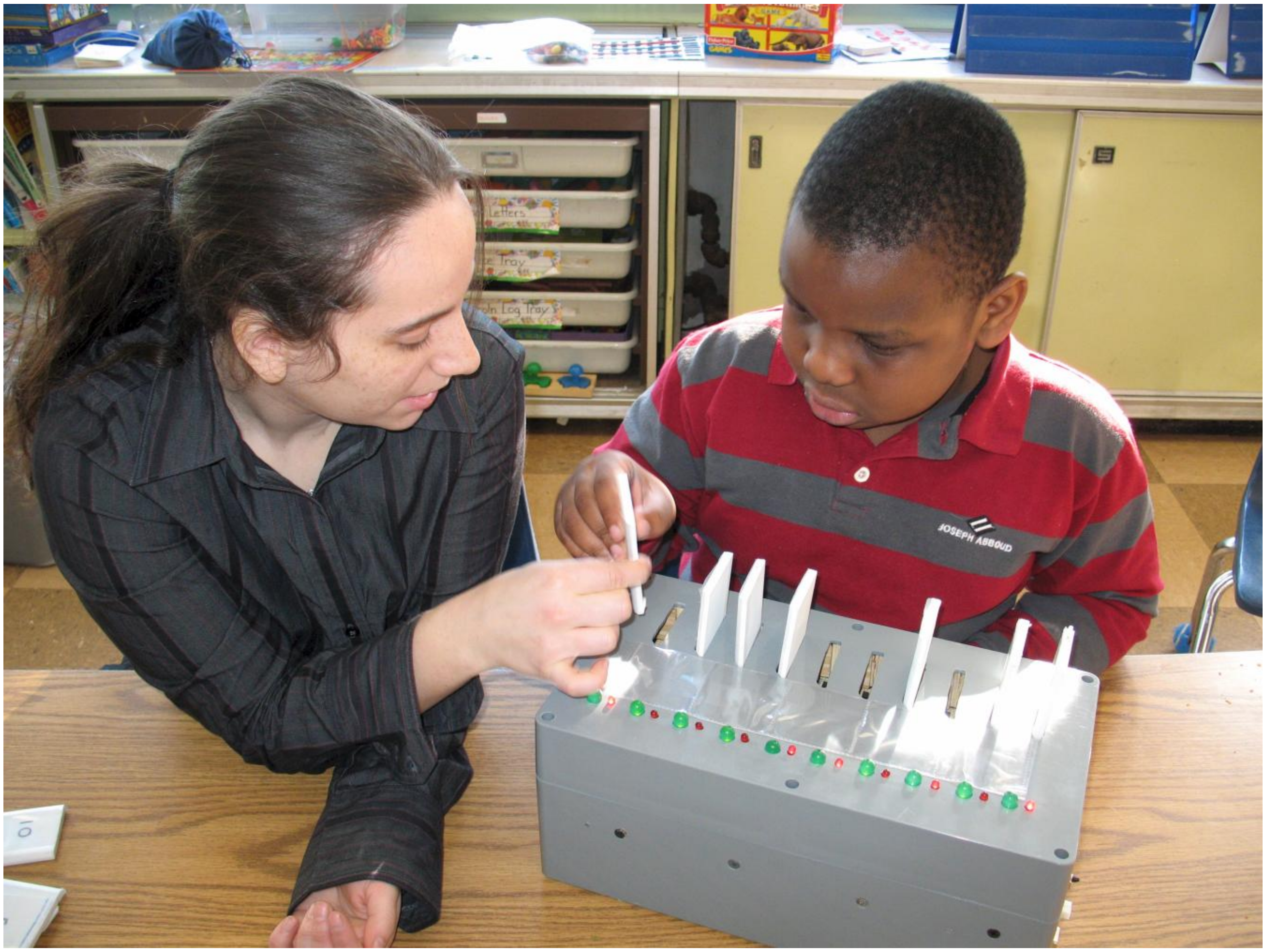

Fig. 16.4. Matching Card Game.

AUTOMATED LASER POINTING DEVICE

Designer: John C. Newton
Client Coordinator: Jill, Helping Hands Monkey Helpers, Boston, MA
Supervising Professor: Alan Rux
Department of Electrical and Computer Engineering
University of Massachusetts at Lowell
Lowell, MA 01854

INTRODUCTION

The Automated Laser Pointing Device was designed to help individuals who train or have Capuchin monkeys to point out objects in a room. The monkeys are trained to help individuals with disabilities by retrieving the selected object(s) or by performing a task on the selected object(s). The device consists of a hand-held joystick that communicates the desired coordinates wirelessly to a receiver. The receiver controls the position of the laser via two servos.

SUMMARY OF IMPACT

The device helps individuals who are unable to physically manipulate a typical laser pointer. It provides the clients more control over their environment and decreases their dependence on caretakers.

TECHNICAL DESCRIPTION

The automated laser pointer has two separate modules (Fig. 16.5): 1) a transmitter and 2) a receiver. The transmitter module is a wireless handheld unit. It has: 1) a power switch; 2) a button; and 3) a small analog 2-axis joystick. A microcontroller runs a small program that controls the operation of the device. An RF transmitter sends data wirelessly to an RF receiver in the receiver module. The receiver module contains a microcontroller running its own program. The laser is mounted on two servos, which are directly connected to the receiver via a cable. It has a power switch and a power indicator LED.

The client operates the joystick to select an object in the room. The joystick has an X axis (left and right) and a Y axis (up and down). For fine adjustments, small deviation from the central axis results in slow movement of the laser. For coarse adjustments, large deviation from the central axis results in fast movement of the laser. Once the laser is positioned correctly, the client activates the button to excite the laser. Exciting the laser shakes it in close proximity to the object to get the monkey's attention. The transmitter module wirelessly transmits the desired state of the laser to the receiver module at 9600 baud. The receiver module interprets the state and positions the laser accordingly by sending pulse-width-modulated (PWM) signals to the servos.

The device is intended to operate indoors, in close proximity to the client and the monkey. The laser must remain in the field of view of both the client and the monkey. The receiver module can be mounted to: 1) a wheelchair; 2) a table; or 3) a bed frame. The servo/laser mechanism is affixed to an adjustable arm to ease the initial set up. The transmitter module is a handheld device that remains with the client.

The receiver module is powered by an AC/DC adapter, which provides five volts and ten Watts. The transmitter module consumes less than eight mA during normal operation and is powered by four AA batteries providing 4.8 volts and 2500mAh.

The cost of the parts and materials for each unit is less than $300.

Fig. 16.5. Automated Laser Pointing Device.

SMART INTERACTIVE TEACHER (SIT)

Designer: Manuel Madera
Client Coordinator: Pamela Fraser (Teacher), Lawrence High School, Lawrence, MA
Supervising Professor: Prof. Alan Rux
Electrical and Computer Engineering Department
University of Massachusetts at Lowell
Lowell, MA 01854

INTRODUCTION

The Smart Interactive Teacher (SIT) was designed for a high school class for students with disabilities. The device helps students learn to count from one to nine. The device lights up a random number of lights and the student identifies the number by choosing a number on a keyboard. If the student chooses the correct number, the device plays pre-recorded music and displays the number. If the student chooses incorrectly, then a "try again" message plays.

SIT can also connect to a computer to function with SM software, which is a computer program displaying a random number of animals for the student to identify. If the student chooses the correct number, the computer plays pre-recorded music and displays the number; if the student chooses incorrectly, then a voice message plays.

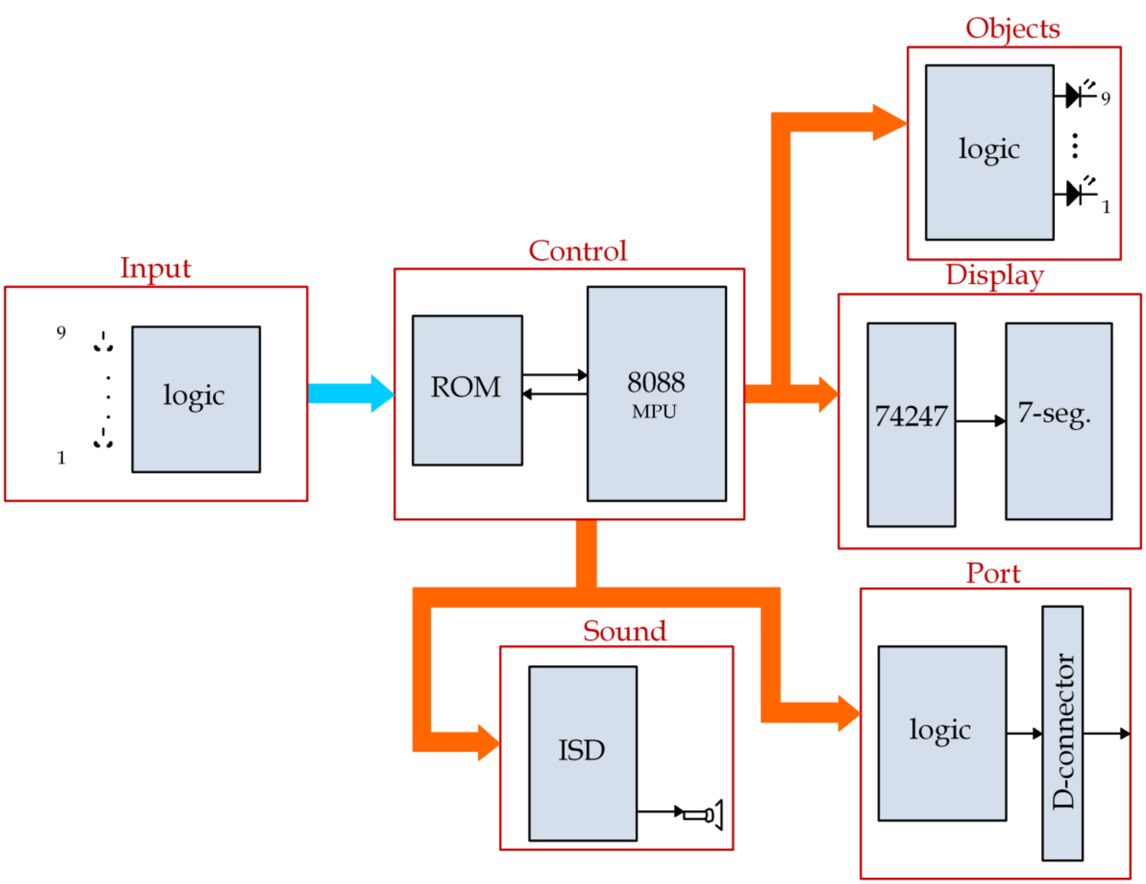

Fig. 16.6. Smart Interactive Teacher Block Diagram.

SUMMARY OF IMPACT

The teacher requested a device that will help teach her students to count. SIT uses auditory and visual stimuli to help the students. It will help lay the foundation for students learning how to count in addition to aiding the teacher with an added teaching tool.

TECHNICAL DESCRIPTION

SIT has nine red outputs that are used as objects for the students to count. These lights are controlled by the system through combinational logic. It has a 7-segment display, driven by a 74LS246 or a 74LS247. The display is used to indicate the correct number of lit LEDs. The device has nine switches that enable students to input a number. Each switch has a plastic cap in the shape of the number it represents. They are connected to the system through combinational logic. SIT has a speaker, driven by an ISD2560, used to output music when the correct switch is pressed or a voice message if a wrong switch is pressed. In order to communicate with a computer, SIT has a parallel connector that is attached to a 74LS245 through combinational logic. To coordinate all the functions, an Intel 8088 MPU and an EPROM were used (see Fig. 16.6). The device is powered by five volts DC, which is supplied by an AC to DC converter.

SM software

The SM software is a computer program developed in C++. This program uses an array of pictures as objects for the students to count. It uses the computer's sound card to output pre-recorded music that is saved as a .wav file if the correct switch on SIT is pressed or a pre-recorded voice message if an incorrect switch is pressed. To communicate with SIT, the program uses the computer's parallel port (Fig. 16.7).

The cost of the parts and materials was about $95.

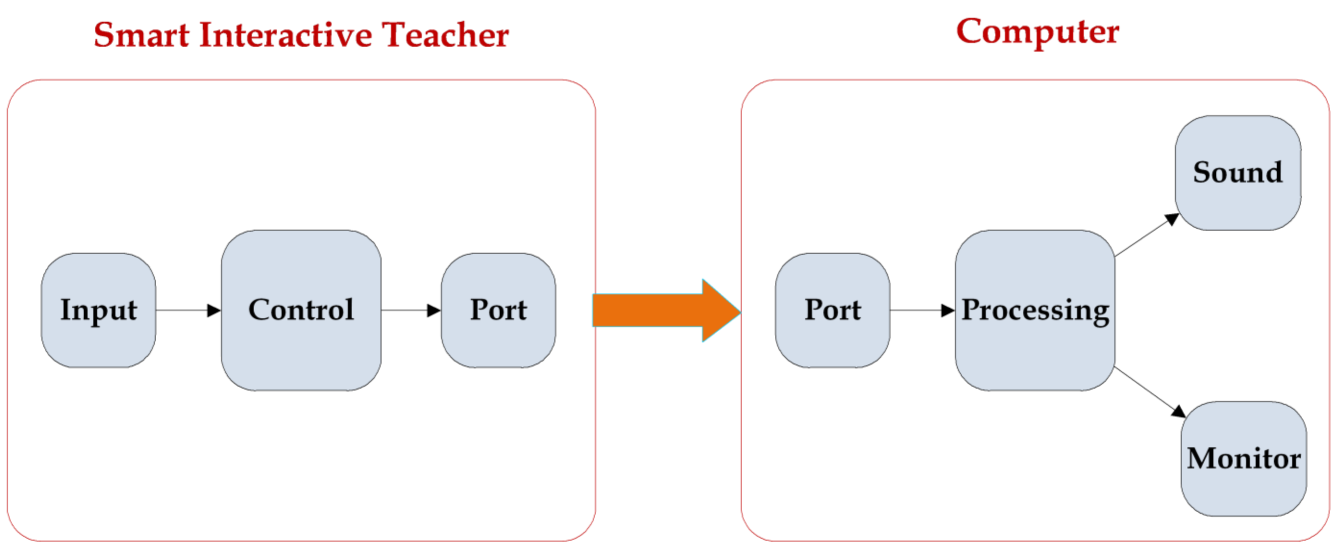

Fig. 16.7. Co-op Block Diagram.

SOAP DISPENSER

Designer: Mark Houseman
Client Coordinator: Bethany Campbell, Forestdale Memorial School, Malden, MA
Supervising Professor: Chuck Maffeo
Electrical Engineering Department
State University of Massachusetts at Lowell,
Lowell, MA 01854

INTRODUCTION

The Soap Dispenser (SD) is an automated soap distributor that provides an independently operable method of hand hygiene for a child with cerebral palsy (see Fig. 16.8). The SD uses an infrared sensor to detect motion, which triggers soap to dispense sideways into a shallow dish. The SD is easily used without rotating the palm upward. The device dispenses soap frequently, efficiently, and without adult assistance to the client. The device may be easily relocated.

SUMMARY OF IMPACT

Using the SD, the client is able to wash his hands without taking up large amounts of the teachers' time while in class. The device increases independence and promotes hygiene.

TECHNICAL DESCRIPTION

The housing for the SD was made from: 1) 3/4" wide aluminum tubing; 2) 26 gauge steel plating; 3) 16 gauge steel plating; and 4) fiberglass. The aluminum and steel plating were bolted together to form a sturdy housing, and the fiberglass was used to coat the housing. The steel and aluminum provide strength for the SD to survive impact, and the painted fiberglass provides water resistance and a finished look.

The dispenser has a 3300mAh battery, which allows for operation in locations without a nearby AC outlet. The battery must be recharged once a week by plugging an AC wall adapter into a power jack on the SD. The battery is a NiMH. It has the advantage over NiCd batteries of being unchanged by the "memory effect," which is when a battery loses overall potential by being recharged before it is completely drained. The charging circuit is monitored by a BQ2002T IC. The BQ2002T monitors the battery voltage with a voltage divider and the battery temperature with a thermistor (a heat sensitive resistor). When the battery is fully charged, the LED lights up and the BQ2002T trickle charges the battery to keep it at maximum charge.

Soap is dispensed when infrared light emitted from an LED reflects off the hand of the operator and becomes incident on a photosensitive transistor. A microcontroller senses a change in the voltage across the photosensitive transistor. The microcontroller provides power to: 1) an ISD1400 sound chip; 2) a solenoid valve; and 3) a linear solenoid. The ISD1400 sound chip plays a sound and then the solenoid valve opens, which enables soap to flow through the nozzle of the dispenser. The linear solenoid then pushes a spring pump for five repetitions. The spring pump moves the soap from a reservoir through a tube and out the nozzle.

When dispensing soap, the SD plays back a variety of Taz noises using the ISD1420 IC. The ISD chip is activated by the microcontroller and is activated prior to the linear solenoid. The ISD chip will play seven consecutive noises before beginning to repeat noises. The audio playback is turned on or off using a switch located on the back of the dispenser. The switch is easily used by an adult, but it cannot be used by a child.

The cost of the parts and materials was about $600.

Fig. 16.8. Soap Dispenser.

PORTABLE TOUCH-SCREEN COMMUNICATION DEVICE

Designers: Matthew B. Johnsen
Client Coordinator: Cathy Reilly, Rockport, MA
Supervising Professor: Professor Alan Rux
Electrical and Computer Engineering Department
State University of Massachusetts at Lowell
Lowell, MA 01854

INTRODUCTION

The Portable Touch-Screen Communication Device was created to allow people who lack verbal skills to communicate using an audio system (see Fig. 16.9). The design is built around a black and white dot matrix LCD attached to a touch-screen. The LCD displays a menu of pictures with words that represent the picture displayed under the word. By touching a box in the grid, the device outputs audio for the word. Buttons at the top of the chassis enable access to different menus, including food, clothes, numbers, and others. By connecting a serial port cable between the portable touch-screen and a computer, a running software program enables the user to edit the pictures, words, and audio files in the menus. The device is portable, so the client can use it to communicate in many environments.

SUMMARY OF IMPACT

The Portable Touch-Screen Communication Device aids the client in being understood by his teachers, peers, and family members. The device also increases the speed by which he is understood by others. The device is easy for the client and his parents to use and improves his quality of life.

TECHNICAL DESCRIPTION

The body of the device is an eight inch by six inch chassis. The device has a tough rubber coating to protect the LCD and touch screen from damage if dropped. The device is powered by a nine-volt battery and will run for months at a time. An evaluation board was purchased to limit the amount of wiring. Most of the design was done by programming the microprocessor, ATmega16 from Atmel, using C code. Attached to the evaluation board are a quad op amp and the audio amplifier, which is used for filtering and amplifying the audio recorded and play back on the device. The buttons used to access the different menus are also attached.

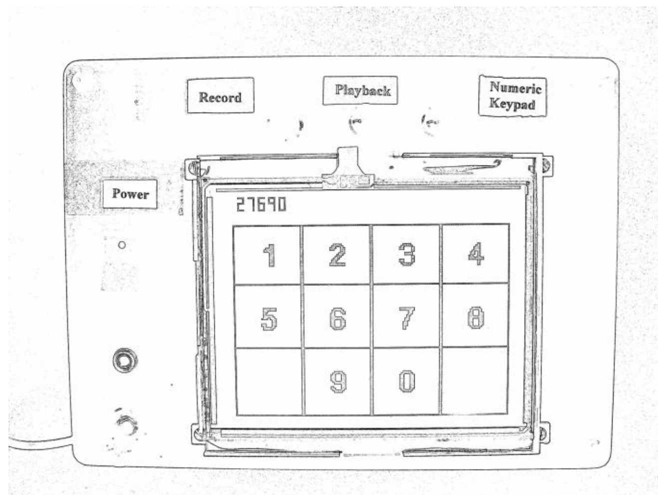

Fig. 16.9. Portable Touch Screen Communication

The circuit (Fig. 16.10) uses two voltage regulators that provide a regulated voltage of +5-volt DC and +3.3-volt DC from four 1.5-volt AA batteries. The desktop computer connects to the microprocessor with a serial port interface on the back of a PC. The software program on the desktop computer sends the pictures and audio files to certain spots within the external 4Mb data flash memory chip, based on where the picture is to be located on the grid. By pressing the momentary push buttons, different types of menus are accessed by loading data from the external memory to the LCD. The touch screen is then used to select a picture and its corresponding audio file.

The microphone amplifier is an inverting amplifier with a first order low-pass filter on top of it. The microphone has a 1/8 "phone jack that plugs into the appliance's chassis. As the audio signal is sent to the microprocessor, it goes through an AD converter, where it is stored into memory as bytes.

The speaker operates in the opposite manner; it forms an AC signal by taking the bytes stored in memory and then uses them to produce a PWM signal at the rate of 15 kHz. The PWM signal goes through two staggered-tuned, 2nd order Chebychev filters and a passive first-order filter.

The cost of the parts and materials was about $120.

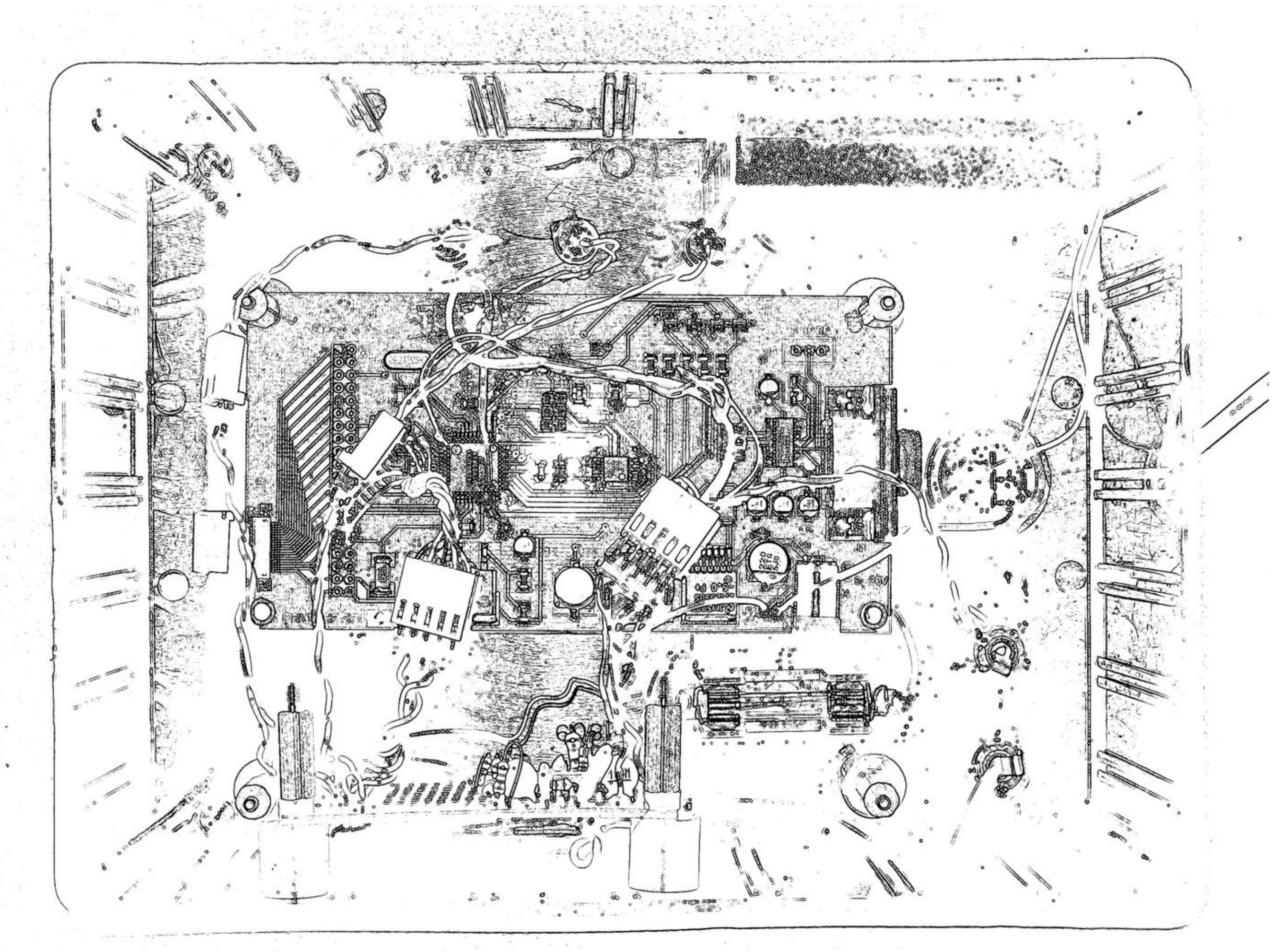

Fig. 16.10. Touch Screen Communication Circuitry.

MEDIA CONTROL CENTER

Designer: Michael L. Bray
Client Coordinator: Deborah Plumer, Coastal Educational Collaborative, Salisbury, MA
Supervising Professor: Jay Fu
Electrical and Computer Engineering Department
University of Massachusetts at Lowell
Lowell, MA 01854

INTRODUCTION

The Media Control Center (MCC) was created for individuals with disabilities at an educational collaborative. The MCC was designed to: 1) provide a computer-based solution to view photos; 2) provide an easy way to handle a growing photo library; and 3) give clients an opportunity to run slideshows independently. The MCC provides an interface box to a PC that runs the MCC application software. The application software monitors the interface box over the parallel port and responds to button presses by opening photos and moving back and forth between photos in the library. The photos are displayed on a wall through the LCD projector. To accommodate for clients with varying degrees of motor skills, the MCC provides three 1/8" jacks, allowing any button with a 1/8" jack to be connected, such as AbleNet's "Big Red Switch" and "Jellybean" style buttons.

SUMMARY OF IMPACT

The ability to customize the button size allows individuals with a wide range of skills to operate the device. The MCC provides the clients with the ability to view photos unassisted, which gives the clients a feeling of independence, and allows staff members the ability to assist others in the facility. The device also accommodates the facility's large library of photographs.

TECHNICAL DESCRIPTION

The MCC interface box contains three 1/8" stereo jacks that allow the user to connect a standard "Jellybean" style input device. Button presses are latched and read by the MCC application software via the parallel port. The application software, written in C++, was designed to run on the Windows 2000/XP platform and utilizes a third-party parallel port driver to access the MCC interface box. The software (see Fig. 16.11) allows the users to select the source location of their photo library, and it stores this path in the Windows Registry to be used as the default. This path can be updated at any time, which gives the clients the flexibility to move and sort their library as they desire. The application looks for files containing the JPG extension. When the user presses the "Start" button, the application initializes the parallel port and begins to monitor the button states.

The application checks for any new button presses every 250 ms when triggered by a Windows Timer event. The associated event handler parses the data read back and performs the appropriate action. These actions include: 1) starting the photo viewer; 2) displaying the next photo; and 3) displaying the previous photo. As the user traverses the directory, file paths are stored in a Standard Template Library (STL) vector of CString objects. These file paths are traversed by the use of a vector iteration. Unlike a standard array, an STL vector grows on its own, reallocating memory as needed. Images are opened on the screen, utilizing the default windows image viewer, and they are then displayed on the wall via the LCD projector.

The cost of the parts and materials was about $65.

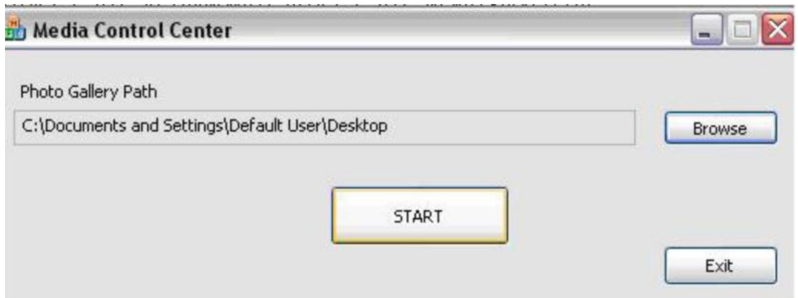

Fig. 16.11. Media Control Center Application Software.

TACTILE IMAGER

Designer: Nicholas H. Brunelle
Client Coordinator: Thomas David, Malden Elementary School, Malden, MA
Supervising Professor: Alan Rux
University of Massachusetts at Lowell
Lowell, MA 01841

INTRODUCTION

The Tactile Imager was designed to provide a textured representation of a digital image for an elementary school student with visual impairments. The interface of the device is an array of actuators that respond to an input from a computer and form a binary topographical map of the image. Fig. 16.12 is an example of how a silhouette of a cat looks when displayed. The blue squares represent a solenoid that is activated, forming a raised bump. The white squares represent a solenoid that is off, forming a recess in the texture. The user feels the image with his or her hands and is able to form a mental picture of the image being displayed. The device is a way of letting people with visual impairments experience pictures in ways they previously could not.

SUMMARY OF IMPACT

Through the use of touch, the client is now able to feel items that could previously only be seen. The device expands the experiences possible for the client.

TECHNICAL DESCRIPTION

The major parts of the device are: 1) the solenoid array (Fig. 16.13); 2) the solenoid controller stack; 3) the USB interface card; and 4) the power supply. Fig. 16.14 shows a block diagram of the interconnections of the parts.

The solenoid array was constructed from two sheets of 3/16" sheet aluminum bolted in parallel with a space in between. The space contains the solenoids. The top plate has an 18 by 18 grid of 3/16" diameter holes that the solenoids mount to. The actuator from each solenoid has a small polymer block mounted to it and, together, they form the tactile surface. One lead from each solenoid is connected to the positive terminal of the power supply. The other lead from each solenoid is connected to a switching transistor on the solenoid controller card (SCC). There are seven SCCs, each of which controls up to 48 of the 324 solenoids. Each SCC has six latches with a common eight bit data buss and up to 48 switching transistor circuits. The SCCs are controlled by loading eight bits of data onto the data buss and enabling one of the latches. After the data is loaded into the latch, it is disabled and holds the data. The output from the latch is used to control the switching transistor circuitry. This is then repeated for each of the 41 latches across each of the SCCs.

Fig. 16.12. Image Output

Cooling fans were installed on the solenoid array to remove the heat generated by the solenoids.

The USB controller card contains a USB interface chip and latch-enable circuitry for the SCCs. The image is sent from a computer and loaded into its memory. Data is sent to the USB controller as a string of 42 bytes of binary data. The circuitry on the USB controller card: 1) reads off 1 byte of data at a time; 2) puts the data onto the data buss; and 3) enables the corresponding latch that holds the data.

The device is operated via a computer program. An image can be loaded into the program, converted to an 18 by 18 black and white image, and then output to the tactile imager via a USB connection.

The total cost of this device was about $2000.

Fig. 16.13. Solenoid Array.

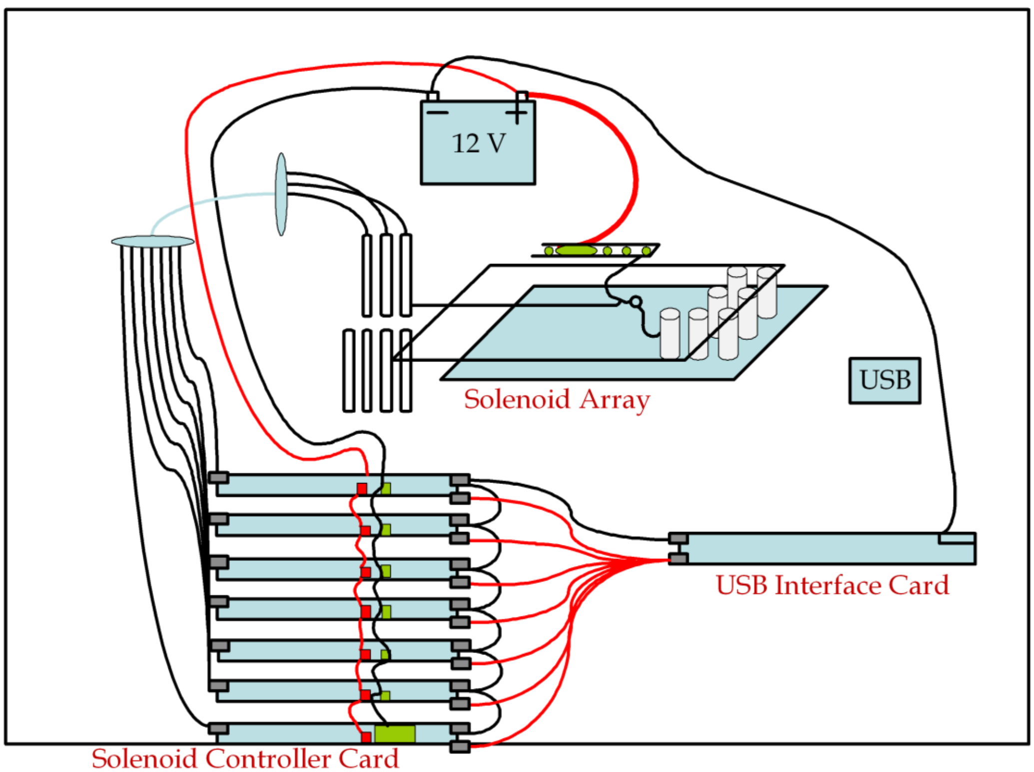

Fig. 16.14. System Diagram.

AUDIO MIXER

Designer: Phong K. Dinh
Client Coordinator: Tony Chavez and Keith Casavoy
Supervising Professor: Prof. Alan Rux
Electrical and Computer Engineering Department
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Lowell, MA 01854

INTRODUCTION

The AMVI (Fig. 16.15) was designed to enable a client to control an audio mixer. The client requested the ability to control the volumes or faders of each individual channel through sliding potentiometers. Large rocker switches and large knobs were used to maximize control and stability of the system. The device allows the client to fully control every aspect of the audio mixer.

SUMMARY OF IMPACT

The device provides the client with increased independence and enjoyment by allowing him control of the audio mixer. The switches and knobs help him locate the controlling devices more quickly. The built-in micro-switches inside each sliding potentiometer also allow the client to simultaneously control mixer functions, which he could not do previously.

TECHNICAL DESCRIPTION

The AMVI is a modified version of the Arrakis 150SC Console. The audio mixer is powered by an AC to DC converter. The power converter converts 120-volts AC to an adjustable 12-volt DC output. The console consists of five input channels. Within each channel are two different sections: A and B. The total number of inputs for the AMVI is ten. The inputs for each channel are located directly on top of the audio mixer. The inputs include eight phono jacks and two microphone XLR female connectors. The controlling interfaces for the AMVI are six sliding potentiometers and seven rocker switches.

The audio feedback circuit for the AMVI (Fig. 16.16) consists of a Basic Stamp 2E microcontroller from Parallax. A voice recorder chip, ISD 2560, was used to process and store prerecorded messages. The messages tell the client the status of the mixer. The ISD 2560 provides a large sampling frequency (8 kHz/sec). The ISD 2560 has 60 seconds of record and playback time.

Fig. 16.15. Audio Mixer.

When in operating the AMVI, the six rocker switches enable the individual reed relays to be energized so that sound or music is output to the program buss. The Basic Stamp 2E also plays back the stored messages through the ISD 2560. The messages are heard through the phono jacks, which are located directly in front of the client. The audio feedback tells the current status of a particular channel. Pressing the status pushbutton plays the entire status of every channel on the audio mixer. The status pushbutton is isolated from the other buttons.

The cost of the parts and materials was about $1500.

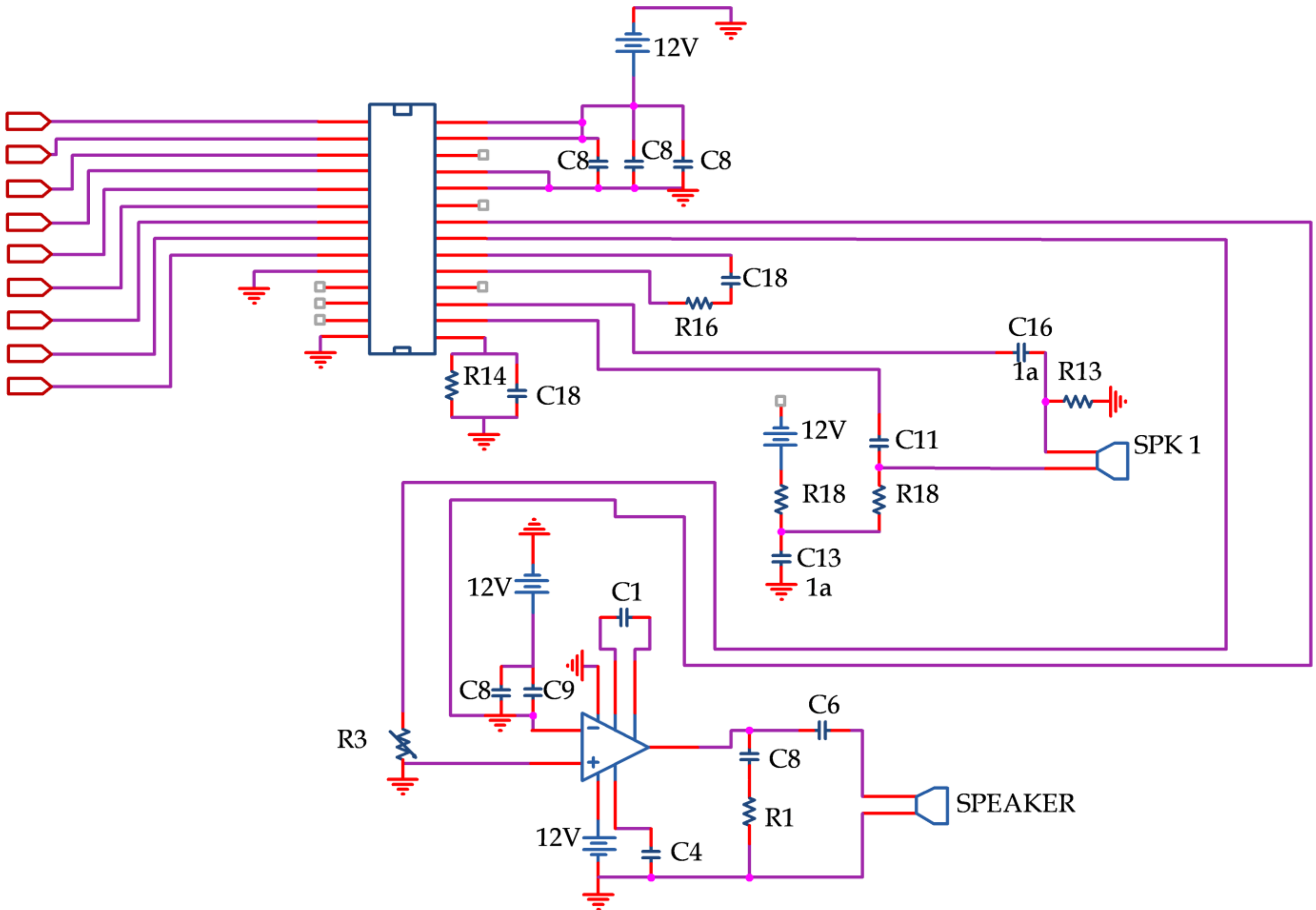

Fig. 16.16. Schematic for Audio Feedback.

WIRELESS REMOTE CONTROL WHEELCHAIR TRAINER

Designer: Run Ron
Client Coordinator: Bonnie Paulino, Franciscan Hospital for Children, Boston, MA
Supervising Professor: Prof. Alan Rux
Electrical and Computer Engineering Department
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INTRODUCTION

The Wireless Remote Control Wheelchair Trainer (WRCWT) was created for children with disabilities at a hospital. The device was created by mounting a miniature wheelchair frame to the body of a remote control toy car (Fig. 16.17). The children may practice motorized control with the WRCWT before controlling a full-size motorized wheelchair. Practicing helps the children familiarize themselves with the joystick control on a full-size power wheelchair.

SUMMARY OF IMPACT

The device helps children with mobility and fine motor control difficulties to increase motor control by exercising their fingers while using the joystick. It also provides a form of entertainment for the children.

TECHNICAL DESCRIPTION

The structure of the WRCWT includes an 18″ tall toy wheelchair from the American Girl Company. The frame underneath is a 6″-high toy car frame from

Fig. 16.17. Wireless Remote Control Wheelchair Trainer.

New Bright Company. The two frames were mounted together with two 3/8” screws. Both the wheelchair and remote control have a power switch.

The remote control step design is similar to that of a controller on a real power wheelchair. The joystick moves in a 360-degree rotation. The transmitter and antenna were designed into the remote control joystick (see Fig. 16.18). A window comparator connects the three circuits. The window comparator has high and low reference voltages. The high references voltage is 1.6-volt and the low references voltage is 1.4-volt. The LM339 chip was used for the comparator.

The transmitter is an electronic device that sends an electromagnetic signal through the antenna. The power source has three volts from two battery sources, which turn on the transmitter and receiver.

The transmitter was designed with: 1) an oscillator; 2) a modulator; and 3) an amplifier. The transmitter module mount sends the radio frequency (RF) through the antenna to the receiver. The RF is 45 megahertz. The receiver was mounted on the bottom of the toy wheelchair. The receiver gets the RF through the antenna and decodes the RF signal to navigate a position desired by the user. The code uses three bits binary code: one as on and zero as off. The code is then decoded to the position sent to the motor, and it makes the wheelchair move to the desired location.

The WRCWT is powered by six Energizer batteries (AA, 1.5-volt). The batteries power the remote control and the motor connected to the wheelchair.

The cost of the parts and materials was about $170.

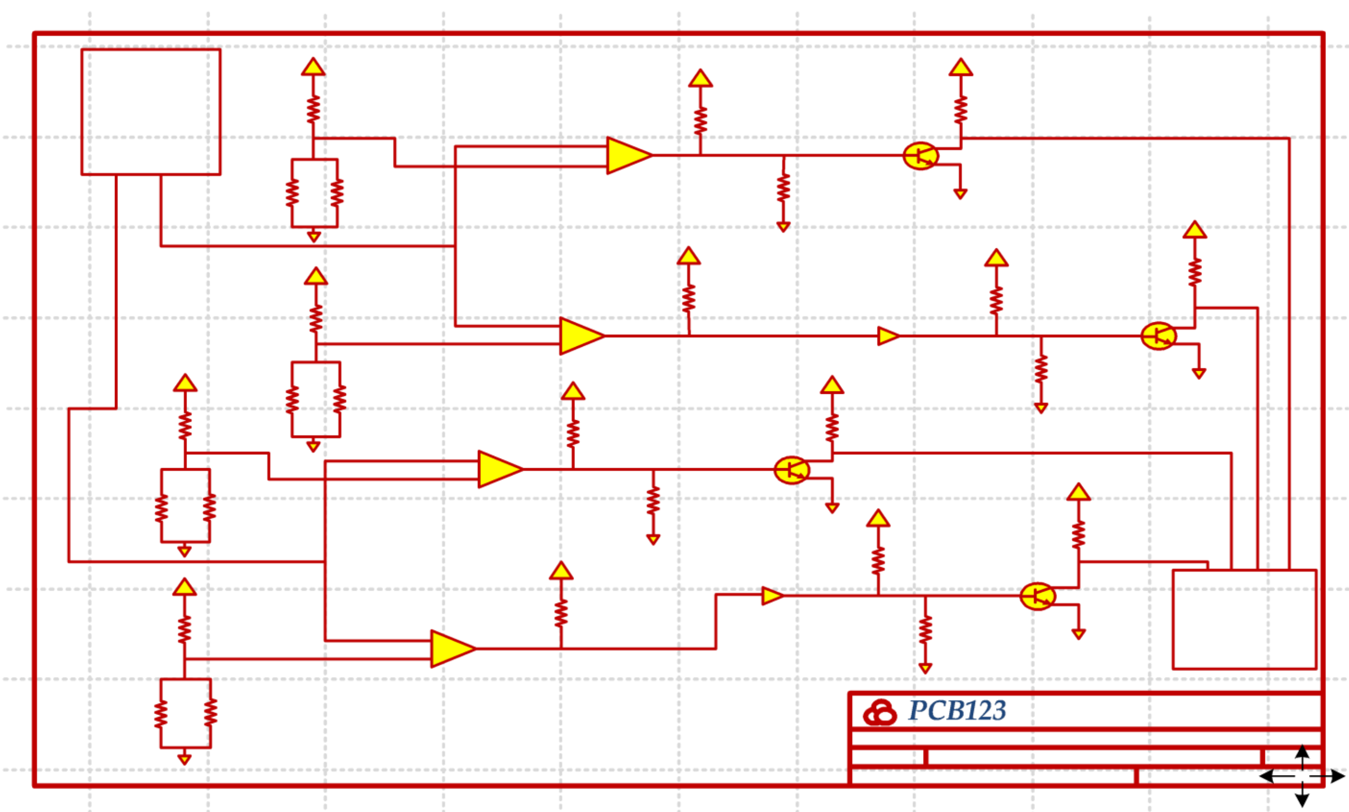

Fig. 16.18. WRCWT Joystick Schematic.

HANDS DOWN, SIT UP STRAIGHT

Designer: Shawn P. Garvey
Supervising Professor: Alan Rux
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University of Massachusetts Lowell
Lowell, MA 01850

INTRODUCTION

Hands Down, Sit up Straight (HDSS) (Fig. 16.19) was designed as a learning tool for a child with autism. The HDSS detects arm motion and tilt angle, and it plays a prerecorded message from the teacher to ensure that the client holds his hands down and uses good posture. When the client raises his hand past his upper chest the HDSS detects the motion and plays a message: "Please keep your hands down." A tilt sensor detects the angle of his body when the client is sitting. If the client leans too far forward it plays a message: "Please sit up straight." HDSS gives the client feedback without constant intervention by his teacher.

SUMMARY OF IMPACT

HDSS promotes acceptable classroom behavior and limits the amount of time that the teacher spends reminding the client to put his hands down and to sit up straight. HDSS provides feedback to the child when the teacher is busy working with other students.

TECHNICAL DESCRIPTION

The HDSS consists of: 1) a plastic case for the chassis with four buttons; 2) two LEDs; and 3) a battery pack mounted outside the case. The device is attached to a strap that the client wears comfortably. The buttons are for the teacher's use only and they are: 1) on/off; 2) play/record; 3) start/pause; and 4) stop/reset. On/off turns the power on and powers up the circuit with six volts DC. Play/record is always in the play mode unless the teacher wants to record a new message. To record a new message, the teacher switches to record and pushes the start/pause button. To stop recording, the teacher presses start/pause again and switches back to play. Start/pause resets the circuit if a problem arises. The LEDs are green and red. The green LED turns on to indicate that HDSS is powered up. The red LED indicates that the recording mode is on.

Fig. 16.19. Client Using Device.

HDSS internal circuitry uses two main sensors for tilt and arm motion. A playback/record IC chip is used for message storing and playback (Fig. 16.20). When the sensors detect motion or tilt, they send a low voltage pulse to pin 23 of the ISD2540 and output a pre-recorded message through a speaker. For the ISD2540 IC the main pins used are: 1) the Chip Enable (CE) pin 23; 2) Play/Record (P/R) pin 27; 3) Speaker pins 14 and 15; and 4) the addresses (A0-A8) pins 1-9. The P/R pin must be low to record a message, and the CE pin must be pulsed low to start recording and then pulsed low again to stop recording. When playing a message, the CE pin pulses to a low voltage and an 8-16-ohm speaker attaches to pins 14 and 15. When motion and tilt are detected, the CE pin pulses to a low voltage, which results in the message playing back.

A proximity sensor was used for motion. The proximity sensor has a detection range of 24-cm. When the sensor detects movement, it sends a high output voltage. The voltage goes into a logic NAND gate and then to a logic AND gate, which pulses CE to a low voltage and plays the pre-recorded message. If there is no motion detected, the logic AND gate keeps the CE pin high and does not play a message.

The sensor produces a high voltage when tilt angle exceeds 30 degrees. The high output voltage changes addresses A5 and A7 of the ISD2540 to high. When CE pulses low, it will play the message at the corresponding address. The output voltage of the tilt sensor is 1.7 volts. An op-amp increases the voltage to 3.5 volts. The high voltage goes from the op-amp to a time delay IC, which allows enough time to change the address. The high voltage then goes into a logic NAND gate and to a logic AND gate, which pulses CE to a low voltage and plays the pre-recorded message. If there is no tilt detected, the logic AND gate keeps the CE pin high and does not play a message.

The cost of the parts and materials was about $175.

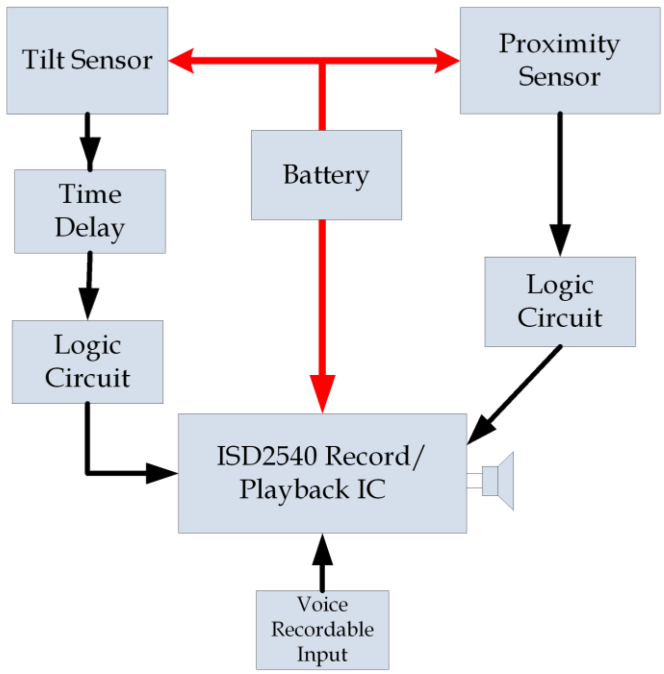

Fig. 16.20. Block Diagram.

SMART HAT

Designers: Thomas M. Donigan
Supervising Professor: Prof. Alan Rux
Electrical and Computer Engineering Department
University of Massachusetts, Lowell
Lowell, MA 01854

INTRODUCTION

The Smart Hat was designed as a learning tool to help an elementary school student with spina bifida and down syndrome pay more attention in school by reminding her to keep her head in an upright position. The device uses a low-g accelerometer as a two-axis tilt sensor mounted on a baseball cap (see Fig. 16.23). The Smart Hat detects when the client's head is no longer in an upright position, and it sends a signal through a radio frequency (RF) link operating at 415MHz to an alarm system. The alarm system simultaneously turns off a music player and sounds a pulsating alarm. The alarm stops and the CD music is turned back on when the SH detects the client's head is once again in an upright position.

SUMMARY OF IMPACT

The device encourages appropriate classroom behavior and reminds the client to pay attention in class. The device also decreases the amount of time that the teachers spend reminding the client to attend to tasks. The device incorporates the client's interest in music.

TECHNICAL DESCRIPTION

The Smart Hat is composed of two basic components: 1) a tilt-monitoring circuit (see Fig. 16.21) and 2) an alarm-triggering circuit (see Fig. 16.22). The tilt monitoring circuit is positioned on the brim of a baseball cap. It monitors the orientation of the client's head by measuring the net force of gravity along the vertical and horizontal axes. This is done with a low-g accelerometer from Analog Devices: the ADXL213. The outputs of the ADXL213 are digital signals, and the duty cycles are proportional to acceleration. When the accelerometer is oriented so that both its X and Y axes are parallel to the earth's surface, it can be used as a two-axis tilt sensor. It is used to measure both the pitch and roll of the client's head. Two pulse-width modulated signals are fed into a Parallax Basic Stamp microcontroller BS2 SX, which

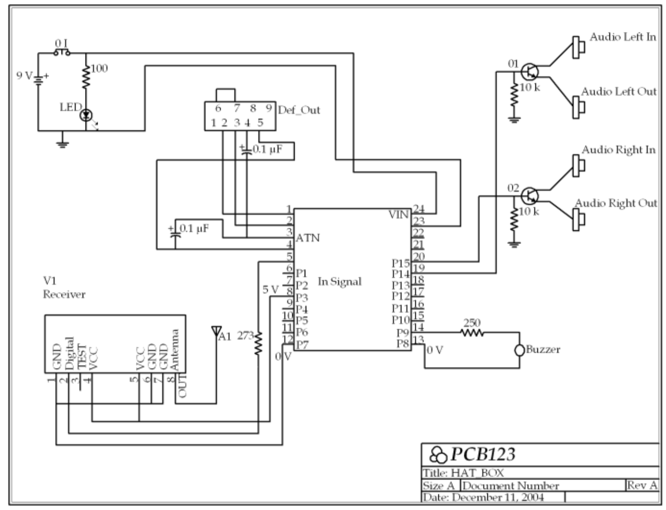

Fig. 16.21. Tilt Sensor Circuit.

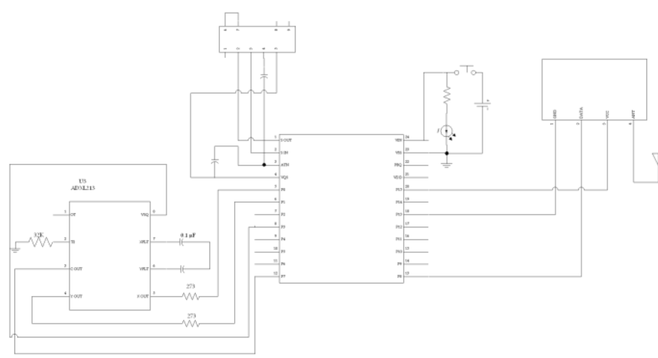

Fig. 16.22. Alarm Triggering Circuit.

measures the pulse width of the signals and then calculates the corresponding angle.

An angle of orientation that exceeds 60 degrees for more than three seconds indicates that the client's head is no longer upright. A signal is then sent to the alarm-triggering circuit. The circuit simultaneously turns off the music coming from a CD player and sounds an alarm. The communication between the tilt-monitoring circuit and the alarm-triggering circuit is generated by a small receiver and transmitter pair operating at 415MHz.

The alarm-triggering circuit has: 1) a transmitter; 2) a Basic Stamp Microcontroller; 3) two MOSFETS that switch music on and off; and 4) a nine-volt battery for power. The circuit is encased in a small project box, and it has: 1) a power switch; 2) a piezzo buzzer; and 3) terminals used to connect a CD player and speakers. A signal that is picked up by the receiver turns the microcontroller and the piezzo alarm on. It cuts off the signal between the CD player and speakers by controlling the gate voltage on the MOSFET.

The cost of the parts and materials was about $300.

Fig. 16.23. Project Setup.

CHAPTER 17
UNIVERSITY OF NORTH CAROLINA AT CHAPEL HILL

Department of Biomedical Engineering
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Principal Investigator:

Richard Goldberg (919) 966-5768

SIGHT 'N' SOUND SHOWER TIMER

Designers: Andres Afanador and Laura Malone
Supervising Professor: Richard Goldberg
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INTRODUCTION

The Sight 'N' Sound Shower Timer (SSS Timer) was created for a client with cerebral palsy who has difficulty following sequences of steps. The client requested a timer with: 1) accessible controls; 2) a large display; 3) loud sounds; and 4) highly visible indicator lights.

The SSS Timer is a multi-step programmable timer that is interactive (see Fig. 17.1). The device has two modes: "Shower" and "Non-Shower". The timer is also versatile and allows for saved settings. Icons light up on the timer to tell the client what task he should complete. The timer has bright lights and a customizable alarm to notify the client when time is up. It also uses: 1) large LEDs; 2) a low-frequency buzzer that is easier for the client to hear; 3) an LCD screen that displays the step and countdown time; and 4) illuminating icons corresponding to each step.

SUMMARY OF IMPACT

The SSS Timer allows the client to have greater independence while showering and reading and during mealtimes. The client uses the timer about three times per week. His mother stated, "The device is great. It is easy to use. The flashing lights and buzzer really engage him. The 'GO' button is perfect for him. He seems to really like the count down lights." The device corresponds to the client's color and style preferences and appears to be enjoyable for him to use (see Fig. 17.2).

TECHNICAL DESCRIPTION

The SSS Timer is housed in a 7 ¾" x 4" x 2" case with a white acrylic face and plastic sides and bottom. The acrylic face has milled sections of 0.05" thickness so that each of the 13 LED lights can shine through. The lights are inside to ensure water resistance. Screening spline was used to seal the gap between the face and sides of the enclosure.

The SSS Timer is controlled by a PIC microcontroller (PIC16F876), programmed in C. A regulator (LP2957) controls the voltage output to the circuitry from 4 AA batteries. The PIC chip outputs to an LCD screen and 13 lights (SSP-LX6144D3SC). The LCD screen displays the programming instructions on the front plate and also counts down the time once the timer has been initialized. Five of the lights count down the last five minutes of each stage. The lights are situated vertically in the center of the front face. Two of the lights are green, two are yellow, and one is red. The other eight lights are used to indicate which step the user is on. Transparencies are attached to the face of the timer with icons and words that represent each task. The images light up from behind when the timer is on the corresponding step.

A low frequency buzzer sounds when the time reaches zero for each stage. The PIC outputs a square wave to a speaker to produce this sound. When the timer reaches zero time, two blinking LEDs flash on the front of the SSS Timer.

The only button that the client has access to is the "GO" button. The button is used when time is up and is used for the client to turn off the buzzer and blinking lights and advance to the next step. It is a piezo pushbutton located on the front face of the SSS Timer. Four SPST Switch Pushbuttons (RP3502MA) are located on the sides of the shower timer for programming use. These are used by the parent or caregiver. The programming buttons include: 1) two black pushbuttons for UP and DOWN; 2) a red ENTER button; and 3) a red INTERRUPT button that adds time during the timer countdown.

The cost of the parts and materials was about $289.

Fig. 17.1. SSS Timer Showing Time Remaining.

Fig. 17.2. Client Learning How to Use SSS Timer.

ADAPTED BUBBLE BLOWER AND CONNECT FOUR GAME

Designers: Andres Afanador and Laura Malone
Client Coordinators: Barbara Tapper, PT
Supervising Professor: Richard Goldberg
Department of Biomedical Engineering
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Chapel Hill, NC 27599

INTRODUCTION

Two different toys were modified for a girl with spastic cerebral palsy so that she could access them to play independently or with her peers. A commercial bubble-blowing toy was adapted so that the client could blow bubbles independently. The bubble gun holder stabilizes the toy to her wheelchair lap-tray or to a desk (Fig. 17.3). It is equipped with a handle to ease triggering and dampen spastic pulls. The bubble gun also strengthens the client's shoulders and back.

A Connect Four® game was also modified to meet the client's needs. Funnels were placed at the top of the slots to improve accessibility. The funnels help the client to improve her motor control as she drops checkers into the desired slot. Further modifications were made to tilt the entire unit forward to decrease the amount of reach needed to access the top of the funnels (see Fig. 17.4).

SUMMARY OF IMPACT

These two devices allow the client to interact with other children during leisure time and also help to improve strength and motor control. The devices can be used independently if desired.

TECHNICAL DESCRIPTION

The bubble gun holder is made of 1 1/4″ PVC joints resting on a 7″ x 7″ white ¼″ acrylic base. The gun handle fits in one opening of the PVC design and a bubble solution well sits on the other end. A rubber-lined clamp is located between the trigger and handle of the gun to dampen the force of spastic pulls. Colored straps tie the gun to the holder. Colored 1/8″ inch rope was fed through the ring-shaped trigger and wrapped around a ¼″ dial to create a handle. The bubble gun can be easily removed from the holder for cleaning.

The Connect Four® adapter is made out of 1/16″ clear acrylic. A 3 1/4″ tall inverted pyramid-shaped funnel with a rectangular base runs the length of the game unit. The opening is 3 1/4″ wide at the top and 0.37″ wide at the bottom where it meets the slots. Colored triangular dividers separate the slots to improve visibility. The adapter and game unit are bonded together by an acrylic adhesive. The unit is attached to a base, which clamps to the client's lap tray for stability. The entire unit is hinged so that it can be tilted toward the client. Custom acrylic pieces are attached to the base to limit the tilting to an appropriate angle.

The total cost of the materials was $99.

Fig. 17.3. Bubble Gun.

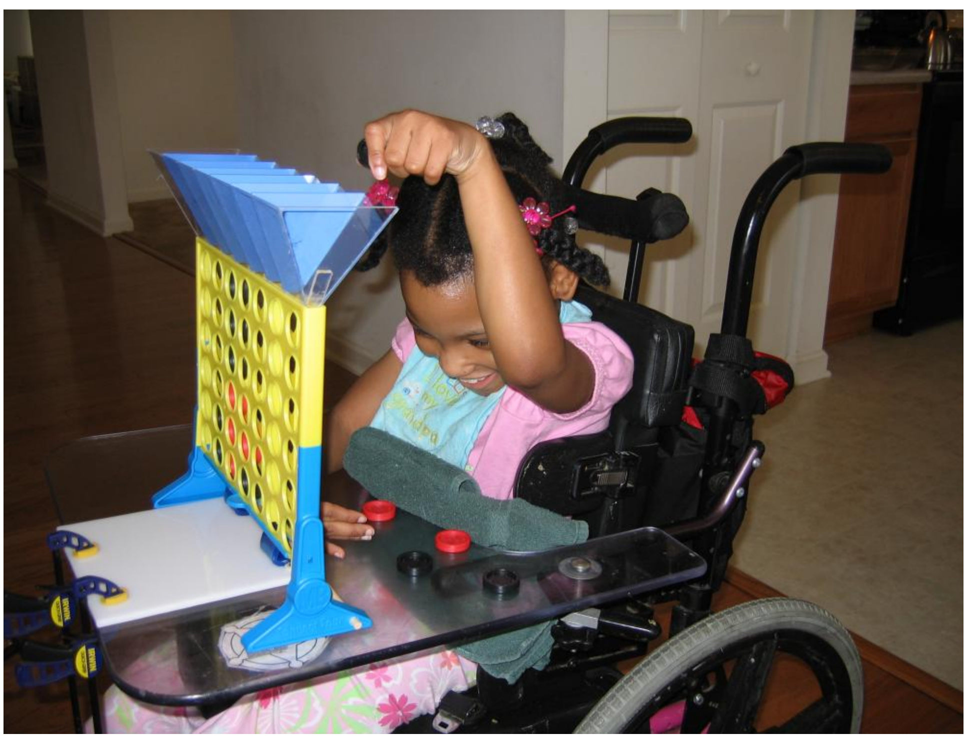

Fig. 17.4. Connect Four® Adaptations.

WALKER MONITOR

Designer: Nancy Du and Shawn George
Client Coordinator: Linda Cates, PT, Duke University Medical Center
Supervising Professor: Richard Goldberg and Kevin Caves
Department of Biomedical Engineering
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University of North Carolina at Chapel Hill
Chapel Hill, NC 27599

INTRODUCTION

The Walker Monitor (Fig. 17.5) was designed for a woman with Parkinson's disease. She requested a walker that would minimize "freezing of gait" episodes, falls, and loss of balance. The Walker Monitor constantly monitors the patient's position behind the walker and automatically activates visual and vibratory stimuli to help the client break a freeze. The device also promotes correct posture and position.

SUMMARY OF IMPACT

The device serves as a preventive measure to remind the client to step forward and regain proper position behind her walker, helping prevent injury. The vibratory cue allows the client to focus her gaze ahead. The client coordinator said that the device will be of great benefit to people with Parkinson's disease who experience freezing of gait.

TECHNICAL DESCRIPTION

A Sharp GP2D12 infrared distance sensor, with the ability to measure from 10 cm to 80 cm at an accuracy of ±1 cm, continuously measures the distance between the torso and front of the walker. The sensor outputs the distance to a Basic Stamp 2 (BS2) microcontroller chip (Parallax, Inc., Rocklin CA). The distance is compared every 50 ms to a threshold distance, which is set by the clinician and represents the upper limit of the "safe-zone." When the measured distance exceeds the threshold, the BS2 activates external cues to remind the user to take a step closer.

One of the external cues is a horizontal laser light beamed on the ground in front of the client's feet to remind her to take a step. Vibrating (pager) motors that are sheathed in pads are attached to the handles of the walker. They provide a tactile prompt and indicate when the client should be taking a step.

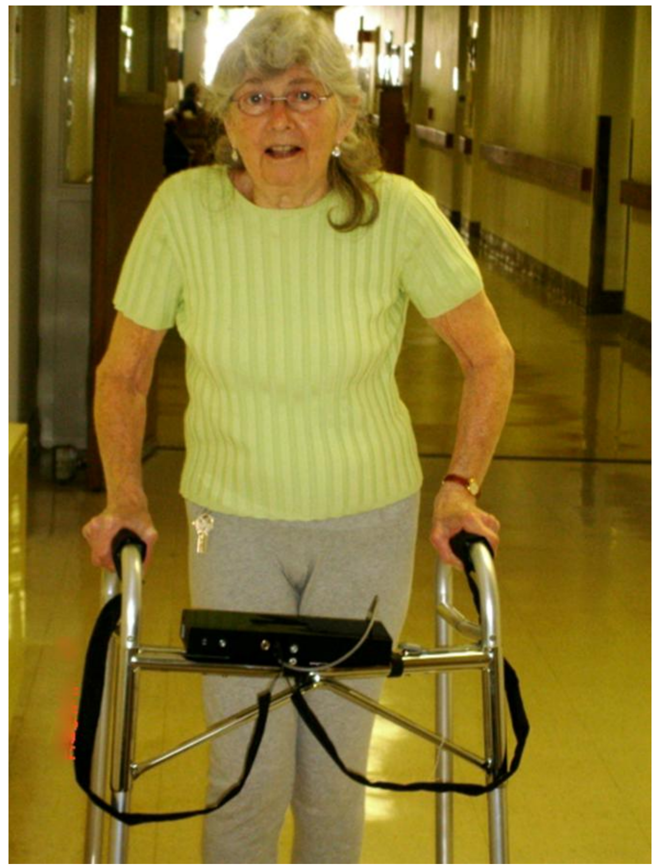

Fig. 17.5. Client with Walker Monitor.

The clinician or client may set the threshold distance on the device by turning a knob attached to a potentiometer. The threshold distance (in cm) is on the LCD display of the device. The LCD also displays the distance that is read from the distance sensor. It instructs the client to "move away" when she is too close and to "step closer" when she gets too far. Switches allow the client to choose between the laser cue and vibratory cue. Diagnostic switches are used for testing and calibration of the laser and the motors. They allow the therapist to adjust the laser light position for the client, and they also allow the client to feel the vibratory motors. All components except the laser were enclosed in a low-profile custom built box (Fig. 17.6). The box mounts quickly and securely to the walker using bicycle light mounts.

The device can remain on at all times. When the user steps away from the device, the walker monitor enters a low-power sleep mode. When in sleep mode, the device briefly wakes up and reads the sensor every four seconds to see if there is an individual in front of the device. When a client is detected in front of the walker, the device returns to operational mode and scans every 50-ms. The energy efficient function enables a battery life of more than three days when fully charged. A rechargeable 7.4-volt Lithium-ion battery powers the device. It can be recharged by plugging in a detachable battery charger, which also disconnects the main circuit from the battery during charging. A 'low battery' LED prevents over-discharge of the battery and reminds the user to plug in the charger.

The cost of the parts and materials was about $377.

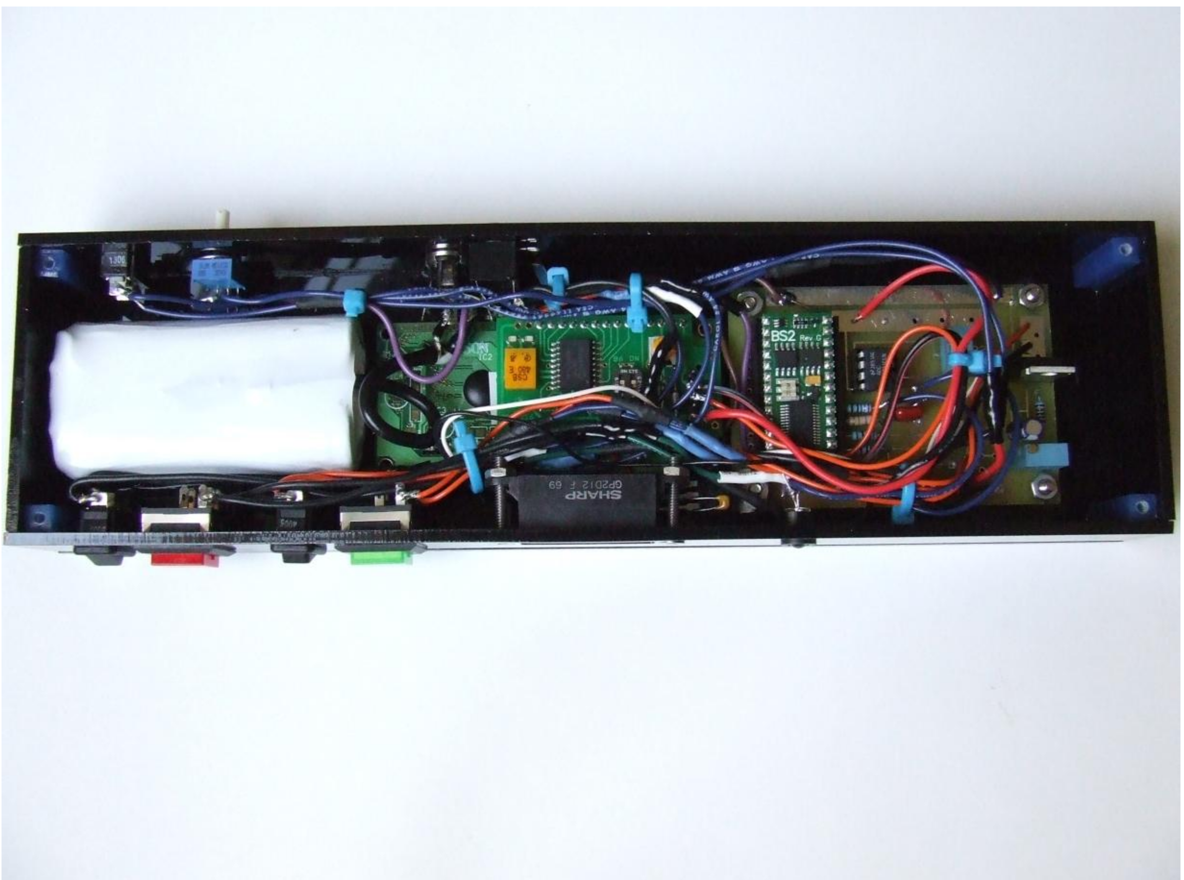

Fig. 17.6. Interior of Device.

MOVEABLE ARM SUPPORT

Designer: Eric Dawkins, Justin Braveboy-Wagner, and Aakash Patel
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Department of Biomedical Engineering
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INTRODUCTION

The Moveable Arm Support was created for a man with peripheral neuromuscular disease. The device helps him to lift his arms with minimal strength, and it takes advantage of his relatively good leg strength. His ankles are connected to his wrists via a pulley system such that kicking his legs out causes his arms to lift (Fig. 17.7). Each ankle is connected to the corresponding wrist. The device is mounted to a chair, and it can be easily transferred between his wheelchair and most conventional chairs.

SUMMARY OF IMPACT

This device increases the client's ability to perform tasks that entail lifting his arms. The client stated that to pick up food, "before I had this device, I had to use both hands and bend over, but now I only need one hand. I like being able to sit back and still lift my arm. Also, I can reach more keyboard keys at the computer." Use of the device improves the client's activities of daily living, such as his ability to eat.

TECHNICAL DESCRIPTION

The device is a pulley system that straps to a wheelchair or conventional chair. The system was made from black PVC pipes. It is left-right symmetrical so that it can be used with both arms and legs simultaneously. Each side is in the shape of a "C". The upper end is just above the client's shoulders for the arm connection, and the lower end is just below the seat of the chair for the ankle connection. A cross-piece connects the left and right halves, which allows for easy adjustment to change the distance between the two halves. The "C" shaped pieces also adjust to different heights relative to the chair, which allows for easy adjustment for different chairs.

A pulley system connects the client's leg motion to the lifting of his arms, and it allows for easy movement. Clear picture hanging wire passes through the sets of pulleys. It provides enough strength to lift the client's arms and is relatively discreet. It connects to straps on each end that wrap around the client's ankles and wrists. The straps are adjustable and comfortable for the client.

The total cost of the device was about $100.

Fig. 17.7. Movable Arm Support.

ASSISTIVE PLAY STATION

Designers: Andres Afanador and Laura Malone
Client Coordinator: Lorin Holmes, Teacher, Durham Public Schools, Durham NC
Supervising Professor: Richard Goldberg and Kevin Caves
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INTRODUCTION

The Assistive Play Station was created for a four-year-old client with cerebral palsy (see Fig. 17.8). The station allows him to play by himself and explore different textures. The station can be used in the classroom and when he stays with his mother at work. The station also provides the client with auditory stimuli. It complements physical therapy by strengthening movement in his arms.

SUMMARY OF IMPACT

The Assistive Play Station incorporates the client's senses of touch and hearing. His teacher said, "The toys and textures [of the Assistive Play Station] are very age-appropriate for him. Usually, he has to play with toys for infants."

The device motivates the client to develop and strengthen the use of his left arm and hand. The device is adaptable, and the client can use it while in a group setting as well. It allows for interaction with his classmates who also enjoy activating the music. The client's teacher said that the device impacts his life through "independent exploration [and] social interaction… He can use it at home and school, [to] work on developing cause/effect skills, reach and grasp."

TECHNICAL DESCRIPTION

The Assistive Play Station incorporates cause and effect stimuli. Only auditory and tactile stimuli are used. The device has two push switches (commercial) and two pull switches (custom-made) for motor tasks. All of the switches are interchangeable with any commercial switch that uses a standard 1/8" plug.

The device is adaptable to three different positions: 1) on the floor over the client; 2) attached to the arms of his wheelchair; or 3) on a table in front of him. The device has telescoping sides and a rotating

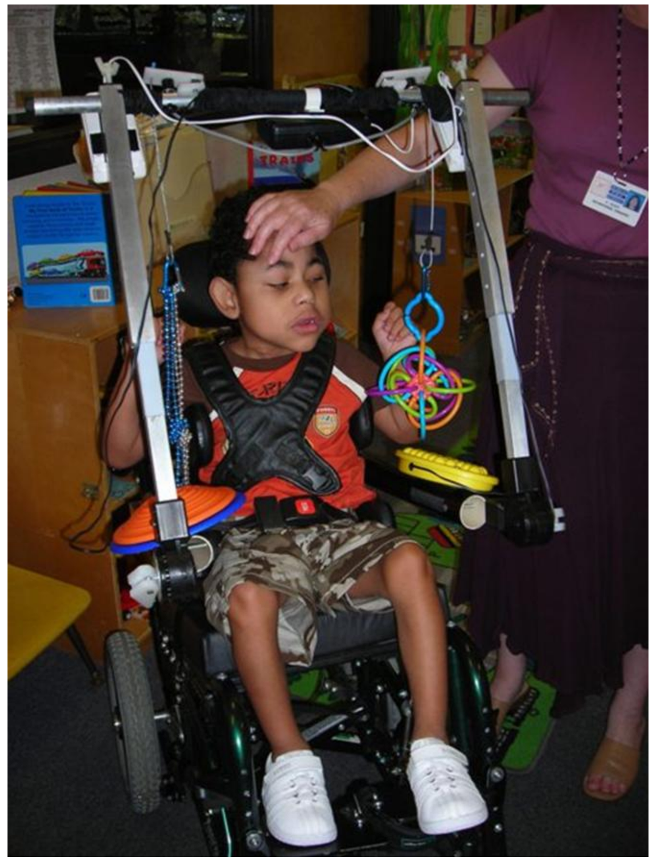

Fig. 17.8. Client Using Play Station.

frame so the configuration can be changed based on how he is using the device and adapted as he grows.

The Assistive Play Station is built out of an aluminum frame. The top crossbar is made out of ¾" diameter aluminum of 1/16" thickness. The telescoping sides are made from two pieces of aluminum: ¾" square tubing inside one inch square tubing. The telescoping tubing is held in place by a quick-release button. Teflon and thin acrylic are attached inside the outer tube so that the inner tube can slide easily within the outer one. The telescoping tubes are attached to incremental-angle position hinges. The hinges lock the frame at any angle based on how the client is positioned. Quick-release cams were included to allow the client to release the locks (Fig. 17.9). They work similarly to quick-release levers on bicycle wheels.

The base is made of ¾″ square tubing, stabilizing the frame. Attached to the square tubing are 1 1/4″ diameter black PVC tubes. The base can be pulled out of the hinge, turned inward, and reinserted so that the PVC tubes face inward. They then slide over the armrests of the client's wheelchair for attachment.

When the client activates one of the four switches, it directly triggers the µMP3 player (Rogue Robotics) to play the corresponding song. The four songs are stored on a Secure Digital (SD) flash card, and different songs can be downloaded to it using an SD card reader interfaced to a computer. The player is set up for uninterrupted play mode; the song will not restart if the client pulls the switch while a song is playing. The MP3 player connects to battery-powered speakers, which have a volume control for listening to the music. A regulator converts the 9-volt DC from the battery into the 5-volt needed for circuitry operation.

The total cost of the device was $466.

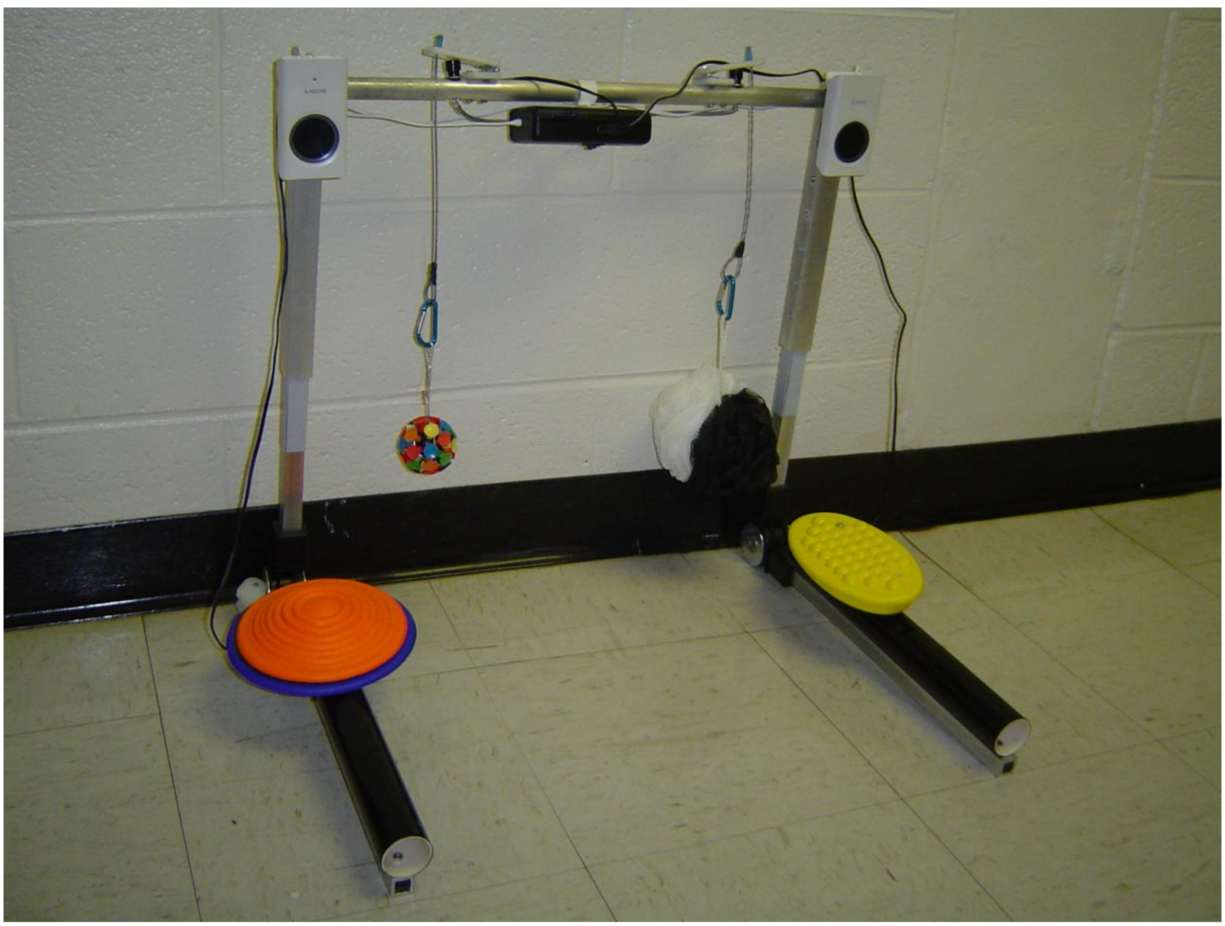

Fig. 17.9. Play Station Device.

C-PAD AUDIBLE ITEM COUNTER

Designers: Yin Song and Jessica Kesler
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INTRODUCTION

The C-Pad counting device (Fig. 17.10) is a learning tool that helps high school students with disabilities learn how to count and package a particular quantity of items. The counter introduces the students to the process of template counting and also increases their understanding of numbers. The counter is used to count any "widgets," which contain a magnet, that trigger the magnetic sensors of the device. In turn, the device provides audio feedback and praise to teach the students how to accurately perform the task. The magnets are in tea candles and a variety of plastic objects.

SUMMARY OF IMPACT

The C-Pad facilitates student progression from a classroom setting to a vocational environment by providing auditory feedback and encouragement. The C-Pad runs smoothly with minimal troubleshooting required from the client. Through the counter's variability and adaptability, the device allows students to progress to a state of counting independence. The client coordinator commented, "Given the multi-dimensional presence of this counting device, a student will have many opportunities to increase the ability to count, recognize numbers and transition the learning to home and pre-vocational… Students… were able to use this device with varying levels of assistance."

TECHNICAL DESCRIPTION

The device has a three-board design. Board one is a storing area for the widgets. Board two is the template where counting takes place. Board three is a containment bin that holds widgets after the student is done counting and clears the template. The smooth surface allows the students to easily transfer the widgets across the board. Board two is designed with a high back lip that prevents widgets from falling off. The teacher or therapist places different templates on top of this area. There are one to eight holes in it to provide a target area for placing the widgets while counting. A switch is set on the device so that it knows which template is being used.

Fig. 17.10. Client Using C-Pad

A PIC 16F877 microcontroller (Microchip) controls the device. Due to limitations of the PIC, a maximum of eight magnetic sensors were possible. Hall effect sensors were mounted to the underside of the template to detect when widgets (with magnets incorporated into them) were placed above them in the appropriate locations on the template. The µMP3 device (Rogue Robotics) provides voice feedback.

The code cycles through the Hall effect sensors and checks for sensor changes. If nothing happens for a prolonged period of time the PIC triggers the µMP3 player to play a reminder cue. If a sensor change is detected the program waits until the sensor stabilizes. The program: 1) counts how many active sensors are detecting widgets above them; 2) updates the seven segment display with the current count; and 3) checks which types of feedback are selected. If the count feedback is on, an audio feedback of the current count is played. If encouragement feedback is on, then audio encouragement is given.

The µMP3 player voices a command to clear the template of the widgets when all the sensors are covered. When all the sensors are uncovered, encouragement is given and then a voice cues the user to begin counting again.

The total cost of the parts and materials was $492.

Fig. 17.11. Client Using C-pad.

CHAPTER 18
UNIVERSITY OF TOLEDO

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ADAPTATION OF A WHEELCHAIR WITH A PAINTING STAND

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Client Advisor: Ms. Jill Caruso
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INTRODUCTION

A wheelchair was adapted for a man with a traumatic brain injury. The client loves to paint and draw while sitting in his wheelchair. Before receiving this device he could only draw when there was a flat table that he could reach. The purpose of this project was to develop a painting stand to allow the client to paint and draw while sitting comfortably in his wheelchair. The stand includes a drawing board that is attached to a frame mounted to the wheelchair. The board can be easily adjusted by an assistant in three directions and tilted away from the client for a more comfortable drawing plane. The stand includes magnetic templates that accommodate various paper sizes and also keep the paper from moving, distorting, or tearing. The stand is portable and lightweight so the client may take it wherever he desires. It can be easily attached and detached from his wheelchair (see Fig. 18.1).

SUMMARY OF IMPACT

The client is now able to paint and draw comfortably from his wheelchair. The stand improves his position and reduces stress in his neck and back (see Fig. 18.2 and Fig. 18.3). The device prevents the client’s paper from moving, which makes it easier for him to paint and draw. The device also brings the painting surface closer to the client and allows for a more enjoyable painting experience. The stand is portable, lightweight, and easy to set up. It can be easily transported from the home of the client to other locations where he paints.

Fig. 18.1 (a) and (b). Painting Stand Attached to Wheelchair.

TECHNICAL DESCRIPTION

The stand utilizes existing holes that are used to mount the wheelchair's footplates, which increases stability. The design includes a feature that allows the board to be tilted for more comfort while painting or drawing (see Fig. 18.4). Quick-release button connectors that are reliable and user friendly were used for attachment purposes. The quick-release button connectors prevent the wheelchair from being marred. Screw clamps were also used along the horizontal guide rails (see Fig. 18.4).

The board design has magnetic templates to hold the paper on the board. A very thin steel sheet was recessed into the board for a better appearance and to allow the magnetic template to lay flat. All of the templates can be stacked on top of each other, which provides easy storage and portability. A cup holder design was used for storage of painting and drawing supplies. This design allows the client easy access when grabbing brushes or pencils.

The material used to construct the frame was aluminum 6061 alloy. A sheet of Ultra High Molecular Weight Polyethylene (UHMWP) was used to make the drawing board. The weight of the board and the tilt bracket attached to it is nine pounds. The weight of the frame is 5.75 lbs; the total weight of the stand is 14.75 lbs.

Solidworks, a CAD software package, was used to model the painting stand. A force of ten pounds was applied to the board to represent the client pushing on it. The finite element analysis was also conducted using Solidworks to perform the structural analysis on the stand and the maximum stresses were calculated. The overall factor of safety of this structure determined by the software was 3.589.

The total cost of the parts was about $350.

Fig. 18.2. Client's Previous Method of Painting with a Table.

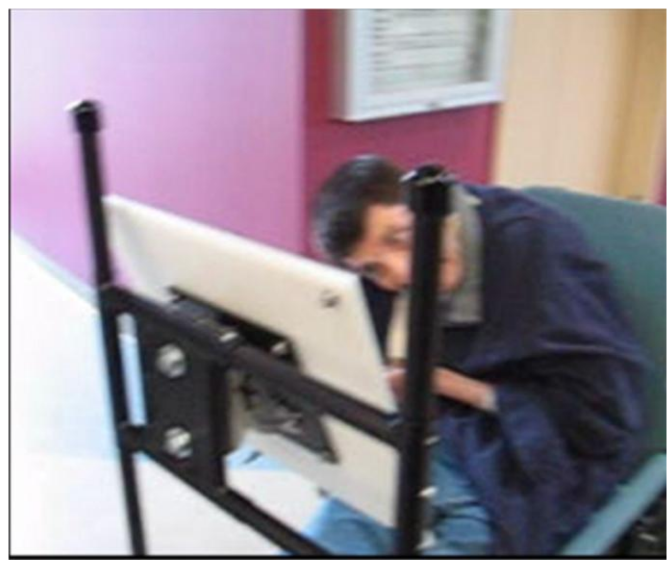

Fig. 18.3. Client Painting with Stand Attached to Wheelchair.

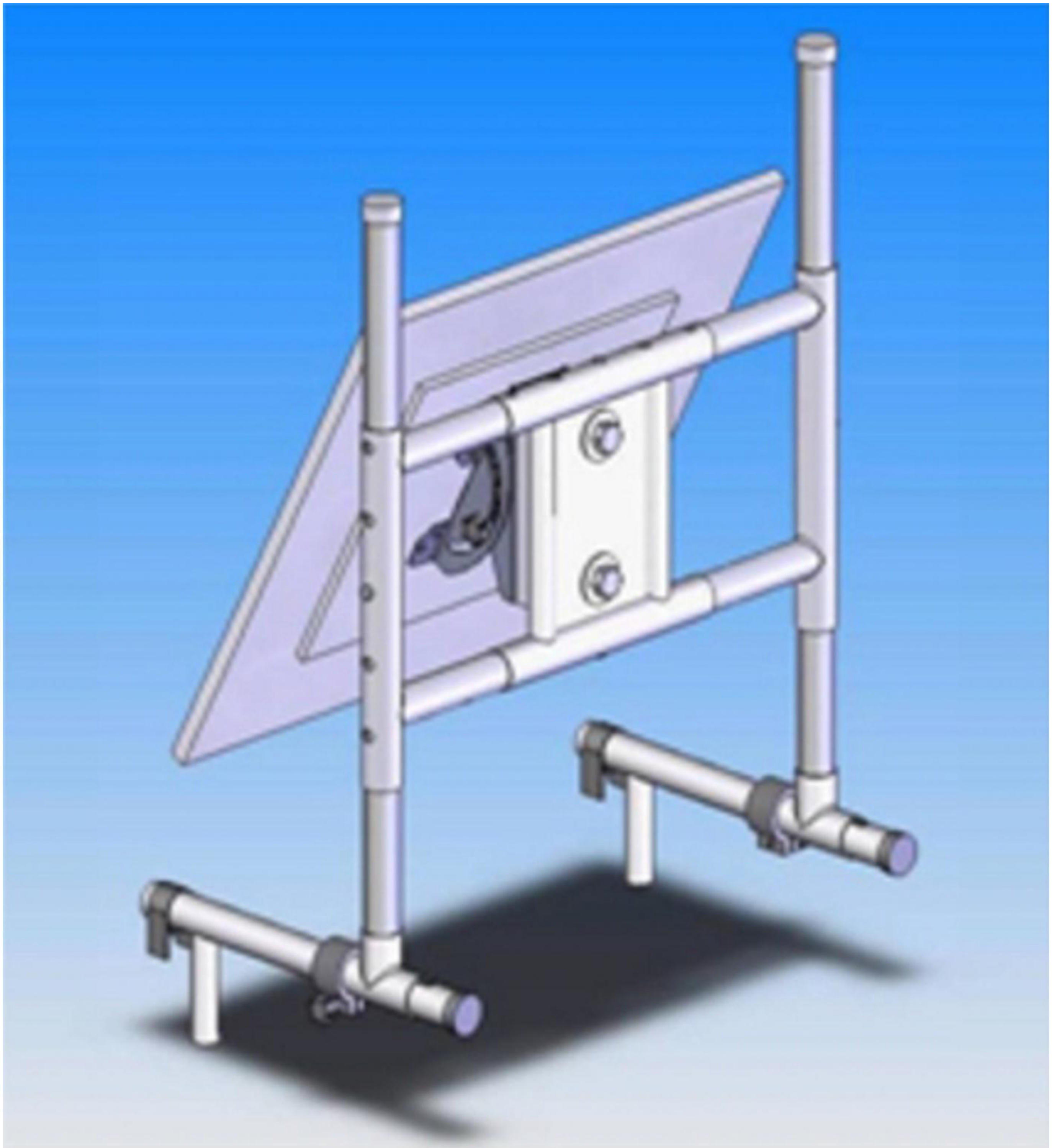

Fig. 18. 4. Computer Model of Stand.

WHEELCHAIR LIFTING SYSTEM FOR A PT CRUISER

Designers: Jason Balint, Joshua Michalak, Carmen Ricco, and Andrew Bishop,
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Client Coordinator: Ms. Jill Caruso
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INTRODUCTION

The goals of the project were: 1) to design and fabricate a lifting system that allows a woman to raise and lower her wheelchair in and out of the rear hatch of her PT Cruiser; 2) to reduce reliance on assistance from others; and 3) to enable continued use of the backseats. The lifting system is securely mounted in the rear of the PT Cruiser. It includes a main fixed post and a rotating cantilever arm attached to the post. A pulley is attached at the end of the arm for lifting and lowering the chair. Bearings in the main post allow the arm to rotate freely, which makes it easy for the client to maneuver the chair in and out of the PT Cruiser. The system includes a 12-Volt DC gear-motor unit that is used to lift the wheelchair and is powered by the car battery. The system is operated using a controller that is mounted on the motor. Fig. 18.5 shows the lift system in the closed position and Fig. 18.6 depicts the wheelchair being lifted into the car with the lift system in the extended position.

Fig. 18.5. Lift System in Closed Position.

Fig. 18.6. Lift System in Extended Position.

SUMMARY OF IMPACT

The lifting system meets all of the client's needs and increases the client's independence. It also allows enough room for full vehicle occupancy.

TECHNICAL DESCRIPTION

The lift provides a total vertical lifting distance of 26" to clear the rear bumper of the PT Cruiser. A power in/power out electric motor, controlled by a free hanging two-button controller, provides the lifting power. The handheld control for the motor allows the client to be positioned away from the system while lifting and lowering the wheelchair. The client can also rest on the rear bumper during the process. A single degree of freedom cantilever beam setup provides ease of use during manual rotation into and out of the vehicle.

The lift assembly consists of a rotating cantilever beam inserted into a main post mounted to a 0.25″ thick base plate made of 1018 steel (see Fig. 18.7). The main post has two circular tubes made of 1018 steel. The outside stationary tube has an outside diameter of 2.5″ and 0.25″ wall thickness. The inner rotating tube has an outside diameter of 1″ and 0.120″ wall thickness (see Fig. 18.8). The cantilever beam consists of an angled shaft and a horizontal arm. The horizontal arm was made from 1018 steel square tubing: 1.5″ x 1.5″ x 16 gauge. A connecting plate was used to weld the inner rotating tube with the cantilever beam. A 12V DC motor and pulley were then attached to the arm of the cantilever. The motor and housing were salvaged from an existing Bruno wheelchair lift system. Two ABEC-1 steel ball bearings capable of handling a dynamic load of 2,405 lbs and rated at 9000 rpm were inserted into the main post (see Fig. 18.8). One integrated steel thrust ball bearing, rated to withstand a dynamic load of 6,700 lbs at a maximum speed of 3800 rpm, was used at the bottom of the main post to support the total weight of the lifting system. The motor was tested to lift a 45 lb weight. A dual-pin setup was installed on the main support post of the lift. It allows the lift to be locked in the loading and storing positions, and it prevents the lift from rotating out unnecessarily.

I-Deas 12, a finite element analysis package, was used to perform the structural analysis. The most stressed points are on the inner rotating tube of the main post.

The total cost of the parts was about $450.

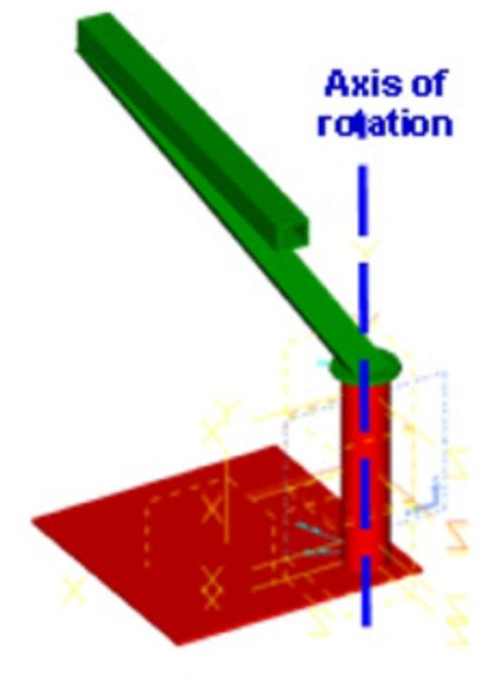

Fig. 18.7. Lift Assembly.

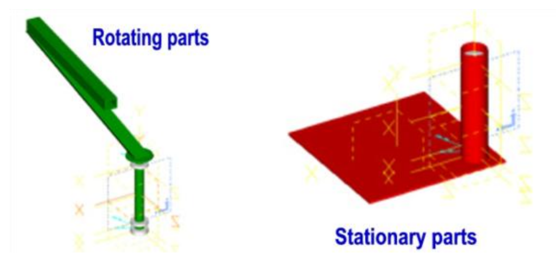

Fig. 18.8. Rotating and Stationary Parts of Lift Assembly.

WHEELCHAIR ATTACHED DEVICE FOR SHOPPING CARTS OR BABY STROLLERS

Designers: Devon Forney, Adonis Eid, Thiago Simiao, and Amy Oxenrider
Mechanical and Industrial Engineering Students
Client Coordinator: Ms. Jill Caruso
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INTRODUCTION

The purpose of this project was to develop a device that enables a woman with a manual wheelchair to safely move a shopping cart or a baby stroller (see Fig. 18.9). The device allows the client to steer, and connect her wheelchair to a cart or stroller. The device consists of two flat aluminum plates, each with three small swiveling casters on which the rear wheels of a cart or stroller are mounted. The wheels beneath the plates are on swiveling casters, which enable the client turn the cart. The two plates are held together by a crossmember that has two pivoting connecting arms attached to it and to the front of the wheelchair.

Fig. 18.9. Client Using Device to Move a Shopping Cart.

SUMMARY OF IMPACT

The device allows the client to easily push and maneuver a baby stroller or a shopping cart in a safe and controlled manner, and it leaves the client's hands free to drive her wheelchair. The device also ensures safety for her child when the client is pushing the stroller. The client is able to keep her hands on her wheelchair while guiding the cart or stroller and maintain constant linear motion. The device meets the client's needs and she is very happy with it.

TECHNICAL DESCRIPTION

Design requirements for the device included: 1) it should provide the user with complete control over a shopping cart or baby stroller while offering increased maneuverability of both; 2) it should quickly attach to and detach from the wheelchair; 3) it should be lightweight so the client can easily handle the device when it is detached from the wheelchair and not in use; 4) it should be compact; 5) it should be simple to operate and, if collapsible, easy to assemble and disassemble without the use of tools.

The device locks the rear wheels of the shopping cart and raises them off the ground. The device consists of two flat 11″ x 9″ x .25″ aluminum plates, one for each of the cart or stroller's rear wheels. A long narrow groove is cut out of the middle of each plate. The rear wheels of a cart or stroller fit in these grooves and are cradled in place by two pins. Each grooved plate sits on three small swiveling casters. The two grooved plates are held together by a telescopic cross member to allow the device to accommodate a variation in widths. Two pivoting connecting arms extend from the cross member to the wheelchair. Each connecting arm attaches to the front of the wheelchair by means of a small clamping block that tightens down around the tubular frame of the wheelchair. The entire assembly weighs approximately 13 lbs. The device quickly attaches to, and detaches from, the wheelchair by means of two quick-release pins. The pins attach each connecting arm to one of the clamping blocks.

Only the clamping blocks remain connected to the wheelchair when the device is not in use. The device is completely collapsible with four additional quick- release pins that hold the entire assembly together.

A 3D model of the device was created and refined using computer-aided drafting software. The strength of the device was evaluated using stress calculations for static loading conditions and confirmed through the use of finite element analysis software.

The total cost of the parts and materials was about $450.

ADAPTATION OF A WALKER

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Client Coordinator: Ms. Jill Caruso
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INTRODUCTION

A man with cerebral palsy uses a Reverse K walker for mobility. This walker is placed behind the user and is pulled rather than pushed. The walker makes it difficult to carry items around independently. A previous senior design group developed a removable tray that attaches to the walker, but it is heavy and has many pinch points (see Fig. 18.10).

The objectives of this project were to: 1) adapt the reverse walker to carry books, a laptop computer, and other various items; 2) minimize difficulty; 3) reduce weight; and 4) reduce the number of pinch points. The heavy aluminum tray was replaced with a vinyl basket, which reduced the weight of the unit significantly (see Fig. 18.11). Thin aluminum tubing was used to construct a frame to hold and support the basket. Quick-release pins were used to connect the frame to the walker.

Fig. 18.10. Original Design.

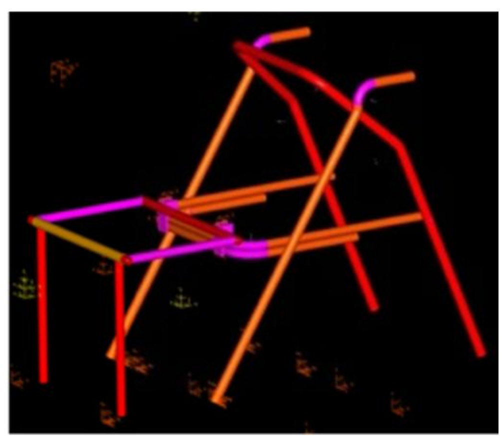

Fig. 18.11. Computer Model of New Design.

SUMMARY OF IMPACT

The removable and collapsible vinyl basket construct stores items for the client and increases the client's mobility and independence. The design allows the client to easily remove the vinyl basket construct from the walker and store it independently at his convenience.

TECHNICAL DESCRIPTION

The vinyl basket is secured to a frame that is attached to the walker. The frame is 20″ wide and 17″ long. It was made of one inch diameter 6061-T6 aluminum tubing, 0.25 inches thick. The basket frame rests on two 19.5″ long metal poles that provide stability (see Fig. 18.12 and Fig. 18.13). Two casters were mounted on the metal poles.

The axle tube for the construct is 1.25″. This tube has two bearings pressed at each end with one inch diameter bores, so it can rotate around the basket frame. The poles fold up when the basket is being stored. The vinyl basket was secured to the frame with button snaps and is 6″ deep. The basket construct weighed four pounds, which is significantly less than the weight of the tray construct. Quick release pins, 0.25″ in diameter, were used to attach the frame holding the basket to the walker at two locations.

I-DEASTM (Integrated Design Engineering Analysis Software) 12, a finite element analysis (FEA) software package, was used to perform the structural analysis. A 150 lb load was applied to simulate the client holding down the walker (75 lbs on each handle), and a 50 pound load was applied to the basket. A minimum factor of safety of 1.5 was calculated.

The total cost of the parts was about $350.

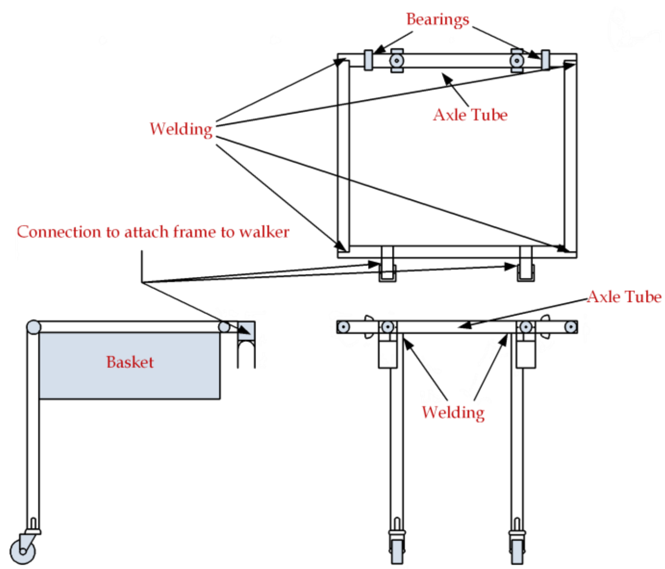

Fig. 18.12. Components of Construct.

Fig. 18.13. Basket Construct Attached to Walker.

SEAT BACK CLEANER AND ERGONOMIC BROOM

Student Designers: Lynette Torres, Adam Weininger, and Pam Wohlfarth
Client Coordinator: Ms. Jill Caruso, The Ability Center of Greater Toledo (ACT)
Ms. Diane Witt, Project SCOUT Coordinator, University of Toledo
Supervising Professors: Dr. Mohamed Samir Hefzy and Dr. Mehdi Pourazady
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INTRODUCTION

Two devices were created for a custodian with a traumatic brain injury to reduce stress on his back while working. The client experienced difficulty sweeping and cleaning the back of theatre style seats in an auditorium. The tools include a device to clean the back of seats and an ergonomically designed broom.

SUMMARY OF IMPACT

The client is now able to perform his work tasks more independently and efficiently. The cleaning tools alleviates discomfort caused by repeated bending and prevent the aggravation of his existing back injury.

TECHNICAL DESCRIPTION

The first device is a seat back cleaner (see Fig. 18.14b). Previously, hand washing the seat backs with a cloth rag required the client to bend approximately 90 degrees at the waist (as shown in Fig. 18.14a). The seat back cleaner allows the client to clean the back of the chairs while standing upright (see Fig. 18.14a).

The material used to build the seat back cleaner was 1″ PVC pipe. The unit consists of two segments: a vertical handle and an angled handle that is connected by a 45° elbow. It has a replaceable mop head with a threaded connection. The vertical handle is 36.5″ long while the angled handle is 10.25″ long. The mop head is 12″ x 3.5″ x 1.5″. The geometry of the cleaning surface provides adequate space to properly clean each seat back.

The second device is a modified version of a straight handled broom made from 0.75″ PVC pipe. The design is very similar to the seat back cleaner. Angles were added to the handle to enable the client to reach completely beneath a chair for sweeping without strenuous bending and reaching (see Fig. 18.15a). The ergonomic broom handle consists of two main components (see Fig. 18.15b). The first component is the angled handle, and the second component is a replaceable broom head with a threaded connection. The angled handle is divided into three links: 1) 35″ long; 2) 15.5″ long; 3) one inch long. These links are connected by two 45 degree elbows (see Fig. 18.15b). The replaceable broom head is 9″by 2″ by4.875″.

Design calculations were performed in order to determine the maximum stresses and the factors of safety in both parts of the unit. Surface electrodes were located above and below the L2 and L3 vertebrae, and muscle activity was recorded. The EMG data showed that a user experiences fatigue faster when using the old rag method to clean the back of the seats than when using the seat back cleaner.

The total cost of all parts was about $100.

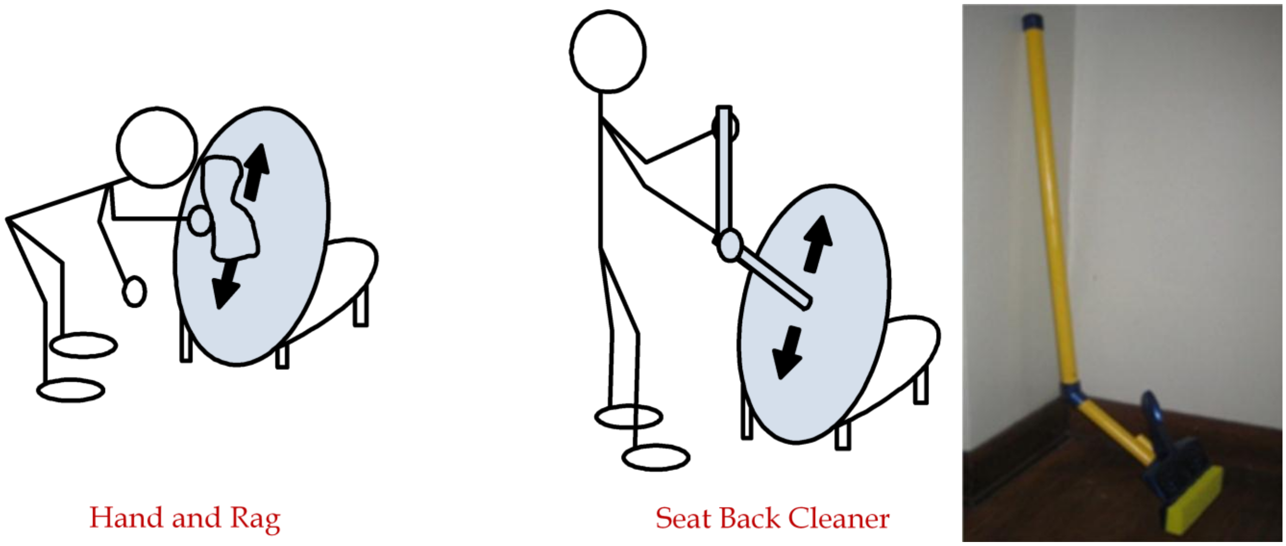

Fig. 18.14a and 14b. (a) Body Posture Improvement with Seat Back Cleaner; (b) Picture of Seat Back Cleaner.

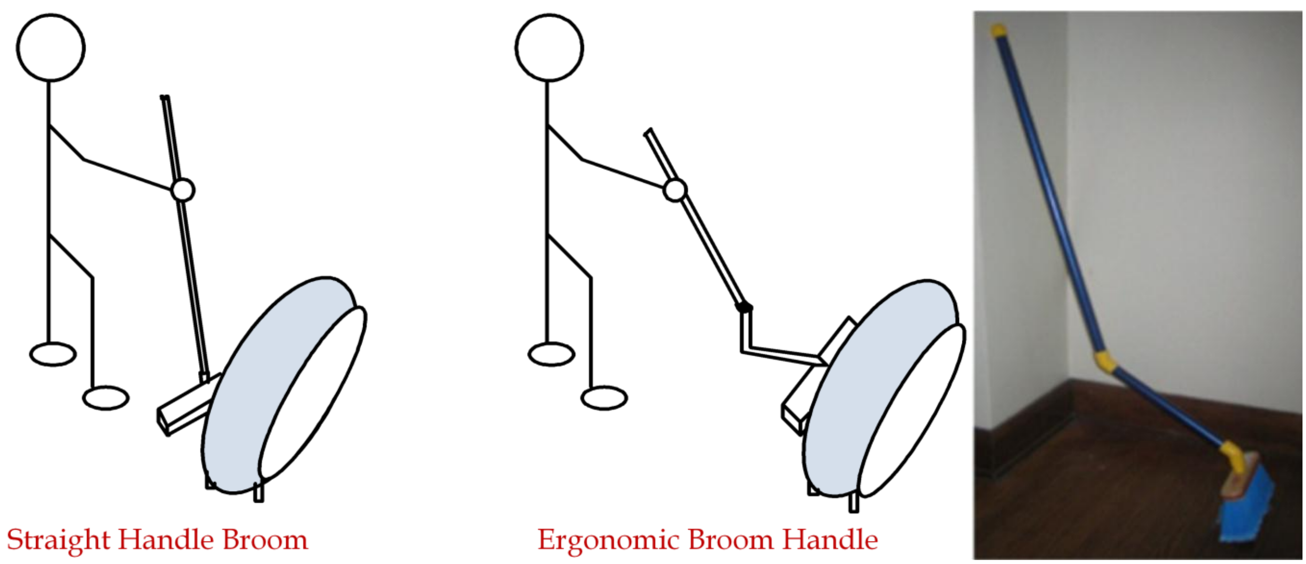

Fig. 18.15a and 15b. (a) Ergonomic Broom Handle and Straight Handle Broom; (b) Picture of Ergonomic Broom.

IMPROVING WORKPLACE ERGONOMICS

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Ms. Diane Witt, Project SCOUT Coordinator, University of Toledo
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INTRODUCTION

An individual with cerebral palsy works as an office assistant. When taking inventory, she has difficulty accessing overhead cabinets used for storage (see Fig. 18.16). The goal of the project was to adapt the client's work environment to allow her to easily reach the two overhead cabinets. This was accomplished by lowering the cabinets to her level

Fig. 18.16. Cabinets before Modification.

instead of raising her to the cabinets. The cabinets were modified to create cabinet inserts that slide out of the bottom of the existing cabinet structures and can be lowered down vertically to countertop level using linear actuators (see Fig. 18.17 and 18.18). Both of the cabinets move independently and are controlled by two switches.

SUMMARY OF IMPACT

The client is now easily able to take inventory of office supplies and access the cabinets. Her adapted work environment allows her to safely raise and lower the overhead cabinets that are used to store office supplies. She is able to now perform her work more independently.

TECHNICAL DESCRIPTION

The two commercial grade cabinets were temporarily removed and modified to satisfy the following design requirements: 1) the client must be away from the cabinets when they are in motion in order to prevent the possibility of injury; 2) reduction of storage space within the cabinets must be kept to a minimum; and 3) the cabinet modifications must not interfere with the suitability of the workplace for others.

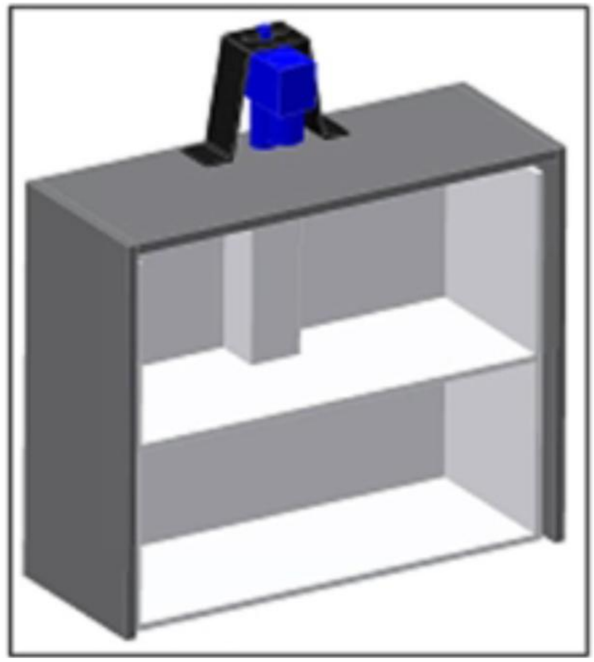

Fig. 18.17. Computer Model of Modified Cabinets with Insert in Raised Position.

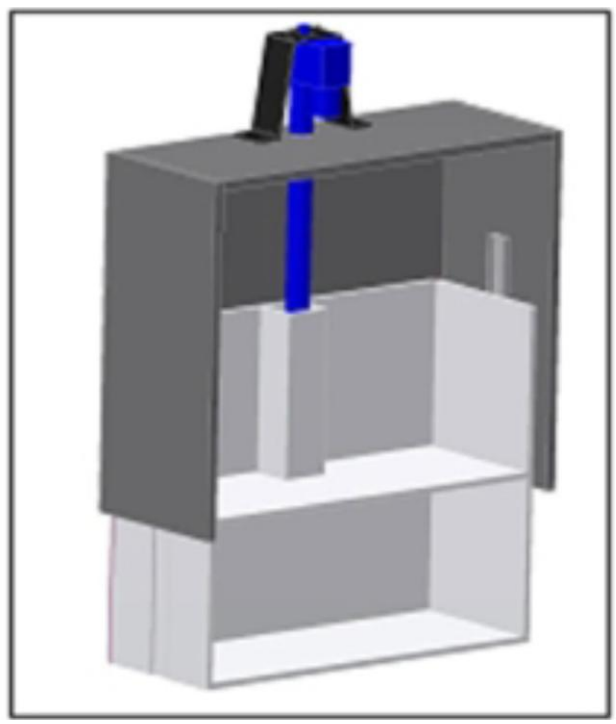

Fig. 18.18 Computer Model of Modified Cabinets with Insert in Lowered Position.

The bottom of each cabinet frame was removed and a cabinet insert was designed and developed. Each insert can carry a load of 260 lbs. Two Warner Linear B-Track K2P1.0G10-90V-BR-18 actuators were used to raise and lower the inserts. Each of these actuators has a static holding capacity of 2000 lbs., 18″ stroke, 1″/sec travel speed and is powered by a 90 VDC motor. Both actuators are controlled by a single SBC-AC-90V control box with two switches. The unit converts 115 VAC to 90 VDC and contains the wiring necessary for the control switches. The control switches are Double Pole Double Throw "momentary on-off momentary on." The controls allow each cabinet to move independently and are mounted on the wall adjacent to the cabinets. Each actuator uses its electric motor and a set of reduction gears to turn a threaded shaft mounted inside a tube. Each actuator was mounted with its motor on the top and outside of the cabinet structure (see Fig. 18.17 and Fig. 18.18). The tube runs through the inside of the cabinet insert and attaches to the middle shelf. A cover was constructed in the cabinet insert to protect the tube of the actuator. Each insert is guided by industrial grade drawer slides mounted between the insert and the cabinet frame (see Fig. 18.17 and Fig. 18.18). Upper and lower mounting fixtures were designed and constructed to mount the actuators. The lower fixture includes a ¼″ thick steel plate that is screwed underneath the middle shelf and attached to the actuator with a ½″ 1018 CD steel clevis pin (see Fig. 18.19). The upper fixture was also made of ¼″ thick steel plate, 8″ tall, and was attached to the

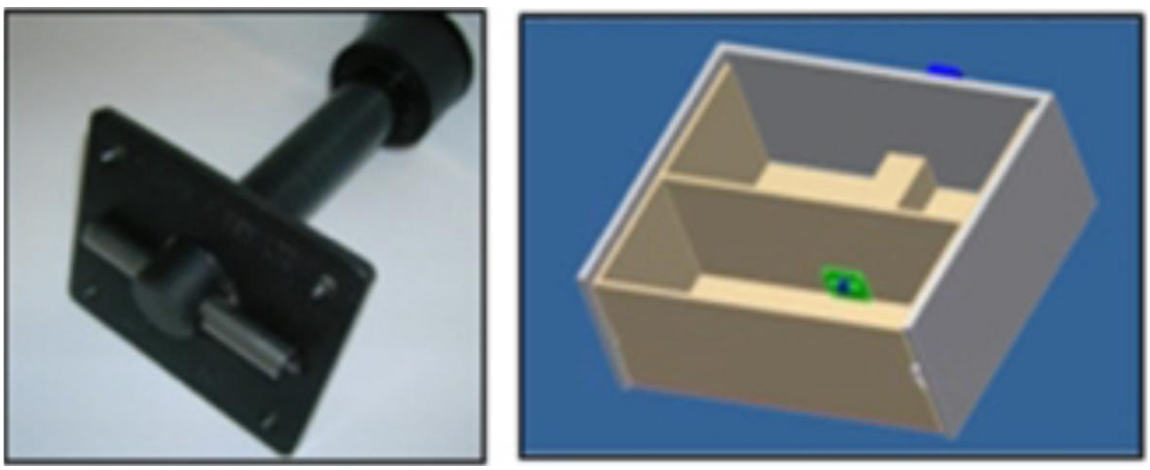

Fig. 18.19. Lower Fixture.

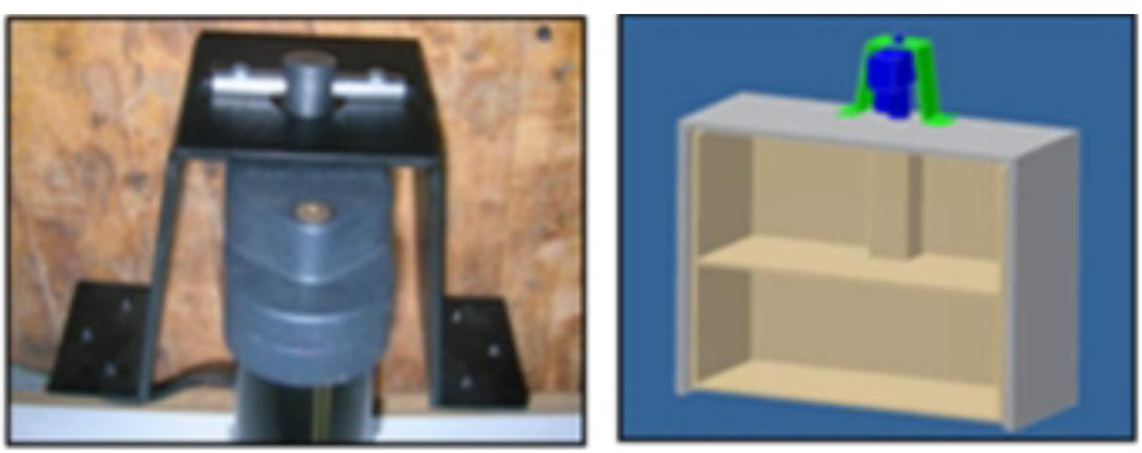

Fig. 18.20. Upper Fixture.

actuator with a ½” steel clevis pin (see Fig. 18.20).

I-Deas 12, a finite element analysis package was used to perform the structural analysis of the unit. The most stressed point was found to be on the top of the cabinet frame where the upper fixture is mounted, and a factor of safety of five was calculated (see Fig. 18.21). The total cost of the parts was about $1,050.

Fig. 18.21. Modified Cabinet During Testing.

WHEELCHAIR ACCESSIBLE PASSIVE LEG EXERCISER UNIT

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INTRODUCTION

An individual with spina bifida uses a wheelchair. She is very active and wanted a way to work out her legs. A wheelchair accessible passive exercise unit was developed to allow her to work out while seated on her chair (see Fig. 18.22). The unit allows the client to perform both arm and leg movements. The unit uses a motor to power the motion of the legs and arms. A control box was mounted to the side of the client's wheelchair. It allows her to control the speed of the machine and to quickly stop it with an emergency stop button. The pedals of the unit were made to accommodate for the client's different leg lengths.

SUMMARY OF IMPACT

The unit accommodates the client's different leg lengths and provides her with a way to exercise her arms and legs. The exercise builds muscle strength in her legs and provides her with the ability to stand for a reasonable length of time to do the dishes and other household chores. The unit is accessible to a wheelchair and is safe for her to operate. It secures her feet to the pedals, and the controls are easy to reach. The unit is also lightweight and portable.

TECHNICAL DESCRIPTION

The passive leg exercise unit has a large rear base, made of plywood, which allows the user's wheelchair to rest on it during use for stability (see Fig. 18.22). It includes a side-mounted electric motor that rotates a crankshaft to which foot pedals and handlebars are attached. The handlebars rock back and forth due to a linkage that attaches the handles to a smaller crank on the crankshaft. With the electric motor driving the system, this option provides a completely passive upper and lower body workout. However, with the motor

Fig. 18.22. Client Using Exercise Unit.

disengaged, the user's upper body can actively drive the system. This can be accomplished by rocking the handles back and forth, which in turn rotates the crankshaft and pedals. A thicker footrest was developed to allow for the client's different leg lengths.

The crankshaft was made of steel. The throw of the pedal crank was specified to be five inches. The pedals are made of wood and are ten inches apart from each other. To reduce the chance of splinters, the pedals were sanded, stained, and treated with three coats of lacquer. Rollerblades were used to secure the client's feet to the pedals. The boot of a rollerblade holds the entire foot, ankle, and lower calf of the leg in a secure position. By using a large enough rollerblade, the client is able to leave her shoes on. The wheels were removed from the rollerblades, which created holes that were used to secure the boot to the pedals. Creform pipes were used for the handlebars. Angle brackets were used to connect the upper and lower sections of the handlebars. The motor operates at a maximum of 50 rpm with 45 in-lbs. torque. The motor is wired directly to the control panel.

Based on the client's body weight, it was estimated that a load of 20 lbs is applied to each pedal. Also, a load of 20 lbs acts on each handle. Handle loads are transferred to the crankshaft through connecting links. Solidworks software was used to develop a computer model of the unit and to calculate the stresses in the crankshaft, its vertical supports, and the handlebars (see Fig. 18.23).

The total cost of the parts was about $450.

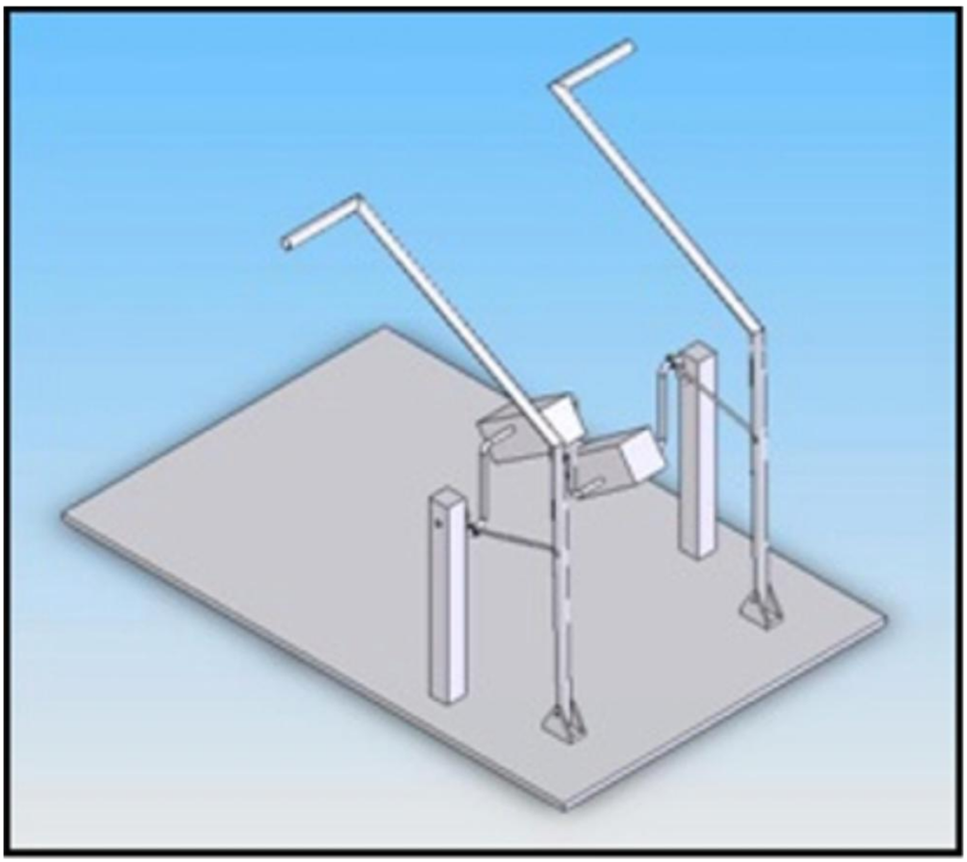

Fig. 18.23: Computer Model of Exercise Unit.

CHAPTER 19
UNIVERSITY OF WYOMING

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VIBRATING ALARM CLOCK

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INTRODUCTION

A Vibrating Alarm Clock for the people with hearing impairments (VACHI) was built using Freescale 68HC12 chip technologies. The main goal was to help people with hearing impairments to wake up in the morning. The base unit has a fully functional clock and alarm.

The requirements for this project included: 1) a fully functional alarm clock with buttons to set the clock display, alarm clock display, alarm on/off, and snooze; 2) no buzzers or radio components in the base unit; 3) the ability to send a wireless signal using a LINX Technologies RF module; 4) a wristband to receive a signal from the base unit when the alarm goes off to start vibrating the motor; and 5) an external microphone system to alert the user of any loud noises during sleep, such as an intruder or a fire alarm. The clock uses input from the microphone to send a signal to the wristband via the transmitter and receiver. The sensitivity of the microphone can be set by the user using an external potentiometer.

SUMMARY OF IMPACT

Any time an alarm goes off, a signal is sent to a wireless wristband, which causes a vibration to occur. The base unit has an internal microphone capable of picking up noise in the surrounding area. The microphone's sensitivity level can be adjusted by the user via a knob on the outside of the base unit's case. When an alarm sounds, lights in the base unit blink on and off, indicating an event has occurred.

TECHNICAL DESCRIPTION

BASE UNIT

The base unit consists of a 68HC12 microcontroller embedded in a Minidragon Development Board (Wytec, Inc.). The Minidragon regulates the clock's Liquid Crystal Display (LCD), pushbutton switches, alarm ON/OFF switch, clock functions, and alarm functions. If an alert is detected by the microphone the microcontroller will send a signal to the onboard LINX transmitter, which will in turn transmit a 418 MHz signal to the receiver in the wristband. If the preset alarm occurs, the microcontroller will again send a signal to the transmitter, which sends a 418 MHz signal to the receiver in the wristband. In both cases of alarm status, the bulb on the inside of the base unit will blink on and off for as long as a signal is being sent to the transmitter.

WRISTBAND

The wristband has three separate systems: a voltage source, a battery monitor circuit, and a motor vibration circuit. The voltage source consists of a CR2477 3 VDC 1000 mAH Lithium Ion battery. The battery monitor circuit is a Maxim 6435 battery supervisory circuit. This supervisory circuit monitors the 3 VDC supply for two threshold voltages as set by an external voltage divider network.

The motor vibration circuit consists of the LINX receiver, a Rx 418 LC planar antenna (which lies flat on the printed circuit board), a 2SK221100 N-channel MOSFET used as the motor driver, and a 3 VDC vibrating motor.

The packaging for the base unit is transparent blue Plexiglas so the components are visible. The bulb inside the base unit, when flashing, lights up the base unit with a blue glow. The wristband has a cloth case.

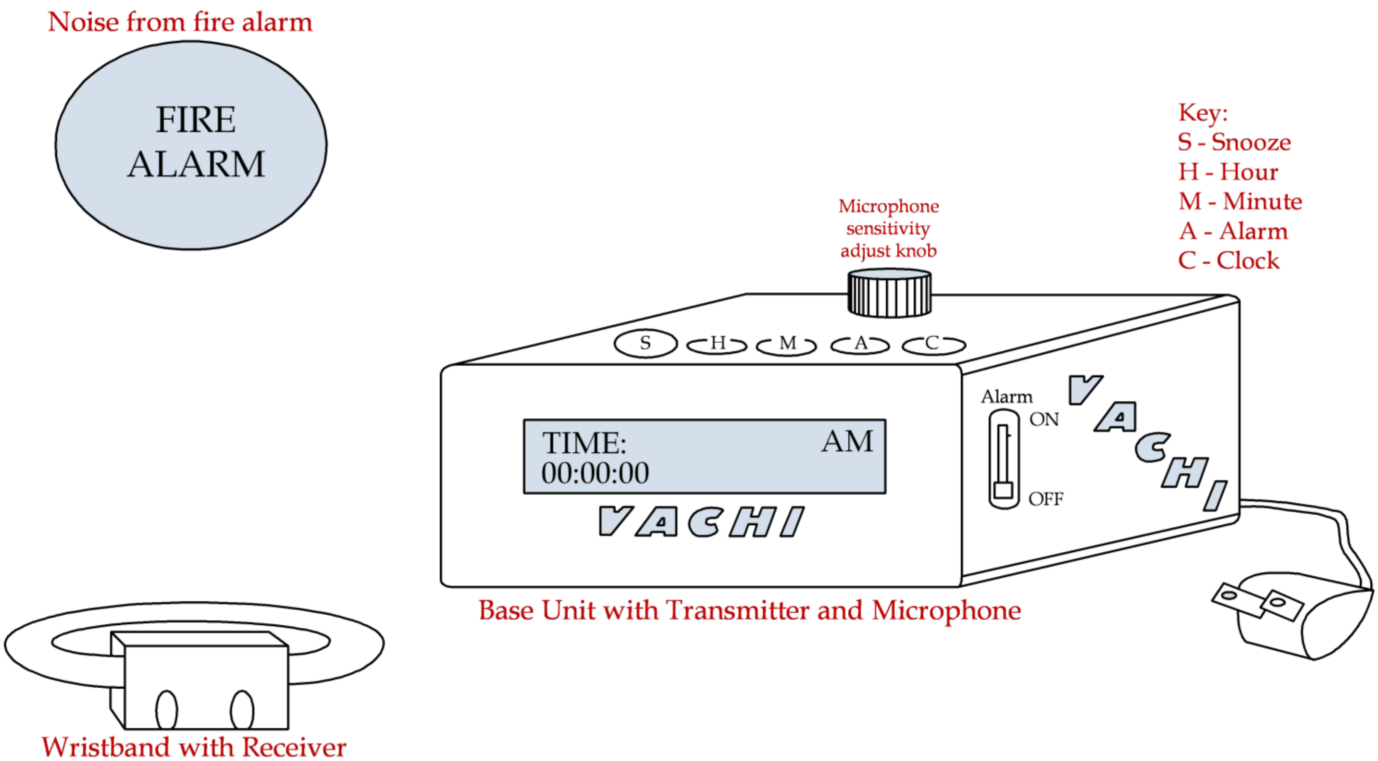

Fig. 19.1. An overall diagram of the project

INDOOR CHILD MONITORING SYSTEM

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INTRODUCTION

A teacher at an elementary school requested a device that could be worn or carried by a student with limited cognitive abilities so that he could be monitored remotely by a caregiver. The design of includes a radio frequency (RF) transmitter to be carried by the student. The transmitted signal is received by a set of RF receivers placed at strategic locations throughout the school. The receivers have a received signal strength indicator (RSSI) feature that enables measurement of signal strength via a central microcontroller. The microcontroller communicates with a Windows-based computer through a network cable. The computer runs software displaying a plot of the student's location on a floor map of the school.

SUMMARY OF IMPACT

This system is able to track an individual's movements. Due to time constraints, crucial testing for accuracy of measurements was not conducted.

TECHNICAL DESCRIPTION

This project has two primary components: hardware (transmitter and receivers) and software (Microsoft NET user interface). The microcontroller connects the two. Figure 19.2 shows a general outline of the project components connected together.

HARDWARE

Transmitter

The transmitter portion of this project consists of the following components: a prefabricated radio frequency (RF) transmitter, a binary counter, a crystal oscillator, a voltage regulator, an antenna, and a battery. The transmitter had to be small, compact, and easily mountable on a printed circuit board (PCB). It also had to have low-power RF output to prevent bodily harm and ensure compliance with Federal Communications Commission (FCC) standards. Cost was also a consideration.

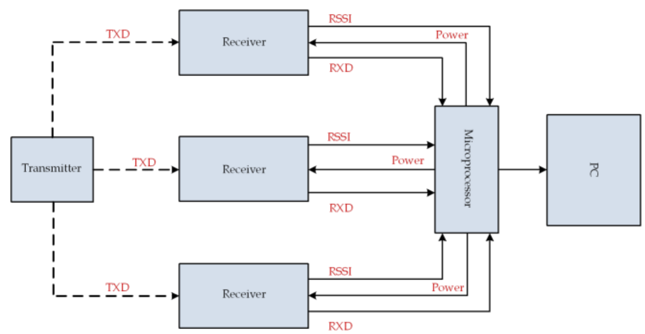

Fig. 19.2. System Overview.

The TX3A-914-64, a miniature ultra-high frequency (UHF) transmitter module designed by Radiometrix was mounted on a PCB. The TX3A operates at 914.5 megahertz (MHz). It has a 1 milli-watt (mW) RF output and conforms to the FCC regulation part 15.249. Figure 19.3 shows the transmitter and the 7-pin configuration. Pins 1-3 are designated for the RF transmission of data. Pin 2 is connected to a 50 ¼ wave-whip antenna, while pins 1 and 3 are connected to RF ground. Pin 4 is an enable pin used to put the transmitter in a low-power state while it is not being used. A switch that turns the unit off and on was not used in this design. Pin 4 is simply tied to the 5 V supply, so when the power is switched on, the transmitter is enabled. Pin 5 is the supply voltage and pin 6 is 0V, or ground. The transmitter operates at a regulated 5V from a common 9V alkaline battery. Pin 6 is tied to the ground terminal of the battery. Pin 7 of the transmitter accepts the data to be transmitted. This pin accepts digital data between 0 and the high voltage, which it clips to 2.5 volts. For this design, pin 7 was given a 15.6 kHz square wave generated by a 1.0 MHz crystal oscillator and a 14-stage binary counter was used as a frequency divider. The crystal oscillator generates a precise 1.0 MHz signal that is fed into the 14 stage binary counter. This binary counter acts as a frequency divider and is able to generate fractions of the input frequency by dividing it by a power of two, from 24 to 214.

The power for the transmitter comes from a common 9V alkaline battery. This 9V supply is regulated down to 5V by a voltage regulator in order to provide the transmitter circuit with a lower and more constant voltage.

Receiver

The receivers consist of the following components: a prefabricated RF receiver, a voltage regulator, an operational amplifier circuit, and an antenna.

The RX3 receiver is the receiving unit complementary to the TX3A transmitter. Designed with a surface acoustic wave (SAW) front end filter for good immunity to interference, this receiver module can receive transmissions in-building from a distance of roughly 30 meters or 120 meters line-of-sight. This receiver also has an RSSI with a 75 dBm range (power in decibels referenced to 1mW). This is crucial to the overall design as the RSSI signal enables plotting of the transmitter based on the relative strengths of the RSSI signals from the three receivers.

The RX3 pins are shown in Fig. 19.4. The receiver is a 9-pin device, in contrast to its 7-pin transmitter counterpart. The two additional pins on the receiver are a pin for the RSSI output and an analog RF output pin. The RF output pin is not used in this design. Pins 1-3 of the receiver are for the RF input. Pin 1 is the RF input and is connected to a 50 ¼ wave whip antenna. Pins 2 and 3 are connected to the RF ground plane. Pin 4 is an enable pin, used to put the receiver in a low power standby mode. This is not necessary in this design. Pin 5 is the RSSI signal output. The RSSI gives a DC voltage in the range of 0.0-1.0 volts. In this design, this value is used to calculate the distance from the receiver to the transmitter. Pin 6 is the 0V pin, or ground for the voltage supply. Pin 7 is for the supply voltage, which in this design is a regulated 5V. Pin 8 is an analog frequency output that is not used in this design. Pin 9 is the output of the received digital data. For this design, pin 9 receives a 15.6 kHz square wave, used by the microprocessor to affirm that the signal received is the intended one.

The receiver circuit also contains an operational amplifier circuit used to amplify the RSSI signal from a range of 0.2-1.0V to (ideally) 0.66-3.3V. This allows use of a larger range of the analog to digital (A-D) converter, allowing for values between 0 and 3.3V.

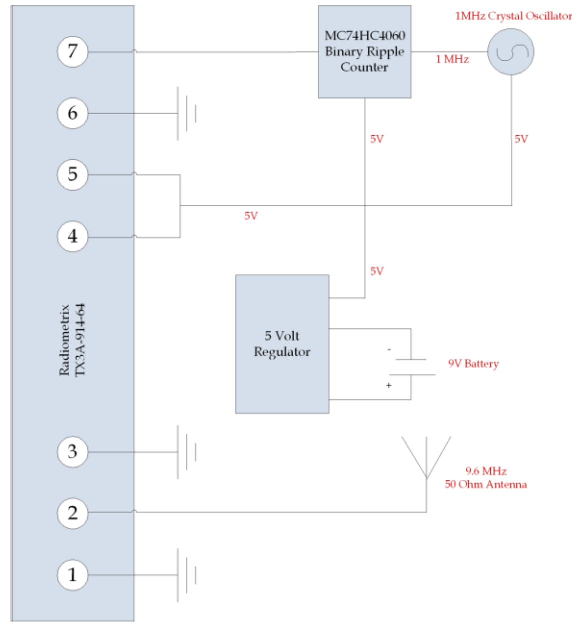

Fig. 19.3. Transmitter Schematic.

Power for the receiver units is supplied along category 5 (CAT5) cables that connect the receivers to the central microprocessor. Power is supplied by the power port on the microprocessor evaluation board. A measured 9.20V is supplied by the evaluation board's power port and delivered to the receivers through a CAT5 cable where it is regulated down to 5V for use by the RX3. See Fig. 19.4 for a diagram of the receivers.

Microprocessor

The microprocessor is the M9S12NE64. This is an HC12 variant with an Ethernet 10/100 megabit-per-second (Mbps) transceiver. The M9S12NE64 was purchased on the EVB9S12NE64 evaluation board from Freescale. This allowed easy connection of the receiver CAT5 cables into the evaluation board's breadboard to be read by the A-D converter.

The microprocessor takes in the RSSI signals from each of the 3 receivers, packages them in a UDP packet, and broadcasts the UDP packet onto a network. The RSSI signals are run into the A-D converter to digitize the analog signal. Once these signals are digitized, they are packaged by the microprocessor into the UDP packet. This packet is broadcast onto a network as a bit stream where it is retrieved by a PC for further processing.

SOFTWARE

The Microsoft NET programming environment is user friendly and provides a number of pre-programmed features that facilitate the process of designing a Windows application. First, when the program is started, it immediately starts sampling the network for data. When data are received, they are decoded and the values are stored. Then the program checks to see if 1000 samples have been taken since either the beginning or the most recent average, and if so, it averages these last 1000 samples. It then calculates a new point to draw a line to, indicating the child's current position and most recent movement. It draws the required lines on the map of the school, and then returns to sampling the network.

UDP is the protocol for broadcasting the RSSI information onto the network cable. An alternative to broadcasting the packet onto the network cable would have been to hard-code an IP (internet protocol) address into the microcontroller. This idea was quickly discarded, though, because it would have required the user to reconfigure the computer's IP address every time he or she used the program. Then he or she would have had to reconfigure the IP address again to close the program and use the internet. UDP is faster than other protocols and provides the flexibility of broadcasting quickly in case many samples must be averaged in a short period of time. Also, since there will be no other computers or devices on the network formed by the crossover cable linking the microcontroller with the computer, there is no danger of the broadcast bringing down critical office network applications.

When the user interface program is started, the program creates a new thread (process) ,which runs in the background (independent of everything else the program is doing) and continually monitors the network cable for broadcasts. When this thread detects a UDP packet, it generates an interrupt "event." The main program thread recognizes this event as important and stops what it is doing to handle the event. Each time the event is generated, the main program decodes the UDP packet into a stream of bits and then into a series of integers representing the RSSI readings taken from the receivers by the microcontroller. After the main thread has the RSSI values, it runs them through an algorithm that selects the two strongest signals and calculates the position of the tracked individual based on the relative signal strengths of the two

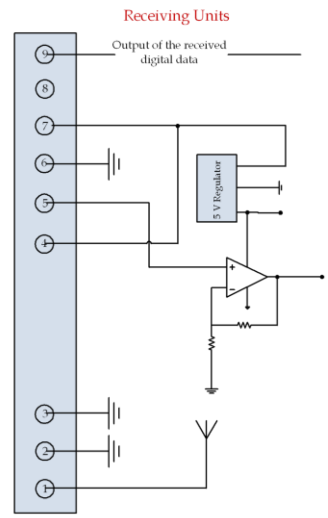

Fig. 19.4. Receiving Unit Schematic..

strongest receivers. A potential drawback to this approach is the possibility of a receiver generating a stronger RSSI reading than one of the receivers to which the individual is actually closer. This is unlikely because line-of-sight signals are stronger than signals that must travel through walls or other solid objects. If the signal strengths of the second- and third-strongest receivers are close to the same value, then the program assumes the individual is close to the location of the receiver for which the RSSI is strongest. It holds that position for a short length of time until one of the receivers begins generating a stronger signal strength reading.

On the main window, there is a picture box with a map of the floor plan of the building. When the program calculates the position of the individual being tracked, it draws a colored line connecting the current location of the signal to the previous location. Map position is specified in terms of the number of pixels from the left edge (x-coordinate) and from the top edge (y-coordinate).

The microcontroller, which uses the C programming language, was programmed to read the RSSI values on the analog-to-digital converter and broadcast them. The microcontroller reads analog values between 0 and 3.3V and converts them to one-byte integer values. This posed a small problem because NET expects four-byte integer values. This was solved by zero-padding the integer values so that the UDP broadcast contains one-byte values represented by four-byte integers.

ULTRASONIC CANE FOR PEOPLE WITH VISUAL IMPAIRMENTS

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INTRODUCTION

An ultrasonic cane was designed to enhance mobility of people with visual impairments. An ultrasonic transducer produces an audible or vibratory signal to alert the user about any large obstacles in his or her path up to 12 feet away. Design requirements were that the device be mobile and use rechargeable batteries.

SUMMARY OF IMPACT

The device is a functional, portable, ultrasonic proximity sensor. It cannot detect small objects or slight changes in surfaces; thus, it would not suffice as a single way-finding aid. As a supplemental device it could speed the user's locomotion by providing a general location of large objects, or holes (such as doorways) 12 feet in advance. It is portable and powered by two standard 9 V DC batteries.

A problem during the testing phase was echoing. The unit was working as planned, but every few seconds it would receive a false positive. The false positive could be confusing to a user and cause him to stop moving for fear of a large object in his path. At this point, the unit would guide a user down the hallway, but once the user was within 30 feet of a bend or junction in the hallway, the echo was bad enough to be hazardous to the user. Using the gating feature of the sensor should eliminate this problem.

Vibrations with only one vibrating motor and audible tones produced by the speaker are also not effective enough for user feedback. Suggestions for a second prototype would be to try and use a Braille display of some sort to "talk" to the user; 18 cell, 8-dot displays are available.

TECHNICAL DESCRIPTION

This project has four primary components: the ultrasonic sensor, the user interface portion, the power section, and the microcontroller. The sensor sends and receives the ultrasonic signal and determines how far away an object is. The feedback portion includes the vibrating motor, the speaker and all the hardware required to make it work. The power section supplies power to all of the active pieces in the design, including the sensor and microcontroller. The microcontroller incorporates all the pieces and gets them to function as a single unit.

TRANSDUCER

The ultrasonic transducer selected was the Senscomp-Mini A because of its versatility. It compensates for temperature internally and also provides a 0-5 VDC output for minimum and maximum distances. Also, the minimum and maximum distances can be changed, making it easy to adjust the distance if needed. One drawback to this model is the current draw during the transmit stage. The unit requires 2A during the 0.5 ms transmit stage. To help compensate for this, a 470 F capacitor is connected in parallel with the transducer and two 9 VDC batteries (connected in parallel with each other for the supply). A 100 ohm resistor is placed between the transducer outputs and the microcontroller input to protect the transducer on microcontroller startup.

USER INTERFACE

Feedback is provided through vibration and an audible signal. The vibration is created by a cell phone vibrating motor supplied by Sanyo. The motor is rated for 1.3 VDC and 160 mA. The PWM from the microcontroller powers the motor. The duty cycle ranges from 60% to 80%. As the duty cycle increases, the inductive nature of the motor averages the voltage coming in and the speed of the motor increases, increasing the vibration as the duty cycle increases. For an object more than 10 feet away, the motor only pulses once; for those between 5 and 10 feet, the motor will pulse twice and three times for objects closer than 5 feet. The current from the PWM pin is not sufficient to drive the motor, so a transistor in the common-emitter configuration is used as a motor interface.

The audio portion of the feedback is provided through a headphone jack. A pulse of noise that is perceived as a click or beep is sent to the user. The audio feedback ranges from 1 to 5 clicks. The vibration pulses in synch with the speaker for an increased impact on the user. No extra circuitry is needed for the speaker; it runs directly from the PWM.

MICROCONTROLLER

The microcontroller chosen for this project is from the Atmel AVR line, specifically the ATmega8. This controller is an 8-bit, 16 MHz processor. It is equipped with a 16 bit timer/counter and three PWM channels, two of which are used to generate the user interfacing signals. The controller also has a 6-channel, 10-bit ADC used for the input from the sensor and to monitor the supply voltage. The Unified Modeling Language (UML) activity diagram for the control algorithm is provided in Fig. 19.5.

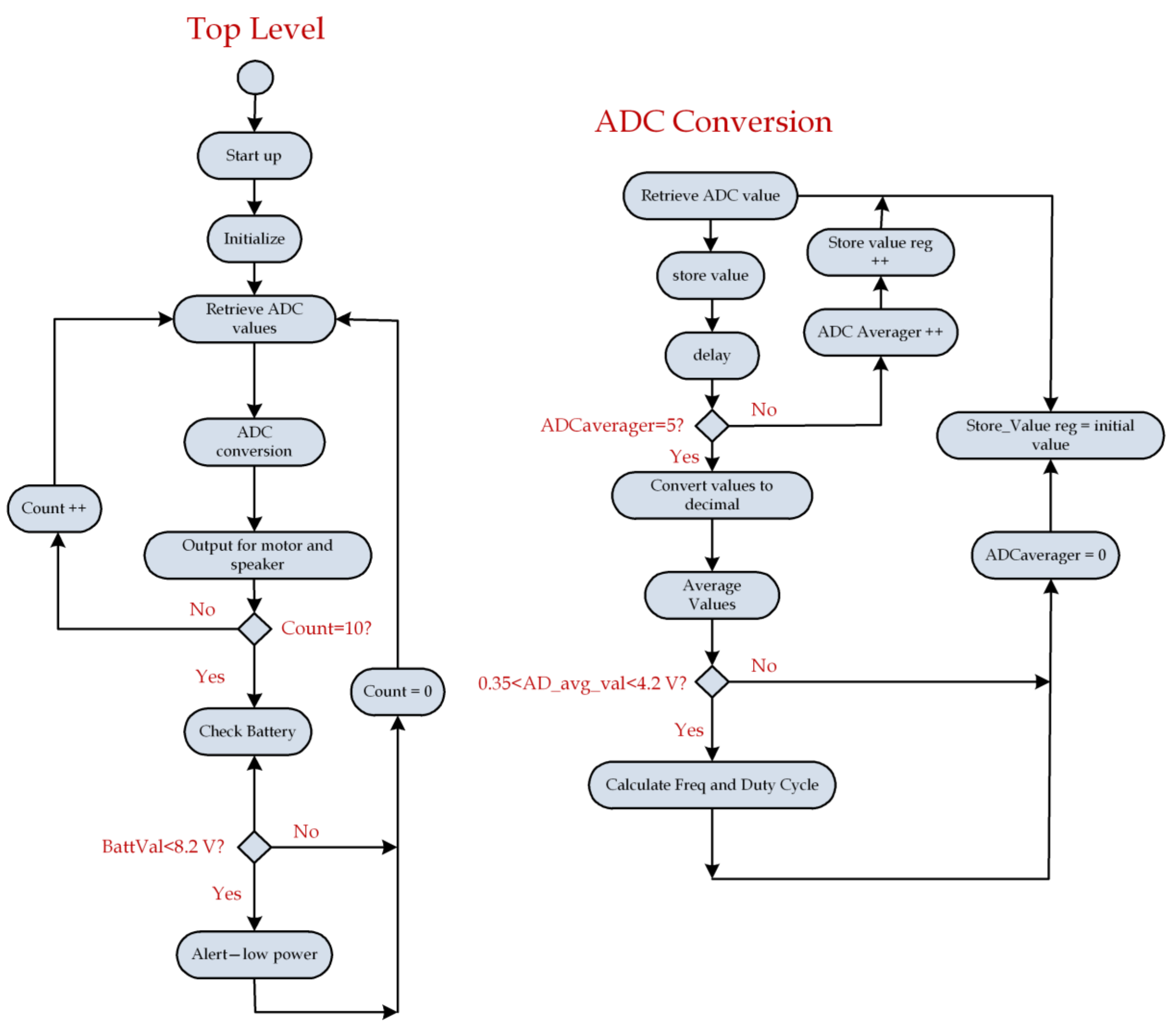

Fig. 19.5. Unified Modeling Language (UML) Activity Diagram for the Control Algorithm

EMERGENCY SIREN DETECTOR

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INTRODUCTION

An emergency siren detector was designed to be placed inside the vehicle of a motorist with a hearing impairment to provide a visual aid when an emergency vehicle sounding a siren is near.

SUMMARY OF IMPACT

The siren detector takes an emergency siren as input and creates a visual signal corresponding to the proximity of the emergency vehicle. The detector is constructed with various analog components such as a microphone, band-pass filter, and RMS-to-DC converter, Atmel microcontroller, and an LED display. The microphone takes in a wide range of frequencies and sends the signal to the band-pass filter, which eliminates unwanted frequencies. The RMS-to-DC converter outputs a steady voltage based on the rms value of the input signal. The microcontroller then illuminate up to eight LEDs based on the steady DC voltage.

TECHNICAL DESCRIPTION

The emergency siren detector works in three stages. The first stage is when a sinusoidal signal is received by the microphone and passed to the band-pass filter to determine if the sinusoidal signal is of the valid frequency range, 1140 to 1650 Hertz. An emergency siren may be defined as a wail, yelp, or high-low signal. The wail is between 1140-1675 Hertz. The yelp has a frequency range of 780 to 1680 hertz. The high-low signal has a frequency range of 800 to 1650 Hertz.

The second stage entails passing the sinusoidal waveform through the band-pass filter and conversion of the signal to a constant DC voltage using an RMS-to-DC converter. If the sinusoidal signal that passes through the band-pass filter has a peak-to-peak value of 10 V RMS, then the RMS-to-DC converter outputs a value of 7.07 VDC.

The third stage consists of an Atmel ATmega8 microcontroller that takes the converted output voltage of the RMS-to-DC converter as an input. The ATmega8 was chosen because of the large number of available input/output pins, the on-chip RC crystal oscillator, and the 10-bit resolution of the analog-to-digital converter (ADC). The ADC on the ATmega8 performs a conversion on the input voltage and excites a bank of eight LEDs based on the output magnitude of the ADC. The block diagram in Fig. 19.6 illustrates the three stages of the emergency siren detector.

The system power for the emergency siren detector comes through a cigarette lighter of the user's vehicle. Using the cigarette lighter allows the device to receive a constant voltage while the vehicle is in operation. The cigarette lighter has an output voltage of +12 VDC, which does not suffice as a voltage for the overall device because some parts on the device require both positive and negative voltages. Therefore, a Mean Well DC/DC converter DCW03 was selected to allow the system to receive both positive and negative voltages. The DC/DC converter is capable of accepting input voltages in the range of 9 VDC to 18 VDC and supplying the system with an output voltage of +/- 12 VDC and a maximum current of 125 mA.

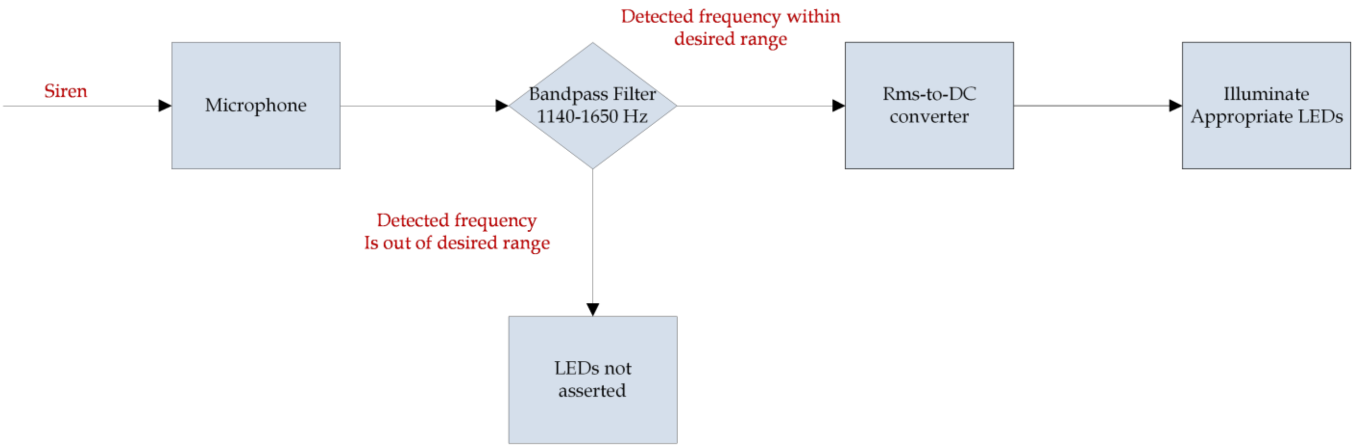

Fig. 19.6. Three Stages of the Emergency Siren Detector.

RUN ANYWEAR FITNESS PERFORMANCE SYSTEM

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INTRODUCTION

The Run AnyWear device was designed to promote physical fitness. The device was intended to provide heart rate, speed, distance traveled, and time elapsed. This can give a better indication of the effectiveness of the fitness program. It allows the user to make sure he or she is keeping his or her heart rate within the target range. This project may be expanded to store the user's exercise data and transfer them to a software program capable of providing statistics to help keep track of progress.

SUMMARY OF IMPACT

The Run AnyWear helps the user monitor his or her functioning during exercise. The main goal was to create an affordable fitness monitoring device appropriate for a wide variety of users. Unlike current machine-specific fitness systems, the Run AnyWear is not dependent upon custom workout equipment, shoes, or other expensive items. The user may use the device in any environment (indoors or outdoors). Due to time constraints, the speed and distance traveled functions were never completed.

The device is user-friendly and easy to read. This makes it more suitable for use by those who may have cognitive disabilities or visual impairments. For example, the display of the device is a four-digit seven-segment display, which has a much brighter contrast than can be provided through other displays.

TECHNICAL DESCRIPTION

The USB microcontroller, the main component of this project, analyzes all of the data from the accelerometer and pulse plethysmograph. It has several different functions. These functions include timing, data conversion, and displaying different statistics that are provided to the user. All of the subsystems are controlled through these functions in the microcontroller. Each data type is displayed for fifteen seconds at a time. The overall system flow is shown in the UML diagram in Fig. 19.8.

Fig. 19.7. The Run AnyWear

C programming was used because it is a high-level language and is easier to read and understand than assembly programming. AVR Studio4 was used to complete the microcontroller code because it has a built-in GCC compiler. This program was available at no cost on the Atmel website. It allowed completion of every step of the programming process, including writing the code, building the project, compiling, and programming the microcontroller chip. The microcontroller used was the ATmega8535, which is a 40-pin dual inline package (DIP) microcontroller produced by Atmel. The completed subsystems of the Run AnyWear are the timer, the heart rate, and the display.

The timer function was set up through a series of if-else loops. These loops control when the variables seconds, ten seconds, minutes, and ten minutes are incremented. Each digit must be illuminated separately so that the value sent to PORTB, which was used to select the appropriate digit, is cycled.

The value of the least significant digit is sent first so PORTB is originally set for that particular digit. This is followed by a 5 ms delay and PORTB being set to activate the second digit. This again is followed by another 5 ms delay, and then the third digit is displayed. This continues until a complete cycle is made, illuminating each digit in turn. A second elapses between each instant that the timer function is called. Another series of if-else statements is within the loop. These statements control which value is sent to PORTC, which in turn controls the illumination of individual segments to form the appropriate number.

For the heart rate subsystem, three separate functions are implemented in the microcontroller. These include an interrupt service routine for when a rising edge is detected on the input capture pin, a heart rate function that calculates the heart rate based on the value of timer1 at the time of a capture event, and a function that displays the heart rate. The heart rate display function is similar to the timer function. The only difference is that the variables that are examined are ones, tens, hundreds, and thousands instead of seconds, ten seconds, minutes, and ten minutes. However, before these comparisons can be made, a few calculations are completed to determine the values of these variables. Once the calculations are completed, a loop is entered, cycling through each digit and displaying the appropriate value. This code operates based on the register settings that are made in the initialize ports function. The heart rate subsystem also requires an interface between the pulse plethysmograph and the microcontroller. The initial testing of the sensor resulted in a waveform that varied between 5mV and 15mV. This waveform is dependent upon the person, the location of the sensor, whether or not the person is holding still, and the lighting conditions in the room.

The first step in creating the interface was to eliminate the DC component of the signal. Because the waveform had such a small magnitude, a gain of 100 was implemented. Both the original and amplified signals were centered around 0V, so the next step in the signal conditioning process involved using an op amp again to rectify the signal. The input capture function on the ATmega8535 senses rising or falling edges of a signal. Therefore, the last step required in the signal conditioning process was to adjust the rectified signal so that it became a square waveform. The effect of this conditioning gave a pulse that could be adjusted to any range between 0V to 5V by tuning the potentiometer. After the voltage waveform is transformed to a square waveform between zero and five volts, it is sent to the microcontroller's input capture pin. This pin is suitable for edge detection. For this project, the microcontroller was set to capture on a rising edge. Every time a rising edge is detected, the timer1 is started. The counter continues incrementing until the next rising edge occurs. From this, the time per pulse is calculated based on the system clock speed and prescaler settings.

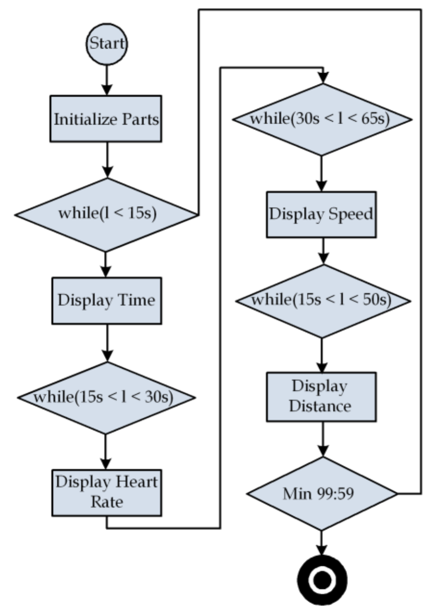

Fig. 19.8. UML Diagram of System Flow.

The user can view all statistics of a workout by simply observing the seven-segment display. The display chosen for this application has four digits, with a decimal point following each one. It also has a colon in the middle of the four digits so that it is suitable for displaying time. This colon is linked to the other decimal point of the second most significant digit on the display's pin configuration. There is a separate display loop for both the timer and the heart rate functions. The timer's display is integrated into the timer function because the loop is actually responsible for keeping track of time by making each value display for one second before entering the if-else statements again. In the case of the heart rate, a separate function is used to display the value.

The overall cost of this project was $209.

SMOKE ALARM FOR PEOPLE WITH HEARING IMPAIRMENT

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INTRODUCTION

A smoke alarm was designed for use by people with hearing disabilities who cannot hear standard alarms. The device uses RF transmission to send a signal from an active alarm to a receiver unit placed at the user's discretion. At the receiver unit two bright xenon tube strobe lights are used to notify the user of a triggered alarm.

SUMMARY OF IMPACT

The device successfully notifies the user of a smoke or fire hazard. The coupled transmitter and receiver has a significant range to ensure signal reliability in an average sized home or office. Multiple receiver and transmitter units can be used on the same frequency to alert multiple users in a large building.

TECHNICAL DESCRIPTION

The alarm unit consists of a standard smoke alarm, a battery powered transmitter unit and a receiver unit. A signal from an active smoke alarm is used to activate an encoder. The data from the encoder is then sent to the transmitter where it is modulated and sent to the receiver. The transmitter section is battery operated and all components operate in the battery-saving low-current mode when an alarm is not present. The transmitter operation is shown in Fig. 19.9.

The receiver unit scans its programmed frequency for data sent by the transmitter. Once data are acquired they are sent to the decoder. Once the decoder verifies the data, it outputs a signal that acts as a control for two solid-state relays. After the relays are activated, the strobe lights are each connected to a 9V battery and proceed to flash. The receiver section's operation is shown in Fig. 19.10.

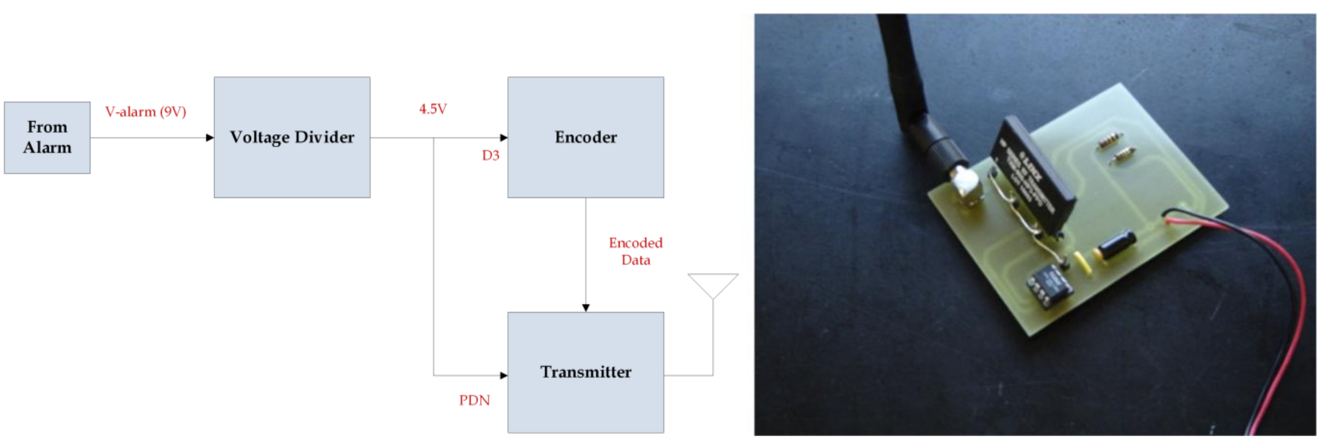

Fig. 19.9. Transmitter Operation Circuit and Photograph.

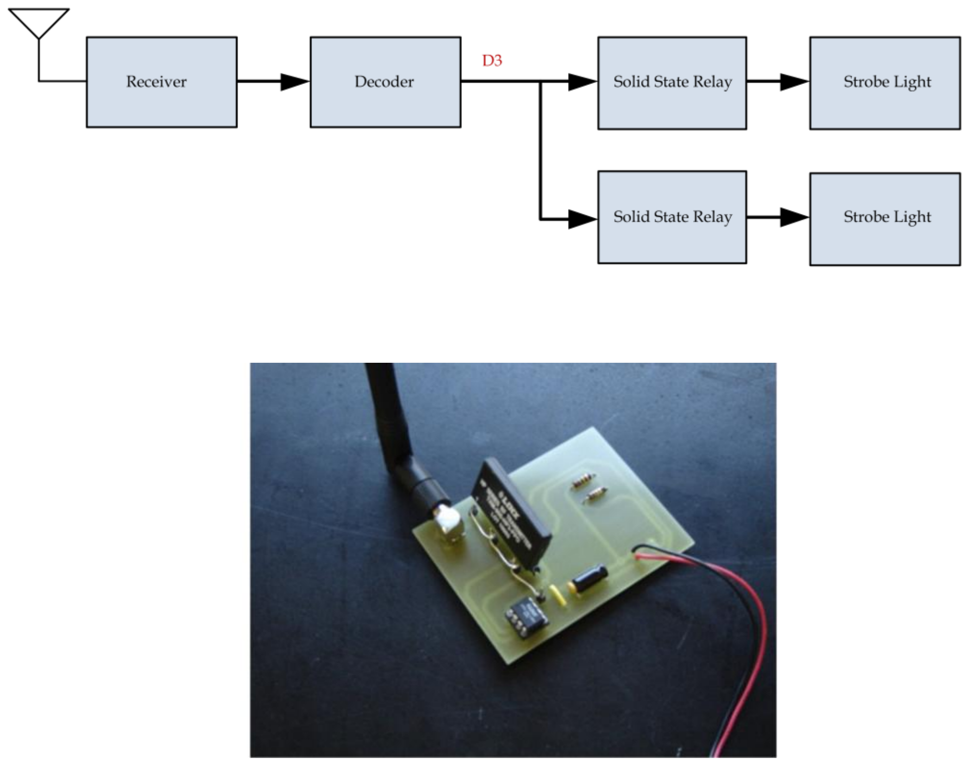

Fig. 19.10. Receiver Operation Circuit and Photograph.

CHAPTER 20
WAYNE STATE UNIVERSITY

Electrical and Computer Engineering
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ART FOR A CAUSE: PROJECT 1: RIBBON CUTTER PROJECT 2: CREFORM PAINTING WORKSTATION & INVENTORY CART

PROJECT 1: RIBBON CUTTER
Phase 1: Preliminary Design
Designers: Mandip Kaur, Vaibhav Kamboj
Phase 2: Final Design and Implementation
Designers: Pavan Kumar Jakka, Umer Khalid
PROJECT 2: CREFORM PAINTING WORKSTATION & INVENTORY CART
Designers: Sonja Daniels, Nicole Bianchi, Golnaz Ahadi
Client Coordinator: Lisa Knoppe-Reed, President, Art For A Cause, 2294 Cole Street
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Electrical and Computer Engineering Department
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Detroit, Michigan 98202

PROJECT 1:

INTRODUCTION

Art For A Cause produces Cute Tools!®, a line of hand-painted, decorative kitchen, household and garden tools. Art For A Cause employs workers with disabilities. Figure 20.1 shows a package of Cute Tools!®, each with the signature ribbon, characteristic of Cute Tools!®. Cutting the ribbons has become a daunting task as business volume has dramatically and rapidly increased. Prior to this design project, workers without disabilities cut the ribbons. Scissors and a variety of jigs and fixtures had been tried, but none were satisfactory. A switch-operated ribbon cutter was designed to be operated by workers with disabilities.

Fig. 20.1. Packaging with Ribbon, a Signature Characteristic of Cute Tools!®.

SUMMARY OF IMPACT

The Switch-Operated Ribbon Cutter is a major improvement over prior methods of cutting ribbon. A supervisor is required to configure the system for a new task, such as determining length of ribbon. after that, workers with disabilities may change the ribbon spool and start the device. The new ribbon cutting process eliminates the use of scissors and the associated repetitive motion and muscle strain that goes with large-scale cutting. Also, the new process enables better quality control with respect to consistent length and quality of the cut ribbon edge. The new ribbon cutter will enable Art For A Cause to increase productivity as required by their expanding business.

TECHNICAL DESCRIPTION

A ribbon spool is placed onto a shaft and is secured by side disks and held using a wing nut. The ribbon is fed into the rollers. The rollers start moving when a sensor detects the ribbon. The ribbon is fed through the device until the desired length is dispensed. At that point a switch is pushed to cut the ribbon. This configuration procedure programs the process controller to remember the desired length. Once the training mode is done a cover is placed over the cutting head and rollers and another

Fig. 20.2. Ribbon Cutter Mounted on Custom Mobile Cart (Note Yellow Emergency Stop Button (Red Cap) Behind Ribbon Cutter).

switch push starts the cutting process. The ribbon is cut into the required lengths and dispensed into a container below the cutting surface. Sensors detect when the ribbon has been depleted and stop the cutting process.

There are numerous safety features. The cover must be securely in place before the cutting process begins. Sensors detect ribbon jams, slips and cutting head jams. The ribbon cutter is affixed to a mobile Creform workstation, which has storage for the required inventory of ribbon spools as well as spare parts for the ribbon cutter, i.e., spare cutting disk blades.

The ribbon cutter is a custom designed device. It uses a rotary blade with a compression cutting technique. A 12VDC linear actuator (Duff-Norton TMD01-1906-4) with a range of 4 inches moves the blade over the ribbon on the cutting surface. A pair of rollers driven by 12V DC gear motors connected in parallel move the ribbon to the cutting surface. Reflective infrared sensors are used to determine the presence of the ribbon. A simple shaft with collars holds the spool of ribbon.

An Omron Zen 10C1AR-A-V1 PLC is used to control the system's operation. The device was programmed in ladder logic using Zen software provided by Omron. The device has a configuration

Fig. 20.3. A Close-Up View of the Ribbon Cutter mechanism. Cut Ribbon Falls into the Tray on the Middle Shelf.

mode and an operational mode. There is an easily reached emergency stop pushbutton. The ribbon cutter device is affixed to a mobile Creform workstation cart, custom designed for this application. The workstation cart has storage areas for ribbon inventory and consumables such as cutting blades. Figure 20.2 shows the ribbon cutter on its mobile workstation. Figure 20.3 shows a close-up of the ribbon cutter device.

PROJECT 2:

INTRODUCTION

The Cute Tools!® all have wooden handles and require several applications of paint. First the wooden handles must be primed, then the decorative pattern applied, and, finally, a protective polyurethane coating is applied.

SUMMARY OF IMPACT

The new design is being used at Art For A Cause and appears to be working well. The workstation is wheelchair-accessible, and its mobility and size are satisfactory. The vertical slatboard allows for hanging a variety of tool types and sizes. The storage drawers and flat workspace on top of the drawers is also satisfactory. One problem arose with a left-handed painter. A few workstations need to be designed for left-handed workers.

TECHNICAL DESCRIPTION

There were four important design constraints. The workstation was to be mobile, wheelchair-accessible, as small as possible, and allow for working with a variety of tools (from hammers and corkscrews to canes and plungers).

A painting task analysis determined that the process of getting unpainted tools to the painters was problematic and entailed a great deal of non-value-added activity. A custom inventory delivery cart was created to address the inventory delivery problem. It is a simple cart designed for the dimensions of the tool's shipping boxes. In this way a painter is supplied with the entire unpainted tool inventory needed for a typical work session. Figure 20.4 shows the new Creform Painting Workstation and Fig. 20.5 shows the delivery cart.

The workstation is built from Creform. Creform is a complete system of pipes, joints and hardware accessories that allows one to design and build custom devices. Creform is widely used throughout industry for designing and assembling material handling, positioning, and storage systems. Creform exemplifies the industrial engineering concept of an agile system, i.e., a system that can easily change to meet new work requirements. Creform devices can be assembled with only an Allan wrench, ruler and saw. The joints use a standard nut and bolt, as do all accessory items. CATIA was used to layout the basic design and determine pipe lengths and joints.

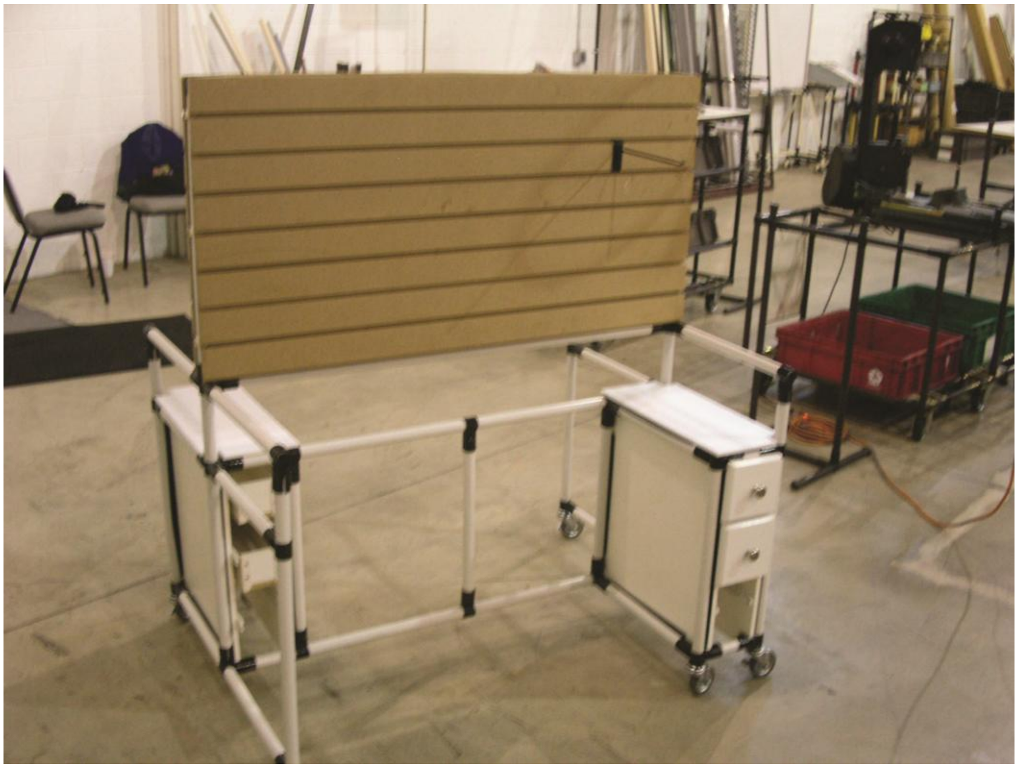

Fig. 20.4. New Creform Painting Workstation with Storage Drawers and Small Work Surface (Note Vertical Surface is Slatboard and Allows for a Variety of Tools to be Hung for Drying).

Fig. 20.5. Custom-Designed Delivery Cart for Raw, Unpainted Tools.

BATS 2: BLIND AUDIO-TACTILE SYSTEM

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INTRODUCTION

The goal of this project was to design and implement a multi-modal system that enables students who are blind or have visual impairments to participate in GIS-related activities. This is the second version of the Blind Audio-Tactile Mapping System (BATS 2). The first was designed and implemented by students at the Computer Science Department, University of North Carolina, Chapel Hill, under the supervision of Dr. Gary Bishop [1].

GIS digital mapping systems are used to study ecological issues related to the Lake Erie watershed system. Blind and visually impaired students cannot use the digital maps and related databases. BATS augments the visual display with tactical and auditory feedback. The original version of BATS used a Logitech Wingman force feedback mouse and text to voice, including recorded sounds (running water, wind through trees, waves, etc.), to provide information about digital map items. BATS2 entails enhanced multi-modal capabilities for enhanced GIS activities involving digital maps and projects.

The original BATS ran under Microsoft Windows 2000 with an outdated version of Python. Python is an object-oriented language used by ESRI in its Arc View product line. ESRI's Arc View is the dominant GIS digital mapping software and the software being used by the client. The original BATS also used the Logitech force feedback mouse, which is no longer made or supported by Logitech.

SUMMARY OF IMPACT

The Python code was upgraded. Software interfaces to support the use of the SensAble Technologies PHANTOM® Omni haptic device, and a variety of sonification software systems, text-to-voice operations, and voice recognition for program control and map navigation and database queries were developed. The system's capabilities were tested on digital maps.

The current system can detect the basic GIS features of points, lines and polygons. Multi-modal output can be provided depending on the information and data contained in the digital maps' attribute table and associated data tables. The system uses auditory icons to provide audible information to the user. Text-to-voice allows the auditory presentation of information contained in the attribute table.

Sonification processes may be associated with data in the attribute tables. "Sonification is the use of sound, mainly non-speech audio signals, for presenting or displaying data. Similar to scientific visualization, sonification aims at enabling human listeners to make use of their highly-developed perceptual skills (in this case the listening skills) for making sense of the data. More specifically, sonification refers to the technique used to create a sound signal that involves the data as essential ingredient for its construction" [2]. The current system uses simple sonification techniques, e.g., rising or lowering frequency for increasing data values, simple virtual spatial positioning (using a stereo-headset) depending on the geographic position of the data source on the digital map. Auditory sound files complement the sonification techniques, i.e., files for running water, waves, wind, etc. There is only rudimentary voice recognition and it is targeted at map navigation.

TECHNICAL DESCRIPTION

The Omni device requires drivers to interface the commands from the application to the device that is connected via the Firewire port. Sonification was achieved using DirectSound – a derivative of DirectX (version 9.0). Microsoft's Speech API (SAPI 5.3) was used to render the text to voice and voice recognition features. Some of these features require the use of C++ drivers, hence, from a technical perspective, the ability to use programs written in C++ or other languages from within Python was the central problem. A visit to online Python support groups showed difficulty of this seemingly simple task. The phantom device requires a multithreaded environment for various schedulers that work with it. The device drivers were not directly compatible with the Python code required for BATS. Also, converting the C++ code to Python using programs such as SWIG was not feasible. The best way to solve this problem with the given device drivers was by running compiled functions written in C++, or other languages, in BATS through a multithreaded DLL. DLLs were written for the Omni device, sonification software, and voice recognition functions. The original code contained the TTS module that enabled text-to-speech.

In accordance with the original BATS system, all the different sound features assigned to each map element were defined in map files by layer attributes. Following this scheme, a new layer attribute named "Haptic Movement" was added to the BATS system. Using this attribute, the user can assign and change the movement to a certain area, which the haptic device will perform when the mouse cursor is moved into that area. For example, if user assigns the "Vibrate Movement" to "Lake", then when the mouse cursor is moved into any lake, the haptic device will start to vibrate. The intensity direction of the force may be automatically derived from the information from the "Haptic Movement" layer. Likewise a "Sonification" attribute layer can be used to assign specific sonification techniques to map data.

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[1] P. Parente, Bishop, G.,, BATS: The Blind Audio Tactile Mapping System. http://www.cs.unc.edu/Research/assist/bats/papers/BATS.pdf: Computer Science Department, University of North Carolina, Chapel Hill, 2003.

[2] T. Hermann, http://www.sonification.de/, vol. Neuroinformatics Group Faculty of Technology Bielefeld University.

WIRELESS TASK SEQUENCING SYSTEM

Phase 1: Smart Sensor and Wireless System Evaluation and Selection
Phase 2: Preliminary Design of the Wireless Smart Sensor
Phase 3: Final Design of the TSS

Phase 1 Designers: Amir Sadri and Christopher Wallis
Phase 2 Designers: Simon Rayes, Adnan Haider and Ning Fu
Phase 3 Designers:
Hardware Team: Matthew Chudy, Arun Sridaran and Charles Patillo
Smart Sensor Team: Jason Mantey, Eduardo Carvalho Neto and Dave Conger
The PC Controller Team: Jablan Djordjevic and Sasha Mojic
Client Coordinator: Dennis McElhone, Special Education Teacher, Visions Unlimited
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INTRODUCTION

The Task Sequencing System (TSS) was designed to provide cognitive support for tasks requiring a sequence of specific tasks. A version of the TSS already existed and had been operational in vocational training facilities [1]. The earlier version uses a serial communications protocol with a daisy-chain cable interconnection. The new design is based on feedback from current TSS users. The most common complaint of the current TSS is "all the cables." The new design uses a Zigbee wireless communication protocol, thereby addressing the foremost user complaint. The new version also uses a new infrared smart sensor for human hand detection. The smart sensor and Zigbee transceiver unit are packaged as a Wireless Smart Sensor (WSS). The basic system configuration is shown in Fig. 20.6.

The basic operation of the TSS is as follows. For an assembly, sorting or packaging job, inventory is presented to a worker in bins. Each WSS module is attached to a bin. To start, the controller signals bin 1's WSS and turns on an indicator light. A voice prompt instructs the worker to take a part out of the bin with a light on. If the worker's hand is sensed in bin 1 by the WSS it signals the controller which turns off the indicator light on bin 1 and turns on a light on bin 2 and provides additional prompting as provided by the supervisor to the PC. If the worker enters a bin without a light, a warning prompt is given. This process continues until the inventory is depleted.

SUMMARY OF IMPACT

Overall, the new TSS addresses user complaints and recommendations from user's of the old TSS and incorporates a number of new features. It is currently being tested and evaluated.

The new TSS is a wireless system, so addresses the major user complaint of the older system. The new TSS automatically configures itself upon startup and runs through a comprehensive diagnostic procedure to identify any malfunctions or defective components. The new WSS modules can easily be attached to a variety of containers using Velcro. The human proximity sensing works as expected. There is a much simpler system configuration process and the system includes data collection facilities and report generation features necessary for monitoring student performance in line with IEP requirements.

TECHNICAL DESCRIPTION

This project had three phases. Phase 1 involved the testing and selection of a wireless protocol and sensor for human hand detection. Phase 2 involved the design and implementation of one WSS prototype module. Phase 3 involved the design and implementation of a working prototype TSS, as shown in Fig. 20.6.

PHASE 1

The requirements for TSS operation led naturally to the Zigbee wireless protocol. The application requires relatively small bandwidth and transmission speeds but, most significantly, it must be power efficient for long-term battery operation.

The next task was to select a specific Zigbee chipset. The TSS must be able to detect a human hand as it enters the bin to take a component. After a review of the available devices, a smart senor configuration developed by Ann Arbor Sensor Systems was selected. It is a low-power device with an embedded microprocessor that signals the presence of a hand in its proximity. Proximity can be specified as a set-up parameter.

A series of experiments was designed and conducted to test the sensing capabilities of the smart sensor and its communications capabilities with an external control microprocessor. Another series of experiments was designed and conducted to test the efficacy of the Zigbee chipset. Of concern was the bandwidth requirements and speed of communications. A third series of experiments established the viability of the entire WSS concept in terms of sensing a human hand within the desired proximity and communicating this information to a control PC via the Zigbee wireless link. The results of Phase 1 were the selection of the smart sensor, a Zigbee chipset, and specific technical requirements for the integration of these components into a wireless smart sensor module.

PHASE 2

Based on the results of Phase 1 a preliminary WSS was designed, implemented, and tested. It was necessary to design, build and test one WSS module to verify the design concept and communication protocols. Concurrent with the circuit design and PCB layout and assembly, was the operational software for the WSS embedded process controller. The design of this code included discussions with the client coordinator as to TSS operational requirements. An operational WSS module resulted from Phase 2 activities. The module did not perform exactly as planned and a list of changes and modifications were prepared for the next phase of the project.

PHASE 3

Based on Phase 2 results, a complete TSS design was developed and implemented. The required changes resulted in a significant modification of the circuit design. Also of special concern for this phase were the power supply and power management strategy. Together these circuit design changes led to a new PCB layout.

The basic functional circuit elements, microprocessor, Zigbee chipset, and IR smart sensor remained unchanged allowing WSS software and communication protocol design to run in parallel with the new PCB layout efforts. The WSS software team used the Phase 2 WSS prototype for software development and implementation. When the new WSS was designed and built, the newly developed WSS software was downloaded to the new WSS.

Concurrent with WSS development was the PC user interface and TSS control software. This element represents the user's view of the TSS; its design is critical to overall TSS functioning. The PC controller team had extensive discussions with the Client Coordinator, which included user walk-throughs of the TSS process using simulated WSS operations. The PC control software was completed and ready for use as the WSS modules came online.

The WSS uses a Maxstream XBee Zigbee Transreceiver module. The smart sensor is from Ann Arbor systems (A2NCT02). It is a non-contact temperature sensor and works on a 1-Wire interface. The WSS uses a PIC 16F767 running on an internal 8MHz clock as the WSS microcontroller. The firmware for the microcontroller was written in C using the CCS cross-compiler. The entire system being battery operated is designed to optimally use batteries and has a battery life expectancy of a few months. This was achieved by using both hardware and software techniques. The sensor modules are designed for AA lithium batteries but will also run on Alkaline, NiMH and NiCd batteries. Carefully chosen surface mount components were used in conjunction to a double sided printed circuit board to achieve a major reduction in size of the sensor module. The boards are housed in an ABS plastic casing that contains a battery compartment, thus making it easy to attach it to a box or a bin and change batteries.

The PC control system was written in VB.Net 2005 and runs on a Windows XP operating system.

REFERENCES

[1] ETL, "Task Sequencing System," 2000.

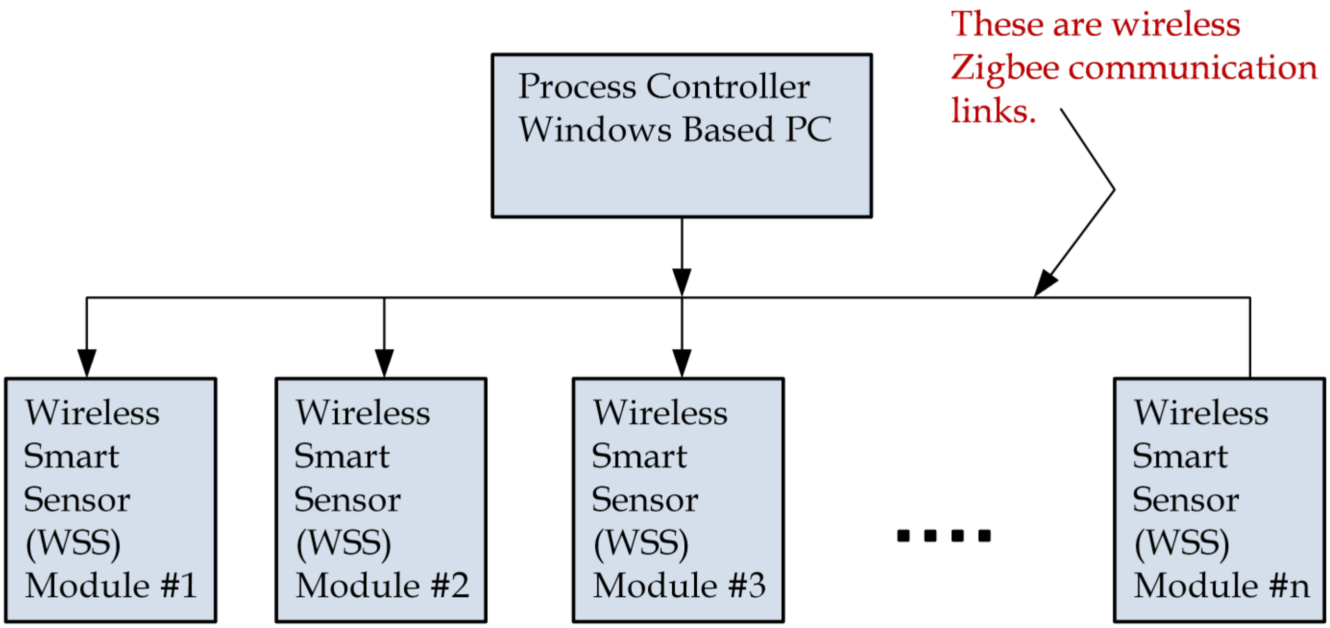

Fig. 20.6. Block Diagram of the TSS System.

CHAPTER 21
WRIGHT STATE UNIVERSITY

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MULTISENSORY ROOM

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Supervising Professor: Dr. Julie Skipper
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INTRODUCTION

A multisensory playroom was created for children with an autism, sensory dysfunction and cerebral palsy. The room allows children to explore various sensory stimuli (see Fig. 21.1), stimulating gross motor skills, eye-hand coordination, spatial awareness, and tactile sensation. The design includes a dark wall, a ball chute and an exploratory wall. Switches were placed on the floor of the sensory room for easy access and on the walls to provide a physical challenge.

Fig. 21.1. Multisensory Room.

SUMMARY OF IMPACT

The clients are able to effectively use all elements in the room to experience sensory stimulation.

TECHNICAL DESCRIPTION

The sensory room has three walls and an open ceiling. The room contains durable mechanical and electrical switches. The electrical switches are powered by an AC source. The height of the room is 60”. The floor is covered with carpeting that can be easily cleaned. The room is to be used by two children and one therapist at a time. The open ceiling allows an adult over five feet tall to stand comfortably inside the room. No choking hazards are present.

Fig. 21.2. Dark Wall and Exploratory Wall.

The dark wall (see Fig. 21.2) has a bubble screen, a color wheel and a light column. The bubble screen has: 1) a timing circuit with 45 LEDs for lighting; 2) a five-and-a-half gallon aquarium to hold water; 3) air mist diffusers to provide bubbles across the aquarium; 4) a nine-volt 30-gallon aquarium air pump; and 5) a foot switch. The foot switch controls the pump. The maximum current of the switch is two amps, while the current rating of the pump is .2 amps. A master power switch, located on the top panel of the sensory room, activates the lighting mechanism. The circuitry controlling the lights includes a 555 timer and a decade counter. Each output controls a total of 15 LEDs each. The LEDs light the water from the top of the bubble screen and change the color from red to green to blue. The color changes every ten seconds. The plywood surrounding the bubble screen is covered in a light green textured fabric. The fabric enhances tactile stimulation and is easy to clean.

The color wheel is in the center of the dark wall. A child spins the knob, which causes the wooden frame to spin. Three colors are revealed. The "wheel" is a wooden square frame that is 13″ x 13″. Four triangles were cut out from the wooden square. A 1″ hole was drilled in the center of the frame to insert a dowel rod. Four colors of cellophane (red, green, blue and purple) were placed between two acetate layers. The acetate prevents the cellophane from tearing. The three layers were glued together with Liquid Nails™. The three glued layers were glued to the wooden frame with Sumo Glue™. The plywood (20″ x 60″ x .5″) was covered with blue fabric.

Three triangles, cut out of the plywood, expose the different colors of the color wheel. A dowel rod connects the wheel to a door knob, which allows the wheel to spin. Behind the wheel, two strips of plywood (2″ wide) were joined together in a triangle for support. Two 1″ holes were drilled through the two strips so the dowel rod could pass through the support mechanism, which also spins the wheel. A fluorescent light is mounted on two 17.5″ horizontal studs that are supported by two vertical 57″ studs.

The Light Column consists of a mechanical switch and a logic circuit. The master power switch, located on the top panel, activates the lights. The lights flash on and off with the appropriate count of the decade counter. When the switch is pressed, the lights stay lit as they ascend. Once the switch is released, the lights flash on during the appropriate count and are deactivated on the next clock pulse. The paneling that covers the light column has six holes. The holes are 4″ in diameter and are cut out from the plywood.

Six 5.5″ colored diffusers were mounted behind the holes. The diffusers have colored cellophane glued to the front to protect the cellophane. A layer of acetate was glued on top of the cellophane to protect it. Behind the diffusers are six square pieces of wood that measure 7″ x 7″. The squares have three holes drilled out for insertion of LEDs. The plywood is covered in the same light green fabric as the bubble screen. The mechanical switch has a force resistance that can be increased or decreased by adding or removing any of four springs that are inside. A child must hold down the switch in order to allow each light to stay lit.

The ball chute is the center wall of the sensory room. It includes: 1) a logic circuit; 2) super bright LEDs; 3) diffusers; and 4) clear tubing (see Fig. 21.3). The lights are placed at each turning corner of the tubing. Mechanical momentary switches are inside each of the corners. A child drops a ball in the tubing, which is on a 40″ x 40″ piece of pegboard. Once the ball hits the first switch at the corner, the light adjacent to the corner remains lit. The ball then drops down to the next corner to hit the next switch. This activates a light and deactivates the previous light. There are a total of four corners and four lights. The circuit consists of two dual JK Flip-Flop logic chips connected to a five-volt DC power supply. Each normally open momentary switch was connected from ground to the preset pin of a flip-flop. Once the ball hits the first switch, a low pulse is sent from ground to the preset pin and activates the output Q, which is fed to LEDs. When the ball activates the next switch, it turns on the next light. The Q output of the second flip-flop goes high, making its output low. The low pulse is sent back to the clear pin of the first flip-flop, and it turns the previous light off. The sequence continues until all four lights are activated and then are cleared by a fifth and final switch.

The exploratory wall (see Fig. 21.2) is the final wall of the sensory room. It includes several acoustic instruments (tambourine, shakers, clappers and guiro) mounted on the wall to promote auditory stimulation. All instruments (except the tambourine) were placed in front of colored foam to provide color contrast.

The Brain Game (see Fig. 21.4) was constructed from an electronics kit purchased at Midwest Electronics. It plays a pattern of lights and sounds that must be repeated by pressing one of the four buttons in order to get a positive response. The positive response is a short tune and lights flashing in a circular pattern. If the child presses the wrong button, all of the lights flash on and off. The game was mounted inside a clear display case and installed on the inside of the exploratory wall below the tambourine.

An 18″ x 18″ chalkboard is also affixed to the exploratory wall. The chalkboard is hidden behind a hinged door. The door was made of plywood and mounted by two 2″ hinges. Two grooves were made in both horizontal 2″ by 4″ boards. The horizontal studs were mounted on the vertical studs of the wall frame. The back grooves hold the mirror into place, while the front grooves allows the yellow door to slide open, revealing a mirror.

The exploratory wall includes a set of mystery pockets with buttons and a mystery box with laces. The mystery aspect was incorporated to encourage children to unfasten the buttons or the lace. The child receives positive feedback by receiving his or her favorite toy once he or she opens the pockets. In this device, the state of each of the lights, located on all four edges, depends on whether force is applied to each corresponding switch. A knob on a track guides the child to each switch that activates a light

The cost of the parts and labor was about $1050.

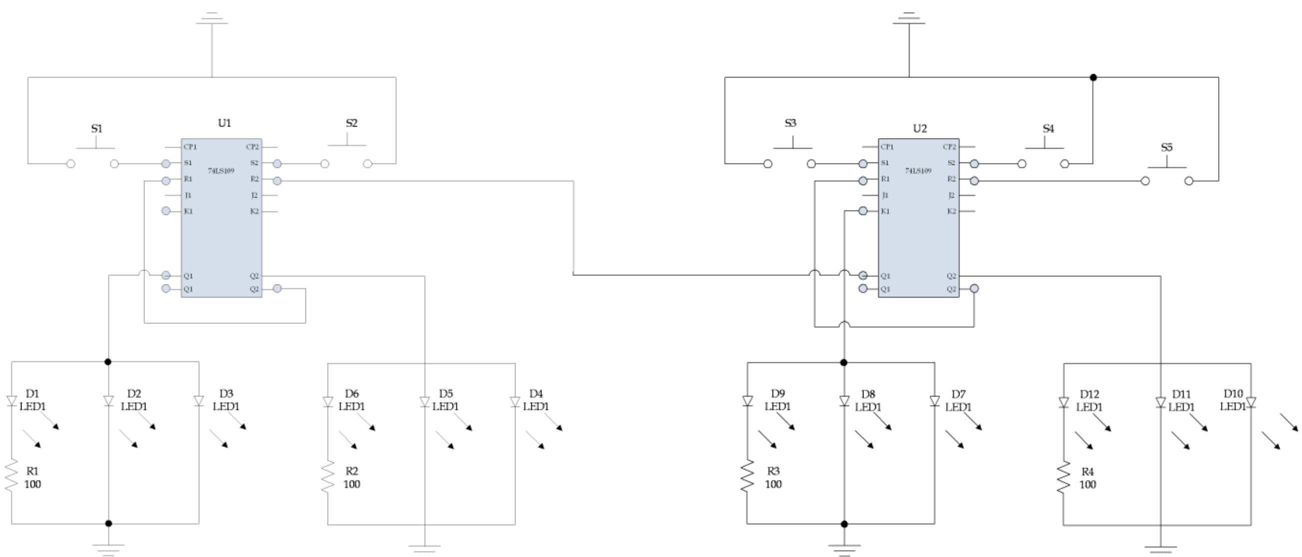

Fig. 21.3. Diagram of Ball Chute Logic Circuit.

Fig. 21.4. Client Interacting with Brain Game.

CUSTOMIZED HEIGHT-ADJUSTABLE TABLE TOP

Designers: Stephanie Auld and Ryan Foster
Client Coordinator: Ms. Cassandra Hoagland, Gorman Elementary School
Supervising Professor: Dr. David Reynolds
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INTRODUCTION

The Customized Height-Adjustable Table Top is a table with a section that can be raised and tilted to accommodate a person using a tall, tilting wheelchair (see Fig. 21.5). The device was created for a student with physical disabilities who uses a wheelchair that tilts backwards at an angle of approximately 15 degrees. The device allows the client to complete in-class activities. The table accommodates groups of students in wheelchairs, including taller wheelchairs, such as the one used by the client. The table has three sections : two are fixed and the third (middle) section may be raised and tilted.

SUMMARY OF IMPACT

The device improves the ease of teacher-student interactions in the classroom. The client is able to access the raised and tilted portion of the table top, while the teacher assists the client from the opposite side of the table. The client coordinator stated, "This is perfect, exactly what I asked for." The device allows the client to be more involved in group interactions as well.

TECHNICAL DESCRIPTION

The table design utilizes basic geometric angles. The acute angles between the three sections of the table are 45°. The surface of the table top is white shelf plywood. A frame of 1″ x 6″ hardwood board supports the bottom of each non-adjustable section of the table top. The support frame decreases the possibility of the table bending and sagging. A white border material was placed around the edges of the shelf plywood to smooth out the edges and provide a more uniform appearance. The eight legs are made of 1.25″ inner-diameter metal piping. Eight 1.25″ flanges are attached to the support frame on the bottom of the table. The ends of the piping are threaded, which allows them to screw into the flanges. Rubber stoppers were placed over the other end of the legs to minimize slippage.

Fig. 21.5. Client Using Adjustable Table Top.

The height adjustment mechanism has: 1) two bracket arms; 2) four side plates; 3) eight rotating pins; 4) a double-ended spring loaded pin; 5) two gas-assisted extension struts; and 6) a lever arm (Fig. 21.6). Aluminum 7170 was used to construct all of the structural components of the mechanism. A force analysis of the adjustable section of the table top was conducted to determine the required properties of the gas struts and then two sets of the struts were selected.

The height-adjustable portion can be raised to a level of 31.125″. The maximum degree of tilt is 15.5°. The maximum tested load of the height adjustment mechanism was 140 lbs. The steps to adjust the table top are: 1) grip the table top; 2) press the lever arm to unlock the pins; 3) move the table top to the desired height or tilt it; and 4) release the lever arm.

The total cost of the parts and labor was $910.

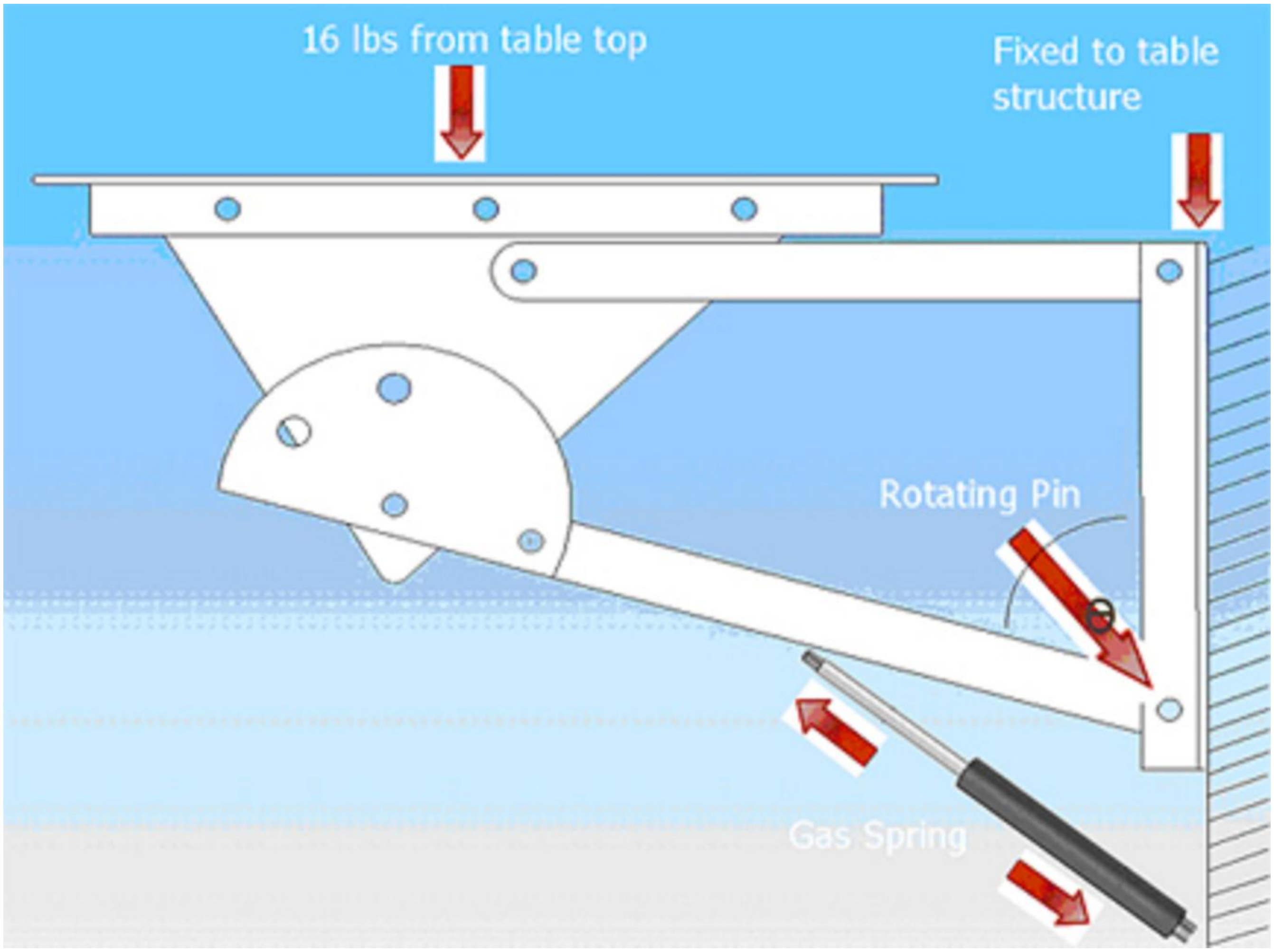

Fig. 21.6. Height Adjustment Mechanism.

CANDY SORTER

Designers: Brian Bottenfield and Nathan Busick
Client Coordinator: Mr. Guy Parworth, United Rehabilitation Services
Supervising Professor: Dr. Chandler Phillips
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INTRODUCTION

A candy sorter was created to help distribute random candies into a container (see Fig. 21.7). The objective was to modify a past candy sorter design into a more functional one. The device was developed to help individuals with physical disabilities sort and count candies so that they can make candy wreaths.

The final product is based on the previous design, involving a rotating drum that pushed the candy down a series of ramps and into the appropriate containers. The drum was unchanged, but the ramp system and controls were simplified. The candy is put into the drum, and the drum then spins, according to user input, and pushes the candy to the ramp. The candy then slides down the ramp into a container. The container is on a spinning platform with three other containers. When the container is filled, the user triggers the spinning platform to turn so that a new container can be filled.

SUMMARY OF IMPACT

The candy can be counted by the client and sorted into separate containers based on the client's control of the device. The device increases the client's

Fig. 21.7. Client Using Candy Sorter.

independence. The client coordinator and the client were both satisfied with the delivered product.

TECHNICAL DESCRIPTION

The device has two individual and separate apparatuses. The drum/ramp portion (Fig. 21.8) is made of a combination of materials. The base structure is made of hard lumber, the rotating drum is made of fiber glass, and the ramp is made of Sintra plastic. All of the fastening was done with a variety of different size steel screws. The drum assembly is 37 " long and 18.5" wide. The total height measured from the ground to the top of the drum when fully tilted is 40". The drum is center-mounted to a high-torque DC motor. A switch (used by the client) completes the circuit between the motor and the power supply. Pressing the switch makes the drum rotate; releasing the switch makes it stop. Inertia and internal braking in the motor prevent the drum from spinning freely.

The second section is the rotating carousel. The base is made from hard lumber, and the top section is made from foam laminate and plastic. Fastening was done with steel screws. The rotating carousel is 23 "wide and 23" long. The height from the ground to the top is 9". For proper rotation, the clearance should exceed 33". The rotating platform is mounted onto a stepper motor. The client has a switch that is pressed to rotate the platform 90 degrees. When the client presses the switch, a signal is sent to a BASIC Stamp II microcontroller. The microcontroller instructs a stepper motor controller (the Little Step-U) to activate the stepper motor.

The length of the power cords is 24" and the maximum distance the controller can be from the unit is 36". The maximum weight limit is approximately that of 15 small wrapped hard candies per receptacle. The drum capacity is approximately 200 similarly-sized candies.

The total cost of the parts and labor was $925.

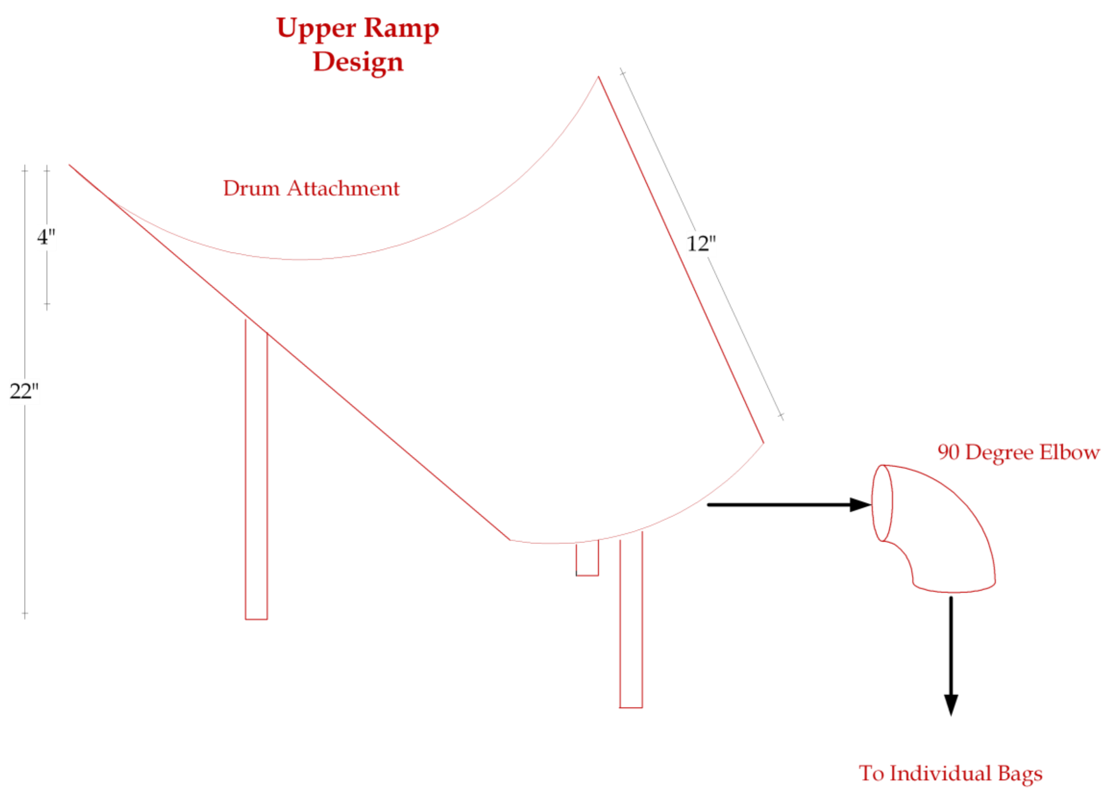

Fig. 21.8. Ramp Design.

NO-TOUCH SOAP DISPENSER

Designers: Roshanak Dezfoolian and Erin Kleismit
Client Coordinator: Ms. Elaine Fouts, Gorman Elementary School
Supervising Professor: Dr. Ping He
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INTRODUCTION

The No-Touch Soap Dispenser is a device that dispenses a specified amount of soap using a motion sensor (see Fig. 21.9). The client coordinator requested a device for children to replace standard soap dispensers in a restroom at an elementary school.

The device is a motion activated control unit. The device is wall mounted with an extension. It has a pre-determined delay for dispensing the soap to minimize the amount of soap wasted from repeated dispensing. The device is washable, battery-operated, and wall-mounted. It has a low battery indicator that notifies the clients when the battery needs to be changed.

SUMMARY OF IMPACT

The dispenser is fixed to an extension box that makes the device more accessible for small children. Only one hand is needed to operate the product. The motion activation feature decreases the possibility of cross contamination. The time delay minimizes the amount of soap that leaks, which reduces risk of falls and prevents messiness. The client coordinator expressed satisfaction with the final product.

TECHNICAL DESCRIPTION

The device consists of a commercially purchased motion sensor soap dispenser that was modified to increase the time delay after the first delivery of soap to approximately 12 seconds. The time delay device is triggered by the falling edge of a square wave output from an eight-bit micro-controller. The RC time constant produces a delay of 10.8 seconds. With the commercial soap dispenser's own internal delay, the total delay of the final product is roughly 12 seconds. A low-battery indicator was also added; it sounds when the battery level drops to 4.5 volts. The soap dispenser is on a hollow wooden extension box measuring 27.5″ x 12″ x 12″. It extends the product out from the wall by 4″. The soap dispenser is 8.375″ x 4.75″ x 3.5″, which extends the product 15.5″ from the wall. The wooden extension box is covered with Formica so that it is easy to clean and is water resistant. There are pre-drilled holes in the back of the box for simple mounting to the wall. The prototype board that houses the electronic circuits is placed inside the box and the buzzer protrudes from the bottom of the box. The electrical components on the prototype board are: 1) resistors; 2) capacitors; 3) integrated circuits; 4) diodes; 5) a potentiometer; 6) 24-gauge wire; 7) solder; 8) and flux. The user must first insert the batteries and then place one hand approximately 2.75″ under the motion sensor, which triggers the motor to deliver 1 milliliter of soap. There is approximately a 12-second delay before the product can be used again.

The total cost of parts and labor was $525.

Fig. 21.9. Client Using No-Touch Soap Dispenser.

FOOT-ACTIVATED CAUSE-AND-EFFECT TOY

Designer: Jacalyn Jones
Client Coordinator: Dr. Debbie Santiago, United Rehabilitation Services
Supervising Professor: Dr. Thomas Hangartner
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INTRODUCTION

The Foot-Activated Cause-and-Effect Toy is a toy with interactive components triggered by wireless foot pedals. The device was created for young children who are not familiar with cause-and-effect relationships. The foot-activated pedals activate visual, tactile, and audiotry stimuli.

The client coordinator requested a modification of an existing toy already in use. The existing toy was a small play tent with various stimuli that were activated via switches. The activating switches were required to be enclosed in foot pedals. These foot pedals are wireless in order to accommodate children of different heights and body structures. The client interacts with the device by lying on the floor, within the tent, and pressing the pedals with his or her feet (see Fig. 21.10).

SUMMARY OF IMPACT

The pedals are durable, compact, washable, and adjustable. They insure user safety and maximum enjoyment while teaching cause-and-effect relationships. Children with limited upper extremity control are able to interact with the device.

TECHNICAL DESCRIPTION

The foot pedals are made out of plastic and metal components (see Fig. 21.11). The case structure is comprised of a plastic commonly used as fascia for installing windows. The metal components are: 1) springs; 2) nuts; 3) bolts; 4) washers; 5) screws; and 6) rivets. The surface areas of the pedals that contact the feet were designed to comfortably fit an average foot size. The contact surface is covered with

Fig. 21.10. Client Using Foot-Activated Cause- and-Effect Toy.

sandpaper to provide grip. The part of the pedal that contacts the floor encloses the electronic components. All of the exposed outer surfaces are washable.

The foot pedals enclose the activating micro switches and the wireless transmitter. Each pedal contains two micro switches. Stops were affixed to the pedals to prevent them from being pushed past the point of activating the second micro switch. The transmitter is secured to the connection between the pedals with Velcro, so it can be easily removed to change the battery.

The foot pedals are affixed to a plastic mat with Velcro. The strips of Velcro allow the pedals to be moved to accommodate users of different sizes.

The total cost of parts and labor was $475.

Fig. 21.11. Completed Foot Pedals with Exposed Internal Structure.

TOTAL ANKLE REPLACEMENT

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Supervising Professor: Dr. Tarun Goswami
Biomedical, Industrial, and Human Factors Engineering Department
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Dayton, OH 45435-0001

INTRODUCTION

The goal of this project was to design a replacement ankle joint that will relieve the symptoms of severe ankle arthritis by reducing pain and restoring normal movement, gait, alignment, and stability to the joint. The products were designed to replace current designs that have high complication rates and excessive bone resections.

Three different ankle implant models were developed (see Fig. 21.12). One is a primary design, while the others are revision case designs. The first design is intended for use as the primary implant for initial replacement of an arthritic ankle joint. The second and third designs are for use in revision surgeries in which a previous ankle implant has failed and must be replaced.

SUMMARY OF IMPACT

The designs were tested using Finite Elements Analysis and meet all required specifications. These designs should reduce the complications associated with existing implants. The designs meet all surgical requirements. They may be manufactured in a cost-effective and reliable way.

TECHNICAL DESCRIPTION

The first and primary design consists of three components. The first components is the tibial component, which fits into the inferior end of the tibia. The tibial component contains a trapezoidal superior ridge that is designed to fix the component within the tibia. The tibial component also contains two triangular ridges on the medial and lateral ends. These ridges are designed to provide additional surface area and stimulation for bone growth to help fix the component. The upper portion of this component is coated with a porous coating, which aids in its fixation. The component is made of metal Titanium 6-Aluminum 4-Vanadium (Ti-6AL-4V).

Below the tibial component is the bearing component. This component is manufactured from ultra high molecular weight polyethylene (UHMWPE). The superior surface contains unique rotation protrusions that snap into corresponding holes in the bottom of the tibial component. The protrusions allow approximately 5 degrees of external and internal rotation of the joint. The bottom surface of the bearing component is shaped to match the articulation surface of the third component, the talar component. The curvature of the articulation surface is designed to limit talar shift and provide stability to the ankle joint.

The talar component is also manufactured out of Ti-6Al-4V and will articulate with the bearing component to allow the ankle joint a normal range of motion. The implant provides 25 degrees in both dorsiflexion and plantarflexion. The talar component is designed to fit over the talus like a "cup". The talus is prepared by chamfering all four sides and then slightly flattening the top. The bottom of the talar component also contains a pin, which provides additional fixation to the bone. A porous coating is applied to all surfaces that contact the bone as the method of fixation.

The second design is used for a revision or secondary surgery. It is a four-component design. It consists of a tibial component made of Ti-6Al-4V, and a middle bearing component, which has a C-ring implemented for a pop-fit fixation between the tibial and poly bearing components. Both the bearing component and C-ring are made of UHMWPE. The talar component is similar to that of the other designs and is made of Ti-6Al-4V.

The tibial component has a long spike on the top to give a larger fixation surface area with the bone. It is longer than other primary surgery designs. The spike has a three-stacked conical structure with slightly chamfered sides; the top piece is semi-spherical. The superior surface of the tibial component contains two triangular ridges on both the medial and lateral sides, which perform the same function as in primary design. A porous coating is added to the superior aspect of this component to add additional bone fixation on a cellular level. The medial and later ends have a slight overhang over the bearing component to minimize the amount of debris and growth between the components. The overhangs allow for a slight degree of rotation to reduce stress on the implant. The inferior surface of the implant contains a groove into which the bearing component is inserted.

The superior face of the bearing component contains a protruding structure that fits into the tibial component. The farthest superior and inferior cylinders have the same diameters and are slightly larger than the cylinder between them. The C-ring fits around the center. The C-ring is inserted onto the protrusion by slightly expanding and then snapping into the place in the middle. The C-ring then shrinks as it is fit into the tibial component and then snaps into place to hold the two components together. The inferior surface of the poly bearing component is curved and grooved to fit the articulating surface of the talar component. This groove helps keep the components aligned and allows for 20 degrees of dorsiflexion and plantarflexion.

The talar component has a superior aspect, which has a grooved geometry in the medial/lateral plane and curved geometry in the anterior/posterior plane. It also has stoppers at the ends of the articulating surface to limit the range of motion to 20 degrees dorsiflexion and plantarflexion. The inferior aspect is covered in porous coating to allow bone in-growth and has a chamfered base to allow for press-fit fixation and to provide additional surface area for fixation.

The third design also consists of three components and is intended for use in revision or deformity cases when the first two designs are not able to be used. There is a tibial component made of Ti-6Al-4V. The tibial component consists of two trapezoidal ridges that help fix the component to the tibia. A porous coating is applied to the surfaces in contact with the bone. The bearing component is made of UHMWPE and also allows for internal and external rotation of the joint. The protrusion on the top of the bearing component is a cylinder with a small ring extending from it that snaps into a matching groove in the tibial component. The talar component fits over the talus by the same method as the primary design. It is constructed out of Ti-6Al-4V. The only difference from the primary design's talar component is the articulation surface, which is flat.

The total cost of parts and labor was $1210.

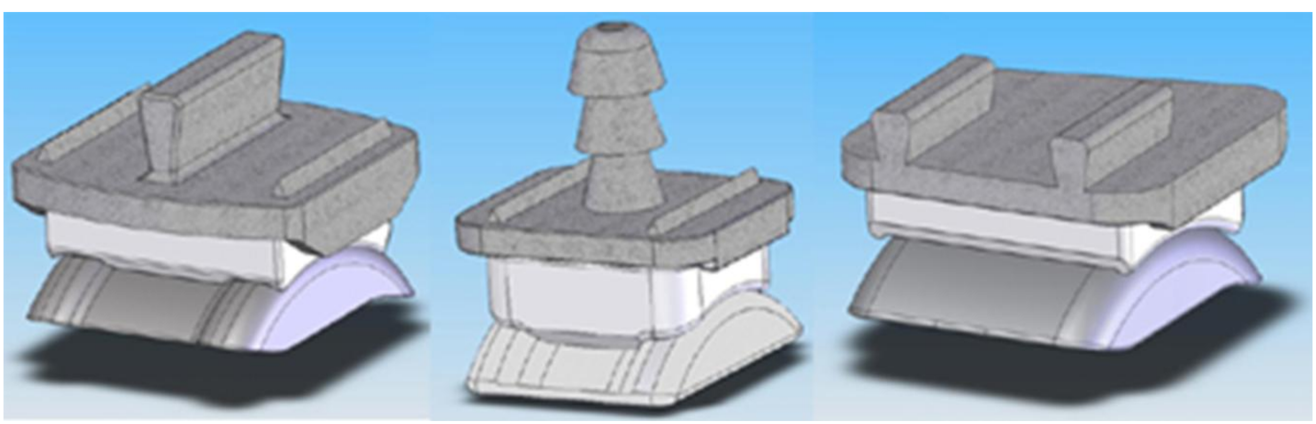

Fig. 21.12. Primary Ankle Replacement Design and Second and Third Revision Designs.

CHAPTER 22
INDEX

F

G

H

I

K

L

M

N

O

P

Q

R