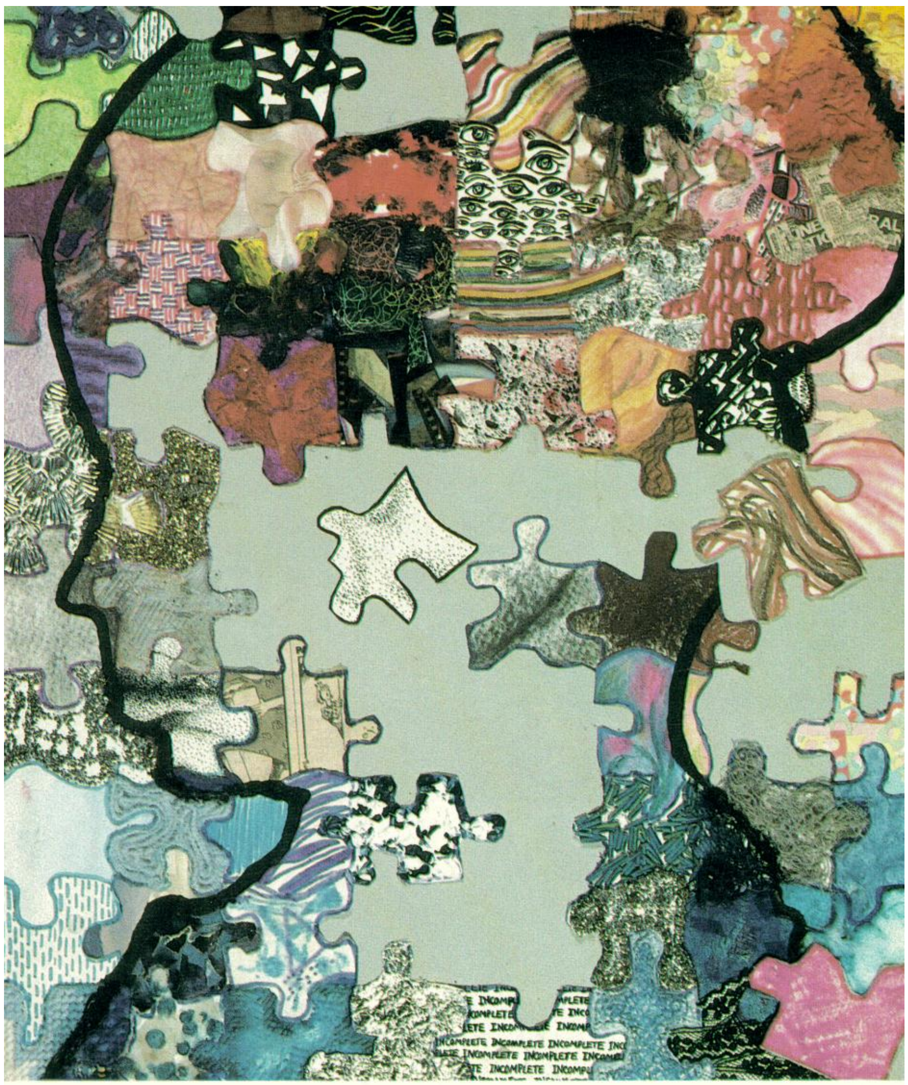
NATIONAL SCIENCE FOUNDATION 2008 ENGINEERING SENIOR DESIGN PROJECTS TO AID PERSONS WITH DISABILITIES



Edited By
John D. Enderle

NATIONAL SCIENCE FOUNDATION

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Creative Learning Press, Inc.
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FOREWORD

Welcome to the twentieth 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

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

to Aid Persons with Disabilities was published, presenting 154 projects carried out by students at 16 universities 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. In 2010, NSF 2007 Engineering Senior Design Projects to Aid Persons with Disabilities was published, presenting 139 projects carried out by students at 16 universities during the 2006-2007 academic year.

This book, funded by the NSF, describes and documents the NSF-supported senior design projects during the twentieth year of this effort, 2007-2008. 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 editor 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.

I acknowledge and thank Alexandra Enderle for editorial assistance. I also appreciate the technical illustration efforts of Justin Morse. Additionally, I 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 the editor 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 I 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, I 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, a faculty member at Ohio University, became the co-editor of this book series beginning with the 1996 edition and ended with the 2007 edition to devote time to other pursuits.

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

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 2007-2008. 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, 12 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

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[2] Accrediting Board for Engineering and Technology. Accreditation Policy and Procedure Manual Effective for Evaluations for the 2010-2011 Accreditation Cycle. ABET: Baltimore, MD.

[3] Accrediting Board for Engineering and Technology. Criteria for Accrediting Engineering Programs, 2010-2011. 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

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 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, National Instrument's *Multisim*, a circuit analysis program, easily analyzes circuit problems and creates the layout for a printed circuit board. For mechanical components, the use of Dassault Systèmes SolidWorks Corp. *Solidworks* allows for computer-aided-design analysis and 3D drawings. 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.

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 worked on many small design projects during the two-semester senior design course sequence. At North Dakota State University, students worked on a single project during the two-semester senior design course sequence. At the University of Connecticut, students were 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.

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. 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 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

[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.

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://www.bme.uconn.edu/bme/ugrad/bmesdi-ii.htm.

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. 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

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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.

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.

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.

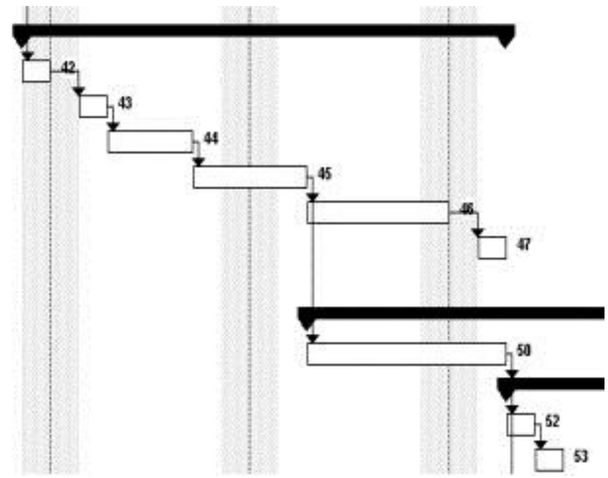

Fig. 2.1. Shown above is a section of a typical timeline. The rectangular boxes represent certain tasks to be completed. These singular tasks are grouped into larger tasks, represented by thick black lines. The tasks are numbered to correspond to a task list that is not shown. The thin lines that descend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

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 implications... would not be

[13] Accrediting Board for Engineering and Technology. Criteria for Accrediting Engineering Programs 2010-2011. 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.

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 educational/training program. Examples are appreciation of various racial, ethnic, or linguistic

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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.

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 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 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.

APPENDIX: Desired Educational Outcomes as Articulated in ABET's "Engineering Criteria for the 2006-2007 Academic Year" (Criterion 3, Program Outcomes and Assessment)[17]

Engineering programs must demonstrate that their graduates have:

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

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

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

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

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

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

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

Brooke Hallowell

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

A Formative Focus

As discussed in the previous chapter, a formative focus on academic assessment allows educators to use assessment strategies that directly influence students who are still within their reach. A solid approach to formative assessment of writing skills involves repeated feedback to students throughout educational programs, with faculty collaboration in reinforcing expectations for written work, use of specific and effective writing evaluation criteria, and means of enhancing outcomes deemed important for regional and ABET accreditation. 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.

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[18]. 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.

[18] 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.[19] 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.[20] 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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19 World Health Organization (2007). International Classification of Functioning, Disability and Health (ICF) [on-line]. Available: http://www.who.int/classifications/icf/en/

20 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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[21] 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 phenomenon 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:

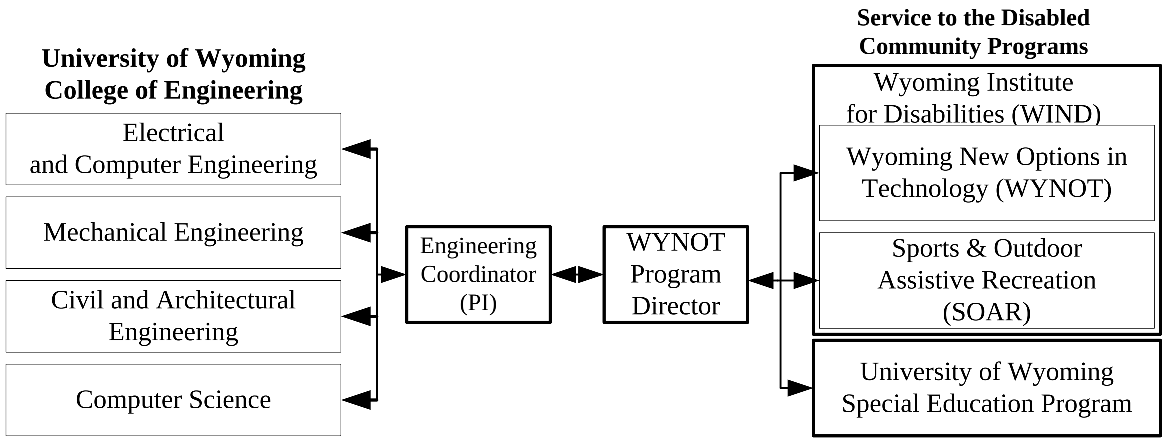

Fig. 5.1. Program Flow for Undergraduate Design Projects to Aid Wyoming Persons with Disabilities (Barrett, 2003).

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

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

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

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

Expected Benefits

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

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

This quote from a student who participated in the program best sums up the expected benefit:
"As an undergraduate student in the college of engineering, this project personally affected my life in many ways. It not only challenged me to think creatively and to be able to come up with an original design, but it also allowed me to see at a young age how the work I do can better other lives. I am proud to have been a part of this project and to know that something that I helped design and build is allowing

people from around the state of Wyoming to be educated about disabilities (Barnes, 2003)."

Resources

Resources on Disability:

The Family Village is a website maintained by the Waisman Center at the University of Wisconsin-Madison,

http://www.familyvillage.wisc.edu/index.htmlx

The Library section allows individuals to search for specific diagnoses or general information on numerous disabilities.

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

Resources on Assistive Technology:

The National Institute on Disability Rehabilitation and Research,

http://www.ed.gov/offices/OSERS/NIDRR/

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

Another valuable source is the Rehabilitation Engineering and Assistive Technology Society of North America (RESNA) http://www.resna.org/. This is a transdisciplinary organization that promotes research, development, education, advocacy, and the provision of technology for individuals with disabilities. In addition, by using the technical assistance project link on the home page, one can 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
DUKE UNIVERSITY

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WHEELCHAIR-MOUNTED LEAF BLOWER

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INTRODUCTION

Our client is an active woman who was born with spina bifida. She enjoys working in her yard, but has difficulty removing fallen leaves because she uses a manual wheelchair. The Wheelchair-Mounted Leaf Blower mounts to the wheelchair using an L-bracket that slides into a mating receptacle mounted on the wheelchair. The design incorporates an articulating arm for lateral movement and a tripod head for swivel motion and angle adjustment. Using this device, the client can independently blow leaves in the yard while operating her wheelchair.

SUMMARY OF IMPACT

The client previously struggled with operating a corded leaf blower simultaneously with her wheelchair or had to pay someone to blow the leaves from her yard and driveway. She commented "It helps me feel more independent. Since I've been in the chair, I haven't been able to do all of the things that I used to do, but this gives me some of that back, even if it is just blowing the leaves."

TECHNICAL DESCRIPTION

The Wheelchair-Mounted Leaf Blower (Figure 6.1) includes four parts: an L-bracket slot, a mount, a tray, and a commercial cordless leaf blower. The L-bracket slot is a 2 x 12 3/8 x 3/8" piece of aluminum with a 1" wide, 1/8" deep slot milled through the entire length to allow for attachment to either side of the slot. Four hose clamps are screwed into the ends of the L-bracket slot. These clamps wrap around the horizontal bars beneath the seat of the wheelchair and are secured in place with screws.

The mount consists of three components: an L-bracket for attachment, an articulating arm, and a tripod head for free range of motion. The L-bracket is bolted to the wall plate of a Sanus Full-Motion Wall Mount Model #VM3b, which provides for lateral movement. A Dynex 60" Universal Tripod Model #DX-TRP60 was modified by unscrewing the legs and cutting off the shaft to a length of 2 3/4". A larger hole was drilled into the end of the articulating arm to custom-fit a solid 5/8" diameter aluminum rod, which connects the arm to the tripod shaft. The rod was placed within the inner diameter of the arm and tripod shaft and secured in place using a bolt through the arm and two screws through the tripod shaft.

Fig. 6.1. Wheelchair-mounted leaf blower.

The tray is made from a 8.5" x 15" x 1/2" sheet of high-density polyethylene (HDPE) with a cutout in the center that is custom-fit to the Black & Decker Cordless Hard Surface Sweeper Model #NS118. The cutout includes an oval hole 6" long and 4 3/4" wide to fit the base, as well as a 4" long and 2 1/2" wide slot to fit the nozzle of the leaf blower. A 1" x 2 5/8" x 1 3/4" block of HDPE attached to the back of the tray provides additional support of the leaf blower battery. A 6 x 4 5/8" U-bolt attached to the bottom of the tray limits the angle of the tripod head, thereby preventing the leaf blower tip from striking the ground. Four 1" slots milled in the front and back of the tray allow two straps and buckles to secure the leaf blower in place. Finally, a beveled connector from the tripod is screwed into the bottom of the tray to connect the tray to the tripod head mount.

The Black & Decker Cordless Hard Surface Sweeper weighs 5.5 lbs. and operates on an 18 volt battery, giving approximately 15 minutes of battery life. A second battery provided to the client doubles the operating time. Figure 6.2 shows the client using the device. Cost of parts for the device was $312.

Fig. 6.2. Client using wheelchair-mounted leaf blower.

PLAY CHAIR

Client Coordinator: Diane Scoggins, Hilltop Home
Designers: Carol Chen, Eugene Kim, and David Wu
Supervising Professor: Larry Bohs
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INTRODUCTION

Our client is a six-year old boy with multiple physical and mental disabilities. He seeks independent movement and outside stimuli, desires that were satisfied through inappropriate, self-injurious behaviors. The Play Chair is a modified booster seat suspended from a custom frame with toy attachment points. The client can generate his own rocking movement, and play with the novel toys presented to him through the device.

SUMMARY OF IMPACT

Since he outgrew his baby rocker, our client has not had an adequate, dependable, and safe way to satisfy his desires for independent movement and external stimuli. The Play Chair fills these, and provides a change from his confining wheelchair, where he spends a significant portion of his day. His primary caretaker says, "(He) loves the chair! It has been wonderful to have an additional positioning option for this very active little boy. He thoroughly enjoys the sensory input that he receives from using this chair."

TECHNICAL DESCRIPTION

The frame of the Play Chair (Figure 6.3) is constructed with 6105-T5 aluminum alloy from 80/20 Inc. Two aluminum side beams connected by a crossbeam make up the base of the frame. Two vertical beams are attached to each side beam. Joining plates hold the frame together. Custom-made Delrin plastic blocks secure four locking swivel casters to the bottom of the frame.

To serve as armrests, two 1"×4" spruce planks are mounted on top of the four vertical beams by corner brackets. To prevent the client from injuring himself when he hits the armrests with his hands, these wooden planks are padded with polyurethane. Waterproof vinyl fabric covers the armrests so that the client's caretakers can easily clean up any spills. U-bolts, cushioned with clear plastic tubing, are

Fig. 6.3. Play chair.

fastened to the armrests to provide attachment points for toys. Additionally, two strips of Velcro are attached to each armrest to allow for more toys to be connected. The U-bolts and Velcro strips allow toys to be changed to continuously provide a novel source of entertainment for the client.

The seat of the Play Chair is a modified commercial booster seat (Evenflo Model No. 3341791A). An easily adjustable 3-strap seat belt is attached, holding the client comfortably and securely in the seat. To reinforce the seat base-to-back connection, two wooden back braces are attached. A wooden wedge inserted into the cavity between the base and the back significantly increases the rigidity of the base-to-back connection.

Two rubber straps suspend the booster seat within the frame. Carabiners connect the rubber straps to eyehooks on the vertical supports. The straps are strung through holes drilled in the base of the booster seat. Custom grommets made of high-density polyethylene plastic reinforce the holes where the rubber straps go through the chair.

To prevent the client from rocking too far forward or backward, two springs are attached from the shoulder section of the booster seat to the eye hooks on the rear vertical beams via carabiners. Plastic tubing covers these springs so that they cannot scratch or pinch the client. Figure 6.4 shows the client sitting in the Play Chair. The cost for the chair is approximately $350.

Fig. 6.4. Client in play chair.

SHOE HELPER

Designers: Andy Huang, John Perkins and Alyx Rosen
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INTRODUCTION

Our client, a woman with cerebral palsy and limited mobility in her legs, requires up to 30 minutes putting on her shoes. The Shoe Helper, made from thermoplastic, consists of a shoehorn pivoting on top of a heel cup. While the heel cup prevents the heel of the shoe from folding under, the extra-wide shoehorn supports the client's heel and guides the foot into the shoe, regardless of the foot's entry angle. A string attached to the shoehorn allows the client to manipulate the hinge connecting the two plastic parts. The top of the shoehorn also serves as a sock aid, minimizing the number of dressing aids needed. The product is portable, adaptable to all shoes, and inexpensive to produce. Using the device, the client now puts on both socks and shoes in under four minutes.

SUMMARY OF IMPACT

The client commented, "The combo sock/shoe assist works perfectly and saves me up to 30 minutes each time I use it. I never have to worry about the time it will take to put on shoes. It just takes a couple of minutes at most for both shoes. This device is life changing!"

TECHNICAL DESCRIPTION

The Shoe Helper (Figure 6.5) includes a shoehorn and a heel cup, connected together with a metal hinge. Both the shoehorn and heel cup are constructed from hand-molded 1/8″ thick thermoplastic. The shoehorn guides the user's heel and also serves as the main component of the sock aid. The heel cup provides a rigid structure that prevents the heel of the shoe from collapsing. The widened rim allows the device to fit around a variety of different shoes. The shoehorn and heel cup are connected via a 2″ steel strap hinge, sandwiched in place with thermoplastic. A 72″ hiker's lace is attached to the top of the shoehorn to allow for rotation. For use as a sock aid, the string is first threaded through a thermoplastic bracket attached to the back of the heel cup, visible in Figure 6.6. This allows the user to pull forcefully on the string from the heel cup end of the device. Figure 6.6 shows the client using the device as a shoe helper. Figure 6.7 shows the client using the device as a sock aid. The device costs approximately $18 to replace.

Fig. 6.5. Shoe helper.

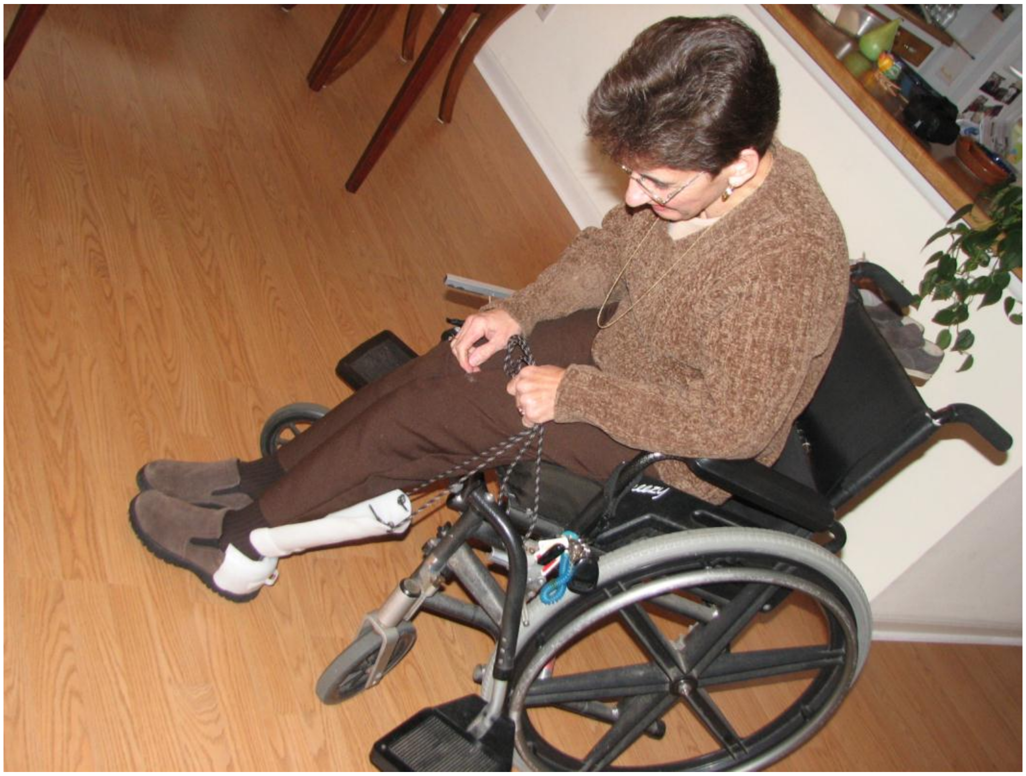

Fig. 6.6. Client using device to put on shoe.

Fig. 6.7. Client using device to put on sock.

PORTABLE SUPPORT SEAT

Client Coordinators: Nancy Curtis, Keri McCauley
Designers: Kristen Bova, Matt Hoover, Jesse Sandberg
Supervising Professor: Larry Bohs
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INTRODUCTION

Our client, an eight-year-old boy diagnosed with autism and cerebral palsy, can sit in a chair independently but needs help correcting his posture. Specifically, he needs assistance with proper hip placement and lateral trunk and spine support. We constructed the Portable Support Seat using high density polyethylene plastic (HDPE). The seat includes a hip belt and small side supports, and allows for adjustments to the seat angle as well as the seat depth. The Portable Support Seat is lightweight and can be easily and efficiently attached to a wide variety of chairs using secure and safe lock straps. The device folds in half for easy transport and storage.

SUMMARY OF IMPACT

Our client can now sit at the dinner table with proper and optimum posture. He no longer pushes his hips forward nor falls off the side of his chair. Since he is fully upright and able to have both arms on the table, he is more actively engaged in

Fig. 6.8. Portable support seat.

dinnertime activities, and his parents now have an easier time bringing him out to dinner with the rest of the family. According to our client's mother, "I am looking forward to taking our new chair on vacation with us to Disney World!"

TECHNICAL DESCRIPTION

The frame of the Portable Support Seat (Figure 6.8) is made of two rectangular blocks of ½″ HDPE. The seat bottom is 14.5″x12″x0.5″ and the vertical back support is 14″x15″x0.5″. The seat and back support are connected with two 16 in-lbs. torque friction hinges. The vertical back support is mounted on a bottom support base of HDPE that is 16″x2″x0.5″. The back support is screwed into the support base with five 1.5″ 10-32 flat head screws.

A length-adjustable padded lap belt is attached seven inches from the back of the seat bottom. Four webbing straps attach the seat to a supporting chair: two on either side of the underside of the seat bottom and two on the back of either side of the vertical back support. All of the webbing straps attach together via squeeze-release buckles. The straps are adjustable in length to allow for various seat sizes and to accommodate for the client's continued growth. Adjustable feet are mounted on 1.25″x1.5″x1.25″ blocks of HDPE at the four corners of the seat bottom. The adjustable feet have heads that rotate and non-slip rubber bottoms. Each can be retracted and extended from its supporting HDPE block, thereby changing the angle between the seat and back of the chair.

On the underside of the seat bottom, a system is built into the chair to that allows the necessary adjustments to optimize the user's proper knee placement at rest. The adjustment system consists of two quarter- inch deep and half-inch wide milled square channels. In each channel, a 5.25″x0.5″x0.5″ aluminum bar is positioned to slide through the channel. The two slide bars are connected by a 14″x0.5″x0.5″ extension cross bar. This cross bar is padded with pipe insulation and covered with vinyl. The slide bars stay in place using two 1.5″x5″x0.5″ blocks of aluminum. Each block has a 0.25″ inch deep and 0.5″ wide square channel milled vertically along its center. The milled channels in the aluminum support bases are each fit over one slide bar and screwed into the HDPE seat bottom. Each slide bar is held in place by two 0.25″ set screws when the bars are in the proper position.

Fig. 6.9. Client using portable support seat.

One and a half inches down from the top of either side of the vertical back support are two 3″x5.5″x0.25″ HDPE lateral supports, which help support the client's trunk from side-to-side motion. A 0.25″ deep and 5.5″ long slot is milled into either side of the vertical back support. A 1″x5.5″.0.25″ HDPE side support extender is fit into each slot. The lateral supports are aligned with these side support extenders and the entire side support system is screwed in place.

Lastly, the seat bottom, vertical back support, and lateral side supports are all covered with padded cushions. The seat cushion is 14″x10.75″.0.25″, the vertical back cushion is 14″x7″x0.25″, and the side cushions are each 5″x2″x0.25″. The cushions are constructed from ¼″ plywood and layers of cotton sheets. They are wrapped in navy vinyl that is attached to the plywood with ¼″ staples. Each cushion is attached to the HPDE via Velcro.

The Portable Support Seat weighs 10.5 lbs. Figure 6.9 shows our client in the device at the dinner table. The replacement cost is $260.

SILICONE TUBE CUTTER

Client Coordinators: Alan Pitstick, John Wiltshire, Jon Kuniholm
Designers: Jason Liu, Meagan Gray, and Pallavi Kansal
Supervising Professor: Larry Bohs
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INTRODUCTION

A device has been developed to enable individuals with disabilities to cut resilient silicone tubing into identical length bands. These bands are designed to replace currently available rubber tension bands that fail quickly and easily on the hooks of body-powered arm prostheses. The device allows for easy insertion of silicone tubing while ensuring proper alignment for clean and uniform cuts. A lever enables workers to cut tubing with minimal effort, and the cut bands eject automatically into a container underneath the device, which is removable for later inspection and packaging. This portable device enables employees with disabilities to mass-produce tension bands safely and efficiently.

Fig. 6.10. Silicone tube cutter.

SUMMARY OF IMPACT

The Silicone Tubing Cutter will enable workers at OE Enterprises, Inc, a vocational rehabilitation facility, to create longer-lasting tension bands for prosthetic arm-hook prehensors. These bands can then be packaged and sold by OE. The device creates a vocational opportunity for workers at OE, an income source for the company, and better tension bands for users of body-powered prostheses "that should make a lot of people [with prosthetic arms] happy," according to Jon Kuniholm of the Open Prosthetics Project.

TECHNICAL DESCRIPTION

The Silicone Tube Cutter (Figure 6.10) is composed of a cutting device, a wood base, and a collection bin. The cutting device includes two custom-milled 5.5''x4''x1.25'' blocks of aluminum. Silicone tubing enters the device through a small square hole in the side of the top block. This entryway guides the tubing into the device and hinders it from curving to the right or left. It is lined with felt to reduce friction between the device and the tubing. The top block contains a rectangular hole through which a spring-loaded plunger slides up and down as the user pushes on a lever. Beneath the plunger in the bottom block, a standard single-edged razor blade is mounted perpendicularly to the tubing axis. As the user depresses the lever, the plunger compresses the tubing onto the blade and cuts the tubing.

The side of the hole opposite the entryway serves as a "stop" for the tubing to ensure it is cut at ½". Mounted to the stop is a light-touch switch, which is connected in series with a LED, current-limiting resistor and two AA batteries. As the user inserts the tubing, the switch depresses and the LED goes on, signaling that the tubing is fully inserted and ready to be cut. Once the lever is depressed, the cut piece of tubing falls through a milled hole in the bottom block into a collection bin.

A lock between the top and bottom blocks prohibits access to the blade during use, while a hinge allows for OE managers to open the device and replace the blade when necessary.

The cutting device is attached to the base, a rectangular box made from red oak. A small rectangular hole in the top surface lines up with the hole in the bottom aluminum block, allowing the cut bands to fall into the collection bin, a commercial plastic container. A hinged door on the front of the base is locked during use so that workers cannot insert hands into the cutting area.

The lever is constructed from 2.5′ of ¾″ steel electrical conduit. A 1.5x3.5x7.5′′ piece of wood serves as the lever fulcrum. A key-shaped hole allows the plunger bolt to insert easily and slide as the plunger arm pivots. An OE Enterprise manager can easily remove the lever by unscrewing the fulcrum bolt and then sliding the lever towards its fulcrum, thereby allowing access to the cutting chamber.

The tubing must be held with its natural curvature as shown in Figure 6.11 for the most accurate cuts. This can be done by the user, as shown, or a reel of tubing can be mounted above the device. Cost of materials for the Silicone Tube Cutter was approximately $160.

Fig. 6.11. Client using the device.

CYLINDRICAL BOTTLE LABEL APPLICATOR

Client Coordinators: Joe Bumgarner, John Wiltshire
Designers: Matthew Dekow, Gregory Meyers, Cameron Smith
Supervising Professor: Larry Bohs
Department of Biomedical Engineering
Duke University
Durham, NC 27708

INTRODUCTION

The Cylindrical Bottle Label Applicator allows individuals with fine motor and cognitive disabilities to precisely apply labels to bottles. The device includes a stand to hold the roll of labels and the bottle to be labeled. The labels are fed onto a solid surface with a sharp edge. The label backing is curled around this edge, thereby removing the leading edge of the label from the backing. As the user rotates a handle, a non-slip roller applies the label to the bottle, while a DC motor automatically collects the backing.

SUMMARY OF IMPACT

Currently, only a handful of employees at OE Enterprises, Inc, a vocational rehabilitation facility, can label large bottles accurately and consistently. This device will allow many more employees to complete this task, increasing productivity and also the rate of pay for these employees. Alan Pitstick, Director of Contract Sales at OE, commented, “The

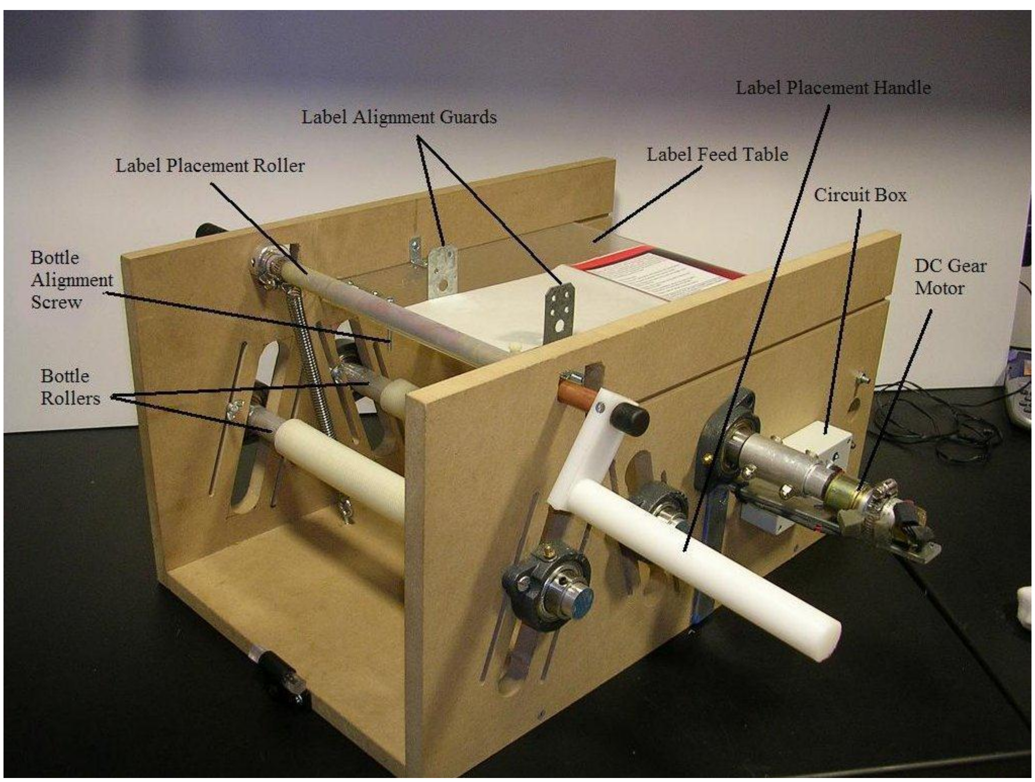

Fig. 6.12. Cylindrical bottle label applicator, side view.

use of the machine will allow more of the workforce to be involved in bottle labeling which is central to the mission of OE Enterprises."

TECHNICAL DESCRIPTION

Our design, shown in Figure 6.12 and Figure 6.13, includes a label holder, backing removal mechanism, label placement apparatus, and label alignment guards. The label holder includes a tailpipe expander, two flange bearings, a friction clutch, a socket, and an aluminum rod. The tailpipe expander allows label rolls with differing shank diameters to be held securely. The friction clutch is attached to the tailpipe expander, providing the rotational friction necessary to keep tension on the sheet of labels for the label backing removal mechanism.

The label backing removal mechanism separates the backing from the adhesive label by curling the label backing around the end of the label feed table, a sheet of ¼" thick acrylic. The label backing collector, a wooden dowel with an axial slit, resides underneath the table and collects the backing to be discarded. A DC gear motor applies a constant torque, slightly less than that required to remove labels from the backing, but sufficient to wind the backing onto the collector.

The label placement apparatus includes two silicone rubber-sheathed aluminum rods, the bottle rollers, supported by flange bearings mounted to angled height-adjustment tracks routed in the sideboards. This arrangement allows the height and separation of the bottle rollers to be easily adjusted to accommodate bottles of different sizes. A label placement roller secures the bottle from the top and firmly rolls the label onto the bottle. Two extension springs add downward tension to the roller, allowing the user to simultaneously rotate the bottle and apply the label by turning a handle.

The bottle and the label are held in alignment with the label alignment guards and two bottle alignment screws. The label alignment guards are 1" L-brackets that face the center of the label feed table. The bottle alignment screws prevent the bottle from sliding along the axis of the bottle rollers, and can be moved to various set positions corresponding to different bottle sizes. Once appropriately set for a particular bottle size, these components make it simple for the user to align the bottle and label, and then to gently press the edge of the label onto the bottle to initiate contact between the adhesive side of the label and the bottle. The user then slides a finger down the edge of the label and rotates the bottle using the handle on the label placement roller, causing the remainder of the label to adhere to the surface of the bottle. The roller pushes down on the bottle, removing any bubbles that have formed at the label-bottle interface. As this process occurs, the label backing collector automatically collects the excess label backing. Cost of parts for the device was $325.

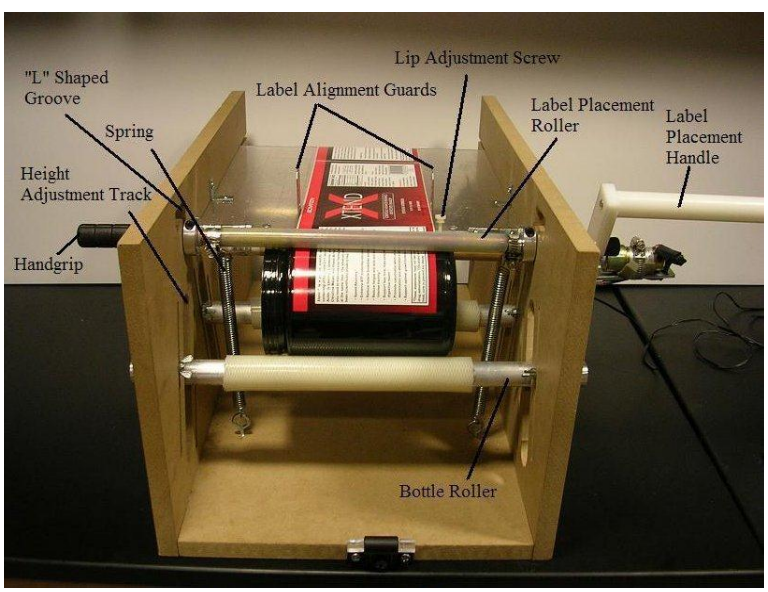

Fig. 6.13. Cylindrical bottle labeler, front view.

CUSTOM TRICYCLE

Designers: Alex Feng, Lola Xie, Jessica Zinck
Supervising Professors: Kevin Caves, Richard Goldberg
Department of Biomedical Engineering
Duke University
Durham, NC 27708

INTRODUCTION

Our client, an 8-year-old boy with Thrombocytopenia Absent Radius (TAR) Syndrome, cannot use a standard tricycle independently because his arms are weak and very short. Braking is difficult due to his limited ability to squeeze a hand brake. Additionally, his right leg has limited range of motion and he cannot effectively pedal with that leg. We modified a commercial tricycle intended for older children so that he could ride it easily. We made modifications to the steering, braking, and the hub.

SUMMARY OF IMPACT

The client's mother commented, "No one who has normal children ever realizes how much it breaks your heart when your child says to you 'Mommy and Daddy, I want to ride a bike like my brother and sister' and they are physically unable to do this due to special needs. These students and North Carolina Sports for Special Kids (NCSSK), have made this a possibility for [my son]. This bike has enabled him to become just a 'normal' kid in one aspect of his life and that is something that is so valuable to our family that few will ever know."

TECHNICAL DESCRIPTION

The handle bars were removed from a commercially available Triaid tricycle and replaced with a four-bar linkage steering mechanism (Figure 6.14). The four-bar linkage moves the point of rotation of the handlebars back, so our client can use his considerable trunk rotation to steer the bike. The steering system was fabricated from 7/8" aluminum square tubes due to their light weight, low cost and corrosion resistance. A round, hollow vertical stabilizing rod made of the same aluminum alloy was added to the tricycle to stabilize the 4-bar linkage at the center horizontal bar. Both the vertical stabilizing rod and the long steering bars are adjustable in length to accommodate the client as he continues to grow. Finally, mountain bike hand

Fig. 6.14. Custom tricycle.

grips were added to the ends of the steering mechanism to provide a larger surface for the rider to push against and stabilize him by gripping with his hands and fingers.

Because the client has poor range of motion on his right leg, he could not use the right foot to pedal. We removed that pedal and put a platform in its place to rest his foot. In addition, the client is not able to effectively use hand brakes, so we connected one end of the brake cable to that platform. When he presses on the platform, it pulls on the brake cable to activate the cantilever brakes. This allows the client to brake using his right foot, while pedaling with the left foot. In addition, the rear gear sprocket was changed to a smaller, free wheel system to allow the bike to move faster and to coast like a standard bicycle. The overall design focused on ease of use, independence, versatility, cost-effectiveness, and aesthetic appeal.

Figure 6.15 shows the client using the Custom Tricycle. Cost of the commercial tricycle was covered by a donation from NCSSK. The cost of the parts for the modification of the steering, braking and gearing was approximately $300.

Fig. 6.15. Client using custom tricycle.

PROSTHETIC CLIMBING AID

Designers: Clark Daniel, Ben Haynes, Archana Ramireddy, and Karli Spetzler
Supervising Professor: Kevin Caves and Richard Goldberg
Department of Biomedical Engineering
Duke University
Durham, NC 27708

INTRODUCTION

Our client is an adult with a below elbow amputation on his left side, who wants to regain his ability to rock climb. He has full shoulder motion, but only flexion/extension at his left elbow. He also lacks the ability to pronate and supinate his prosthetic forearm. The goal of this project was to design an attachment to his carbon fiber socket that will increase his ability to rock climb both indoor and outdoor surfaces. The Prosthetic Climbing Aid uses a set of modified ice axe blades that are set in a rotating aluminum block. The block has 60 degrees of motion and simulates the inversion/eversion motion of the wrist to give him as much range of motion as possible. The device rotates freely when unloaded, but it locks into one of 5 set positions when weight is placed on the arm to prevent it from slipping from the desired grip.

SUMMARY OF IMPACT

The client commented, "The device the students built allows for a couple things. Because of the lateral movement available in the wrist I have a wider variety of holds I can get to, as well as being able to attain some angles of attack that were previously unavailable. And the increased surface area of the "fingers" allows me a more stable position to work from. All in all, it provides for a better degree of mechanical advantage which in turns makes climbing a little more solid and stable for me."

TECHNICAL DESCRIPTION

Climbing Prosthesis

A ¾" diameter aluminum rod was used to attach to the climbing prosthesis to client's existing carbon fiber socket. The rod fits into the rotation mechanism which is made from two pieces of 6061 Aluminum Alloy and holds three custom fabricated ice axe blades made from Type 303 stainless steel (Figure 6.16).

Fig. 6.16. Prosthetic climbing aid attached to the client's existing carbon fiber prosthetic arm.

An hourglass-shaped hole has been machined to allow the rod to fit inside the rotation mechanism. A barrel bolt provides a pivot point for the rotation of the device. Figure 6.17 shows the inner face of the rotation mechanism where there are a series of 3/16″ grooves that accept a 1/8″ coiled spring pin attached to the aluminum rod. The pin slides into one of the slots when the arm is pulled on a rock surface. This locks the rotation mechanism when loaded. When the device is unloaded, the rotation mechanism is free to rotate, but when loaded, the device slides up the rod and the coiled pin rests into one of five grooves, locking it in the specific angle. The weight-bearing element is the coiled spring pin that is rated for 2,000 lbs. of double shear stress. The length of the rod puts the ice axe blades in the same plane as the fingers of his right hand, allowing him a more stable, natural climbing experience.

Device Harness

The device harness is used to reduce the amount of stress placed on the elbow strap of the prosthesis. It is not intended as a weight-bearing device. A bungee cord is used to transfer weight from the prosthesis to the harness. A tricep cuff that attaches to the prosthesis was provided by our client. A ¼″-diameter bungee cord attaches the harness to this cuff and is always in tension. The cuff remains snuggly on our client's upper arm using a 1″ elastic

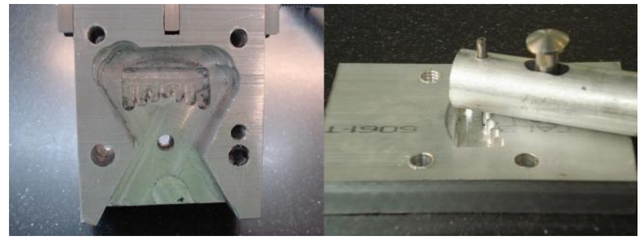

Fig. 6.17. Inside face of the climbing prosthesis.

band with a Velcro attachment. The material for the major straps is 1″ nylon webbing rated at 14 kN tensile strength. To keep the harness from sliding up his body and getting out of position, this harness is connected to the client's actual climbing harness with two cinch lock buckles in the back and two side release buckles in the front. The side release buckles were used to allow for frequent adjustment that can be manipulated with one hand.

Figure 6.18 shows the client climbing with the device. Cost of parts for the device was approximately $170.

Fig. 6.18. Client using climbing prosthesis.

FLIGHT SIMULATION STATION

Designers: Alexa Issa, Neha Krishnamohan, and Swara Paranjape
Supervising Professors: Kevin Caves and Richard Goldberg
Department of Biomedical Engineering
Duke University
Durham, NC 27708

INTRODUCTION

Our client is an active retiree with a slow progressing form of Amyotropic Lateral Sclerosis (ALS). He worked in the aerospace industry, and now enjoys playing flight simulator computer games. He uses a wheelchair for mobility and has limited strength in his arms. He has special flight controls that allow him to more realistically control the simulator. These flight simulator controllers had been mounted to a plywood base. Due to his weakened arms, however, it became difficult for him to switch between using the flight simulator controllers and using the computer keyboard and mouse. We developed a device that provided for ergonomic positioning of the controllers, mouse and other equipment needed for the flight simulator game. The device also is easily stored when the computer was needed for other activities.

SUMMARY OF IMPACT

The client stated that "it's going to make it just a lot easier, because my hands are lower to start with, and I am more relaxed because usually I am sitting up at my computer desk and now I can sit back and still move the controls around, it is going to be a big help. The system is great for me as I now can easily move my hands onto the controls as they now sit at a level that is comfortable with my arms resting on the wheelchair arm rests. Also, as it is closer to my body, I am better positioned in my chair- not having to lean forward to reach the controls when they were on the computer table before. Having the place for the mouse between the control elements makes it easy to access the on-screen icons to make changes in the flight simulation conditions such as weather, location, plane selection, etc. I can sit back and still move the controls around. This project has made my continued enjoyment of flight simulation possible for a long time to come."

TECHNICAL DESCRIPTION

The Flight Simulation Station (Figure 6.19) is made from an acrylic tray that holds the flight simulator

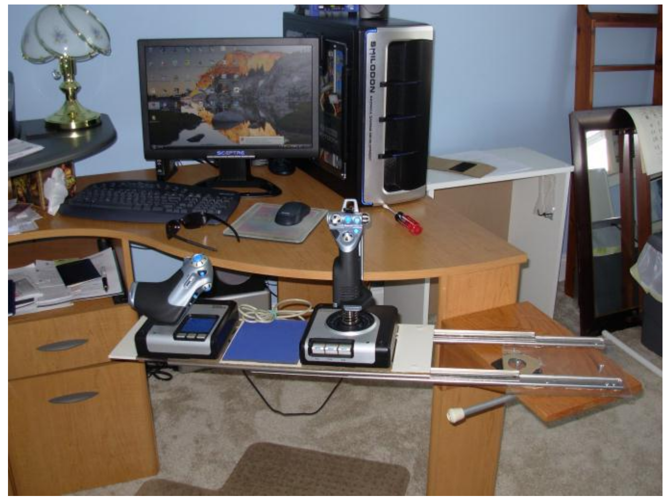

Fig. 6.19. Flight simulation station.

controls. When not in use, the tray can slide and pivot to a storage position using two drawer slides and a lazy Susan pivot. The lazy Susan is attached to an oak platform, which is bolted into the client's computer desk. The device is designed so that the client can rotate and slide the flight controls independently and at the most comfortable position. This allows him to easily switch between using the flight controls, and using the standard keyboard and mouse.

The device is attached to the right side of his computer desk. The 25'' by 7.25'' acrylic tray rotates thru an angle of about 110 degrees on the lazy Susan, and extends 20" on the two drawer slides.

To make the device stable, a docking platform was attached to the left side of the client's wheelchair. The left edge of the acrylic tray slides into this dock and holds the tray and control steady. The right side also has a locking bar that prevents rotation of the tray while in use. Additionally, pair of rollers was attached to the underside of the oak support that provides a counter force to resist the moment of the extended tray.

The flight simulator controls are attached to the acrylic tray via Velcro. The system enables the client stowed and extended his controls independently and with ease. Figure 6.20 shows the client using the Flight Simulation Station. Cost of parts for the device was approximately $217.

Fig. 6.20. Client using flight simulation station.

PORTABLE MINI-GOLF WITH PUTTING ASSIST

Client Coordinator: Marc Roth
Designers: Christine Bestvina and Danial Bokhari
Supervising Professors: Kevin Caves and Richard Goldberg
Department of Biomedical Engineering
Duke University
Durham, NC 27708

INTRODUCTION

We have built a portable and accessible four-hole mini golf course designed for individuals at Extraordinary Ventures, a facility that provides job and social opportunities for people with developmental disabilities. The course is constructed from indoor/outdoor carpet as well as carpet padding layers. The course is easily stored using a grommet and metal rod storage system. In addition to the mini-golf holes, we have built a putting assist device for an individual with cerebral palsy, who uses a power wheelchair. The device allows the client to pull back and release a custom putter via a lifting handle attached to a ratchet. To swing the putter, the client simply pushes on a release bar. The device has been shown to be successful in allowing our client to play mini-golf.

SUMMARY OF IMPACT

Marc Roth, Executive Director of Extraordinary Ventures, commented: "The adapted miniature golf set and the tray release for a member's wheelchair will create the modifications and accommodations that are needed for all our participants to be involved with our recreational activities. This will encourage socialization, problem solving, fine motor control and fun options during our individualized and group activities."

TECHNICAL DESCRIPTION

The Portable Mini-Golf (Figure 6.21) includes four holes: straight, L-shaped, hourglass, and tunneled. The holes were made from a layer of indoor/outdoor carpet on top of at least two layers of carpet padding. The edges of the holes were edged with ½ inch PVC pipe to prevent the ball from leaving the playing surface. The cups had a diameter of 4 inches and were cut out of the carpet layers, so that a successive putt causes the ball to fall into the cup and remain there. A piece of fluorescent paper was taped around the bottom of the each cup,

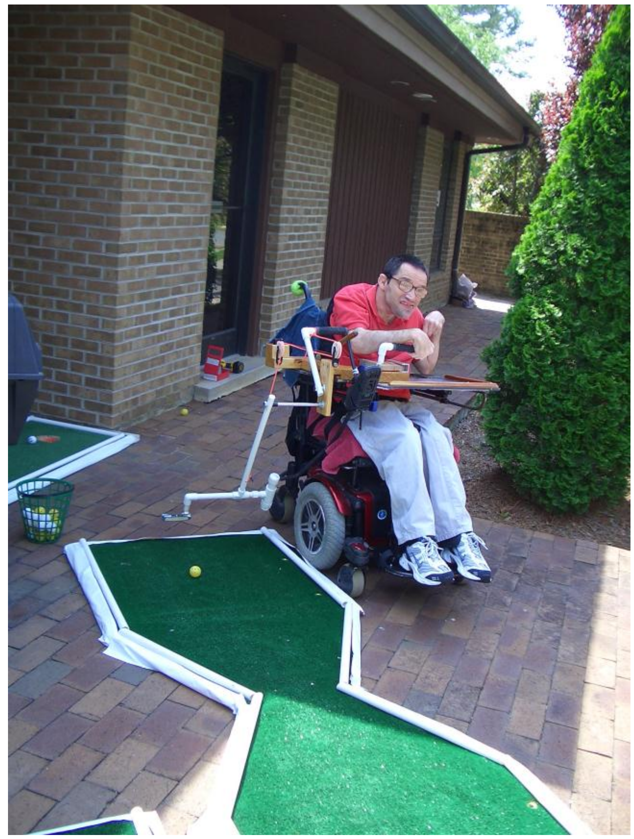

Fig. 6.21. Putting assist and one hole.

making the cups contrast more relative to the background.

The putting assist device is made from wood and is mounted via clamps to the client's wheelchair lap tray. Due to his spasticity, our client can most easily pull back and push forward. The client-interface system features two different handlebars. The first is the "Pull Back Bar" that uses a lever and two pulleys to pull back the putter head, using the client's most efficient physical abilities. The second is the "Release Bar" that the client uses to release the rope ratchet that allows the putter head to swing.

The side of the wheelchair blocks the client's vision directly to the right of his wheelchair. Because of this, an extended putter head was developed to move the putter head 12" from the side of the wheelchair. A counter weight was used to balance the putter head, ensuring free swing. The setup allows our client to line up his shot, pull back and release the club.

The holes can be easily stored by hanging them on metal rods through grommet holes in the carpet. Figure 6.22 shows the client using the Putting Assist on one of the holes. Cost of parts for the device was approximately $540.

Fig. 6.22. Client using putting assist.

SENSORY STATION

Client Coordinator: Shauneille Smith
Designers: Tiffany Chang, Craig Silverman, Wailan Yip
Supervising Professor: Kevin Caves and Richard Goldberg
Department of Biomedical Engineering
Duke University
Durham, NC 27708

INTRODUCTION

This project was designed for two elementary aged children in a special education classroom. These children have severe and profound mental and physical disabilities that include being non-verbal, non-ambulatory, low-vision, and cognitively impaired. The children are developing their cognitive and perceptive abilities through the use of cause-and-effect toys and sensory stimuli. Their teacher requested a sensory environment that will minimize distractions from the classroom and will aid them in achieving their educational goals. We built a tent structure and electronics package to assist developing manipulation skills, keeping the child's head in a raised position, increasing perceptive abilities, and allowing the child to make a preference for which toy he would enjoy most.

SUMMARY OF IMPACT

The classroom teacher reports: "The station provides an opportunity for students to be in an upright and seated position; while being engaged in activities free from distractions. The enclosed station assists in having students sharpened their sense of hearing; as well as focus on manipulation within the station rather than focus on other activities within the classroom setting."

TECHNICAL DESCRIPTION

The Sensory Station (Figure 6.23) consists of a tented structure constructed from 1" PVC and enclosed using thick, sound damping, velvet curtains. The structure contains sensory stimuli, including various lights and music, which are controlled by a central processing unit, known as the Magic Box.

The tent structure was designed to provide a stable, isolated environment that fosters educational development. The dimensions were chosen such that two children in wheelchairs and a teacher could comfortably fit inside. The tent is covered on all sides by sewn black curtains. The black curtains make the inside dark as well as dampen external noise to create an environment free of distraction. Across the entrance, hanging curtains can freely slide to provide easy access yet complete enclosure once inside the tent.

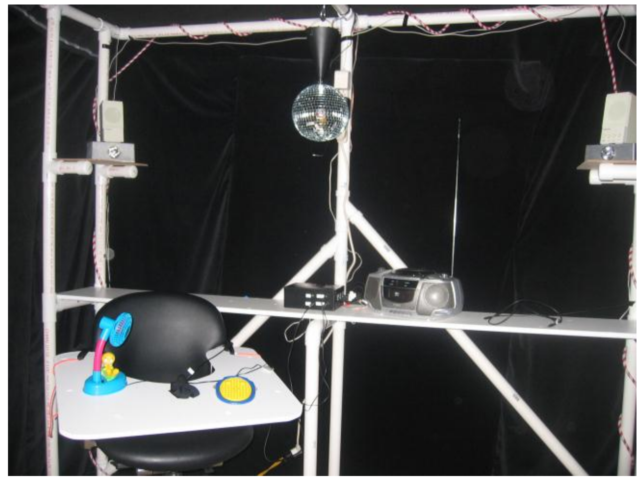

Fig. 6.23. Sensory station.

LED and white tube light lines the back wall of the tent. In addition, a motorized spinning disco ball and a spot light are hung from the ceiling of the tent. The disco ball, which can be operated by the student, was hung from the ceiling in order to prevent hazards and to encourage the children to lift their heads to follow the lights. This visual tracking system is important because it increases the children's perceptive abilities and strengthens their weak neck muscles.

Two lap trays provide surfaces for the students to manipulate toys and switches while seated in their wheelchairs. They were built to fit to the students' specific wheelchair and body sizes. They are made from 5/8"-thick sheet PVC and attach to the wheelchairs by buckling a strap behind the chair and straps around the arm rests. The trays are durable, easily sanitized, and can be quickly installed and uninstalled.

The Magic Box functions as a cause-effect control box. When the child presses a switch, the Magic Box activates the appropriate stimulation according to one of the 5 teacher-selectable operating modes:

1. Play Cassette/Radio (5 second duration)

2. Play Cassette/Radio (15 second duration)

3. Operate Switch Adapted Toys (5 second duration)

4. Play CD Boom Box (play/pause)

5. Auditory Tracking

Modes 1, 2 and 4 enable the child to control a switched-enabled CD Boom Box (Enabling Devices, Hastings on Hudson, NY). Modes 1-3 have a duration time, and when that time has elapsed, the Magic Box automatically turns off the stimulation. This forces the child to pick up his hand and to re-press the switch if he wants the stimulation to continue. In this way, this mode encourages the children to actively move their hands, one of their key educational goals.

The Auditory Tracking mode is designed to motivate the children to raise their heads and follow a sound. When the child activates the switch, music plays first from the left speaker then from the right speaker. This continues for two minutes, switching every 15 seconds between the left and right. If the child lifts his head to track the sound, a light will flash under the cued speaker. A tilt switch is used to track head position. Figure 6.24 shows the client using the Sensory Station. Cost of parts for the device was approximately $780.

Fig. 6.24. Client using sensory station.

MULTI-FUNCTION WORK TABLE

Designers: Jeff Barry, Joseph Kuo, Peter Zolides
Supervising Professors: Kevin Caves, Richard Goldberg
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Duke University
Durham, NC 27708

INTRODUCTION

Our client has a slow progressing form of amyotrophic lateral sclerosis, which results in weakness in his upper arms and legs. As such, he spends much of his time in a wheelchair. He likes to read and work on crossword puzzles but it is awkward for him to rest his book or puzzle on a table or a TV tray because it strains his neck. We designed a portable table that attaches to the clients wheelchair and tilts, allowing him to position his book or crossword puzzle in a comfortable, ergonomic position.

SUMMARY OF IMPACT

Our client stated, "I haven't been able to read more than one book since moving here; with this new table, I'm looking forward to getting back to reading on a regular basis."

TECHNICAL DESCRIPTION

The Multi-Function Work Table (Figure 6.25) is made from quarter-inch thick sheet of Acrylite. It is attached to a furniture grade PVC tube frame that enables the tray to tilt and swing to the side. The tray has a wrist rest at the edge closest to the client, which also serves as a book support when the tray is in book reading mode.

The table consists of two main parts: a mount that is semi-permanently attached to the chair, and a table that is easily attached and removed. A 1" diameter steel tube was attached to the wheelchair via custom plastic mounts that hold the table at the correct height. The table has a ¾" steel bar that inserts into the 1" tube on the wheelchair. The tubes are machined such that the tray can be flipped up 100 degrees to the side, so the client can get out of his chair without removing the tray.

The surface of the tray can be tilted toward the client and locks into place at an angle of 55 degrees. The padded wrist rest serves as a book rest when in this position. The book rest slides in slots milled into the tray surface and can be moved to three different positions to accommodate books of different sizes.

Fig. 6.25. Multi-function work table.

The writing surface is made from Acrylite, a durable and light and surface for writing. It is covered by a sheet of custom-fit InvisibleShield®. This is a material used to coat expensive electronic devices to protect them from scratches. Two section of Stickypad® are attached to the upper left and right corners of the tray, providing a non-slip surface for items such as a pencil or cell phone. Cost of parts was about $240.

Fig. 6.26. Client using multi-function work table.

CHAPTER 7
ROCHESTER INSTITUTE OF TECHNOLOGY

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BALANCE TRAINING BICYCLE

Mechanical Engineering Designers: Carl Mangelsdorf, James Nardo, Jeffrey Tempest
Electrical Engineering Designer: Jonathan Bawas
Industrial Engineering Designer: Jennifer Zelasko (Team Leader)
Client Coordinator: J.J. Mowder-Tinney, Nazareth College Physical Therapy Clinic
Supervising Professors: Dr. Elizabeth DeBartolo, Dr. Matthew Marshall
Rochester Institute of Technology
76 Lomb Memorial Drive
Rochester, NY 14623

INTRODUCTION

In the absence of balance training tools that provide a safe, low risk of injury to the patient, the design team was given the challenge of creating a Balance Training Bicycle to be used by physical therapy patients at the Nazareth College Physical Therapy Clinic. The bicycle design simulates the instability of a freestanding bicycle without the risks associated with actual bike riding. Patients in need of balance training are those who have had strokes, or those who have other neurological conditions that cause an imbalance in strength between the left and right sides of their bodies. The concept behind the bicycle design is to serve as an intermediate balance training tool that is more challenging than a traditional stationary exercise bike, but less challenging than a traditional free standing bicycle.

SUMMARY OF IMPACT

A bicycle frame was designed to allow for easy entry

Fig. 7.1. Completed prototype.

and exit, as well as to provide ride-ability characteristics that mimic that of a traditional bicycle. To meet project requirements, a low cross-member is coupled with a vertical post that positions the handlebars in front of the seating position that is located by two angled posts. The cross-member is supported by two pillow-block bearings that allow for frictionless rotation about the center axis. The rotation about the axis provides the side-to-side tilting capability that mimics the motion experienced on a traditional bicycle. Variable tilt resistance is achieved through the use of a spring cartridge with adjustable preload controlled by an electric winch. The clinic coordinator is excited to begin using the device with her patients and after riding the bike herself, she has determined that it will be beneficial for seated balance training for many more of her clients who would not normally train on an exercise bicycle.

TECHNICAL DESCRIPTION

The finished prototype is shown in Figure 7.1. The bicycle can be locked in the upright position by engaging the spring loaded pin lock at the rear of the bike. There are five spring cartridges corresponding to five different weight classes. Spring compression and tilt level are controlled by shortening or lengthening the cable with the electric winch. The handlebars can be adjusted to accommodate various patient sizes using the rotary hinge. The seat height is also adjustable. Pedal resistance is controlled by varying the amount of friction applied through the resistance knob. There are two wheels located at the front of the bike which allow provide a "wheel barrow" style portability feature for easy transportation. The feedback display provides an indicator of the patient's degree of tilt to both the patient and the physical therapist. As the angle of the bicycle shifts away from upright, the LED array indicates the degree of tilt with green (upright), yellow (tilting but still stable), and red (unstable) LEDs. An audio feedback system begins to beep when the tilt angle is in the yellow LED range, and beeps with increasing speed in the red LED range.

The total cost of the project was $1,865.74 ($2,086.35 including donations).

More information is available at http://edge.rit.edu/content/P08001/public/Home.

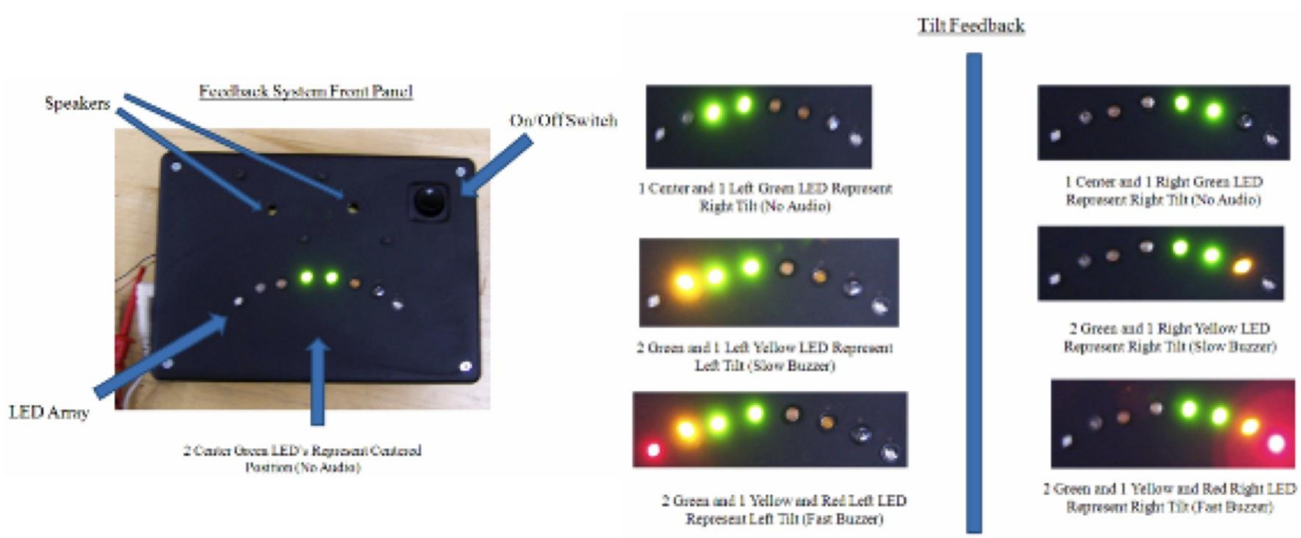

Fig. 7.2. Feedback display.

AUTOMATED PARALLEL BARS

Mechanical Engineering Designers: Ryan Hellems (team leader), Justin Knowles, Jeffery Osborne, Justin Vowles
Industrial Engineering Designer: Jessica Stalker
Client Coordinator: J.J. Mowder-Tinney
Supervising Professor: Dr. Elizabeth DeBartolo
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INTRODUCTION

The physical therapy clinic at Nazareth College frequently uses parallel bars with adjustable height to aid patients in relearning to walk. The previous system was difficult to adjust, consisting of six posts, each with a hole-and-pin system. Due to the length of the bars, the current system is very difficult to properly align. The difficulty lies in accurately matching the number of holes exposed and results in the parallel bars not being parallel, which can make a therapy session difficult for the patient. Additionally, if a therapist positions a patient on the bars and discovers that the height needs a slight readjustment, the patient is required to sit back down. Some patients have such difficulty standing up a second time, it often results in the session being aborted.

SUMMARY OF IMPACT

The redesigned system replaced the current pin and post system with two sets of three power screws, connected in series by a drive shaft, and powered by a stand-alone hand crank. Some strengths of this system include usability, safety, appearance and the ability to revert to the previous system. Both sides of the parallel bars can be easily adjusted from one central location, at the hand crank, rather than walking around to adjust the six individual posts. The system is safe; a drive shaft safety cover protects the patient and therapist against the rotating drive shaft and pinch points. From an aesthetic perspective, the system is finished with a durable, neutral grey powder coating. Lastly, should the customer be unsatisfied or the design does not function as expected over time, the system can be removed and the previous system can be reinstalled. The clinic director is excited to begin using the device with the start of her new academic year this September, and has already identified other ways she can use the new parallel bar system, such as using the drive shaft cover to help with stretching exercises.

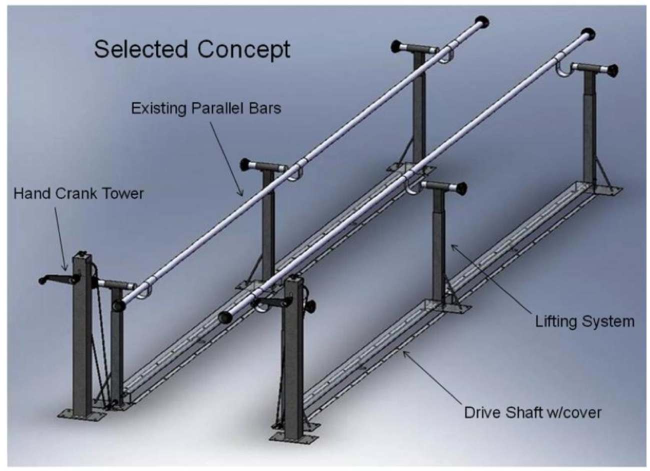

Fig. 7.3. Selected concept.

Fig. 7.4. Actual installed system.

TECHNICAL DESCRIPTION

The selected concept is shown in Figure 7.3 and the actual installed system is shown in Figure 7.4. The two key subsystems are a lifting system and a hand crank tower.

The lifting subsystem consists of three posts tied in series by a single low-profile drive shaft that run along the floor. The drive shaft is protected by a cover so the system is safe for both the physical therapist and the patients. A 1:1 perpendicular miter gears transmits rotation from the drive shaft to vertical motion of an ACME threaded rod in each of the posts. This 5/8-8 ACME Rod supports vertical loads and transmits weight to outer post. An ACME nut is welded to the inner post, and rides up and down rotating the threaded rod (Figure 7.5).

A hand crank tower subsystem was developed with a 4:1 gear ratio for the belt. This results in ½ inch adjustment per revolution of the hand crank. The hand crank was ergonomically located at the height of 36 inches, which is within the elbow to hip height range. Based on test results the system is easy to adjust, with the torque requirements well below the engineering specification. Lastly, the handle for the hand crank is removable to prevent incidental adjustment. See Figure 7.6, which shows the details of the hand crank tower subsystem.

Finally, the user has been left with a user's manual as well as a detailed maintenance guide that includes instructions on how to revert to the previous system should the user be dissatisfied with the new system.

The total cost of the project was approximately $1,500.

More information is available at https://edge.rit.edu/content/P08002/public/Home

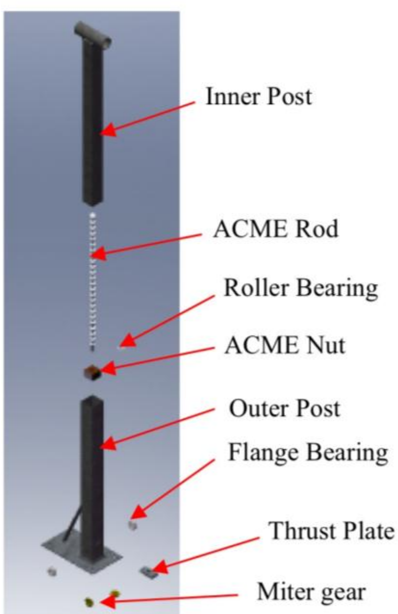

Fig. 7.5. Lifting system.

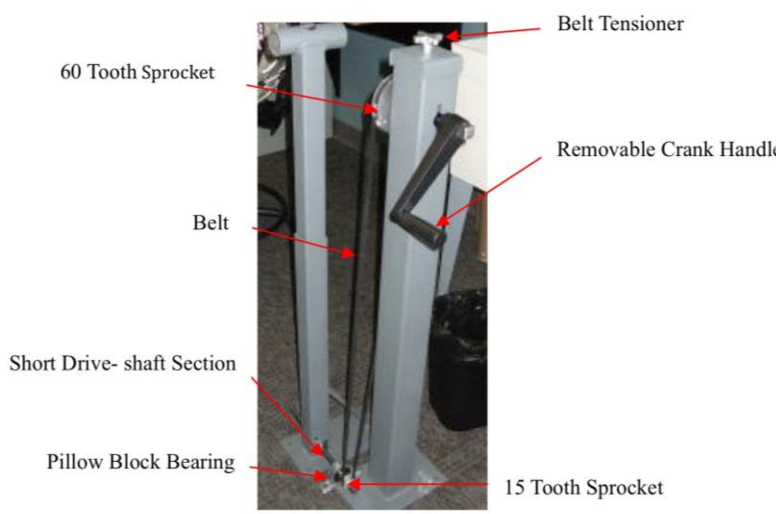

Fig. 7.6. Hand crank tower.

PORTABLE OBSTACLE COURSE

Mechanical Engineering Designers: Shadle Stewart (team leader), Jared Berman
Industrial Engineering Designer: Nicolette McGeorge
Electrical Engineering Designer: Allison Hill
Computer Engineering Designer: Samir Mian
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INTRODUCTION

The physical therapy clinic at Nazareth College works with many individuals who have had strokes and are relearning to perform everyday activities. An important part of their training is learning how to navigate an obstacle course consisting of typical items that might be found in or around a home environment. The physical therapists would like to have a standardized course that can be dismantled and stored when not in use and later reassembled to a prior setting in order to directly track patient progress.

SUMMARY OF IMPACT

The finished project yielded eight walking surfaces than can be assembled to create a walking path approximately 16 ft. long, along with nineteen total obstacles (Figure 7.7). A storage cart for the surface pieces, along with a storage bin for the obstacles was also provided. All surface pieces contain embedded circuitry that includes through-put boards, micro switches and wiring in preparation for future use with a microcontroller and printer to automatically print the course layout for the therapist's records. In the meantime, copies of a tracking sheet, similar to the one the printer will provide, are included with

Fig. 7.7. Sample course setup.

Fig. 7.8. Surface piece layers.

the product. The obstacle course and cart are fully functional without the automated tracking system and can still be used for patient training sessions. In an upcoming class on Embedded Microcontrollers, we will complete the design and implementation of the microcontroller and printer interface. The clinic coordinator, who has been searching for ways to give her patients concrete information about their improvement from session to session, is looking forward to using the new course when the clinic re-opens in the fall.

TECHNICAL DESCRIPTION

Eight surface pieces were constructed with surfaces including light hardwood, dark hardwood, low carpet, high carpet, gym mat, simulated concrete, simulated ice, and simulated gravel. Each surface has five fixed mounting points where obstacles can be placed, and the tracking system wiring embedded within each surface connects these five points with a circuit board and to the neighboring surfaces. Each piece is a laminate of several different layers (Figure 7.8) including foam, plywood, and particleboard. Nineteen obstacles are included with the system, including four rugs, two curbs, a heater vent, a threshold, four shoes, two pillows, two bundles of cables, two stuffed animals, and a stack of books. Each obstacle is equipped with a standard peg (Figure 7.9) that fits into one of the five holes on any given surface piece. When an obstacle peg is inserted into a hole, it depresses a micro switch that records the presence of an obstacle at that location. Although the system is capable of handling four surfaces, each with up to five obstacles, the circuits have been designed for single pin output (Figure 7.10 and Figure 7.11).

Fig. 7.9. Obstacle peg and pillow obstacle with peg attached.

Fig. 7.10. Embedded wiring and circuit board.

The Storage System consists of a cart that holds all eight surface pieces, and a storage bin to hold the obstacles. The cart allows for easy setup by storing the pieces with the handles on top for easy access. This allows the physical therapist to move the cart close to the setup area to minimize carrying distance and setup time.

The total cost of the project was $1,730.

More information is available at https://edge.rit.edu/content/P08003/public/Home

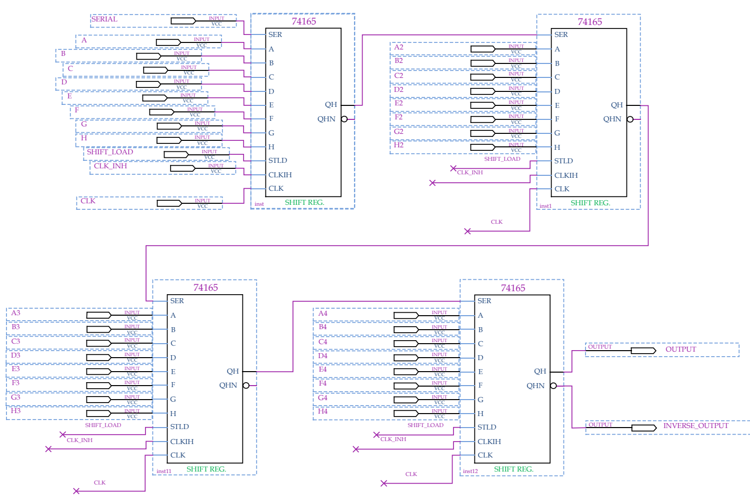

Fig. 7.11. Four serial shift registers chained together to produce single pin output.

ADAPTABLE BOCCE BALL LAUNCHER

Industrial Engineering Designer: David M Ferguson (team leader)
Mechanical Engineering Designers: Bryan J. Fleury, Bradley Johnson, Angela Marcuccili, and Yashawant Singh
Client Coordinator: Laurie Kennedy, Genesee Region Special Olympics
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INTRODUCTION

The New York Special Olympics (N.Y.S.O.) organization wanted to add bocce ball as a sport for their athletes to participate in, but many of the athletes were unable to produce the force required to roll a bocce ball 60 feet. A simple non-intrusive assistive device was needed to enable more athletes to fully participate in the sport. The customer requested that the device not take away the skill level that comes with strategically placing objects, as well as keeping the final device very simple, with no impact assistance.

SUMMARY OF IMPACT

The need for an assistive device led to the development of the adaptable bocce ball launcher, which strategically rolls the balls down a ramp without taking the need for skill development out of the game. This device is essentially a portable ramp on top of a locking swivel base, resulting in providing a means for a greater range of N.Y.S.O. athletes to participate. The device will allow many more athletes to participate in indoor bocce played on a variety of surfaces for both competitive and social interaction.

TECHNICAL DESCRIPTION

The ramp design chosen was a straight V-channel section with a curvature at the end. Several different profiles were explored using simulation, but this was found to be the optimum option based on manufacturing and velocity attained. Exit velocity and rolling distance are determined by placement of the ball on the ramp. Releasing the ball at the very top of the ramp gives the ball the greatest amount of velocity and force to go the maximum distance, or have the most power to strike other balls. The curvature at the end of the ramp allows for a minimal loss of energy upon the balls impact with the court surface. The V-channel allows for both the pallina and bocce ball to be rolled on the same ramp, with only two contact points for each ball.

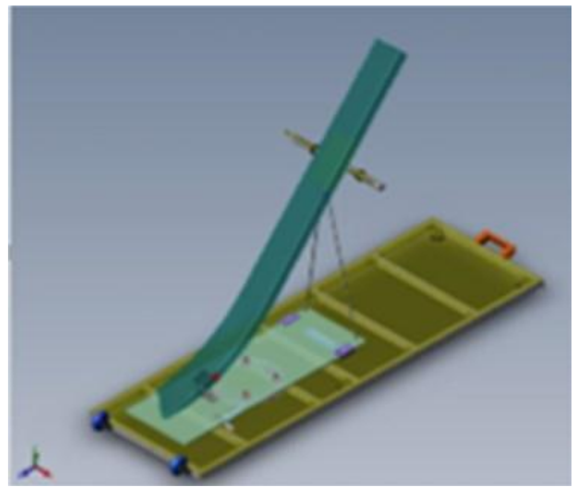

Fig. 7.12. Ramp deployed for play.

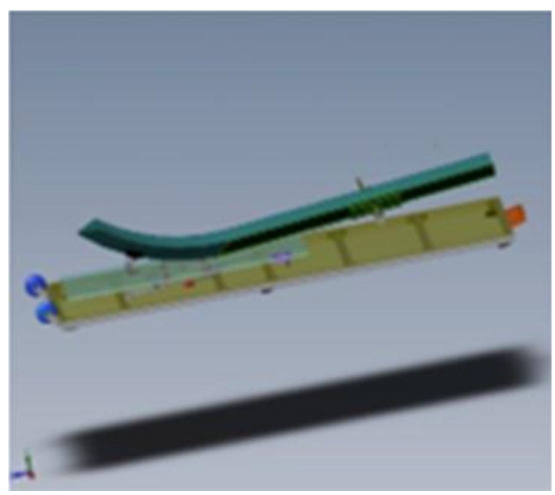

Fig. 7.13. Ramp folded for storage.

The ramp has two positions: extended for use in play (Figure 7.12) or collapsed for storage and transportation (Figure 7.13). The ramp is supported at two locations when extended: the front pivot hinge and the back legs. The top of the device can be reached by 95% of wheelchair users. When collapsed, the legs are pivoted underneath the ramp and the ramp rests on the base. When the ramp is inclined, the legs naturally swing down into place and the user inserts them into their locating holes.

The pivot hinge and legs are mounted onto a platform made of polyvinyl chloride (PVC) that rests on top of a swivel. This piece allows the ramp to rotate 15 degrees in either direction until it hits a stop, enabling a user to aim at any position on the court from either side of the ramp. The swivel is mounted onto the top of the base with a brake system. The base is the footprint of the ramp's length and the width of the PVC platform. These dimensions will safely keep the users far enough away from the rotation of the swivel.

The base has two wheels located on the front at an angle that allows them to only be engaged when the user picks the ramp up from the back with a mounted center handle. These wheels allow the user to easily position or reposition the device in a desired location. When the ramp is ready for game play the wheels are disengaged and do not interfere with the path of the pallina or the bocce balls. Figure 7.14 shows the completed device.

The handlebar system consists of an angled piece of steel plate, contoured to the underside of the ramp and held in place with structural adhesive. This plate has two aluminum rods welded to it creating easily gripped handles. These handles are covered with a grip to provide a safe interface with the user. The handles are the main points of contact for users aiming the ramp from either the left or right side, accommodating users that are either left or right handed. The height of the handles is conveniently located to allow comfort for users that may be seated. Each handle has a lever connected to the braking system.

The brake allows the user to lock the device in place during their turns. This prevents accidental movement of the ramp's position when the athlete rolls the bocce balls. Also, if a volunteer is holding the brake in place until the athlete's turn is finished, shifting the ramp after each turn may prevent "memory" of aiming the ramp in the same location

Fig. 7.14. Final constructed device.

automatically. When a user squeezes the handle the brake is engaged against the swivel, locking it firmly in place. Once the user has finished their turn, the brake lever is released and the swivel is free for movement.

A protective cover was designed to provide basic protection for the device while it is being transported or stored. The composition of the cover consists of the same 80/20 extruded aluminum as the base, giving it an aesthetically pleasing look. When placed over the ramp and locked in place with latches the device is plain shaped and can be easily stacked.

Finally, the user has been left with a detailed user's manual that includes maintenance, operation and future manufacturing instructions, as well as a reusable mold for duplication purposes.

The total cost of the project was $1,422.98.

More information is available at http://edge.rit.edu/content/P08004/public/Home.

MOUNTING SYSTEM AND USER INTERFACE FOR ELECTRONIC COMMUNICATION BOARD

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Mechanical Engineering Designers: Kirk Marquard and Cortney Ross (Team Leader)
Industrial Designers: Amy Koster and Rachel Lepkowski
Client Coordinator: Lisa Drewski, ARC of Monroe County
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INTRODUCTION

The ARC of Monroe County works with an individual who is able to understand when others speak, but who cannot communicate with others beyond some very basic sign language. She has used a notebook with Mayer Johnson symbols to communicate in the past, but frequently gets frustrated with the book and does not use it. A prior senior design team created an electronic communication board that would speak for her, and this year the design was refined, and a system to mount the board to the user's wheelchair was created.

SUMMARY OF IMPACT

The new communication board is smaller, designed to be visually appealing to the customer, and can be securely fastened to the individual's wheelchair. The first time the customer saw the new design and user interface during the demonstration session, she

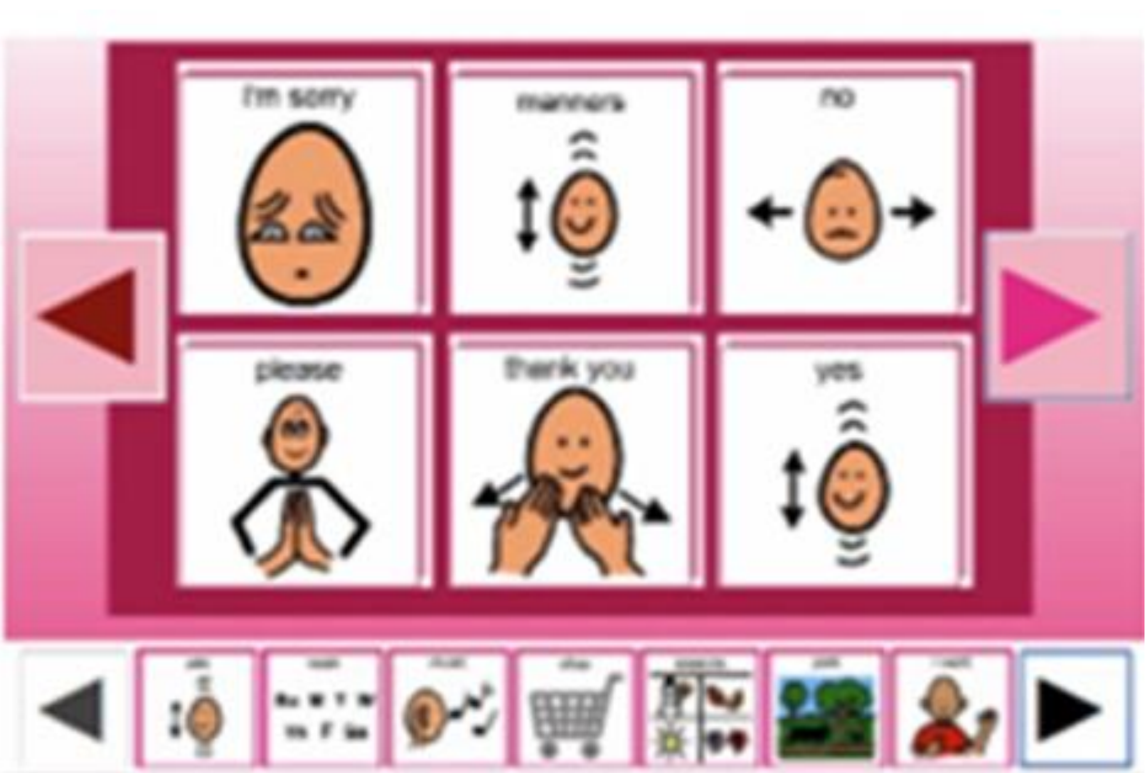

Fig. 7.15. Screenshot of the communication board graphical user interface.

repeatedly pressed the symbol that speaks the word "excited".

TECHNICAL DESCRIPTION

Based on the results of the previous project, the complex nature of designing a robust custom embedded computing system on a limited budget, and the sensitivity to the expectations of the individual and her caregivers, it was decided to approach the project in a phased manner. The system consists of a robust touch-based display, with sound generation mounted and an adjustable boom assembly that is securely and easily attached to the individual's wheel chair. The rechargeable battery based power supply and embedded processor are connected to the display via a multiple conductor cable and located on the wheel chair in the space under the wheelchair seat. In this phase of the project, the deliverables are focused on the display unit, the actual embedded software application (shown in Figure 7.15) and the boom assembly. The application was developed on a Viewsonic V212 wireless tablet running Windows CE. This provided a prototypical embedded development platform that closely resembles the intended system, including an integrated touch screen. This enabled an iterative software development cycle that is quickly modified and evaluated. The software is developed using Visual Studio 2005 and the C# programming language, allowing rapid application generation that is easily be ported to either an embedded operating system (Windows CE) for the target hardware or a conventional operating system (Windows XP) for evaluation on standard desktop or laptop platforms. The development on the Viewsonic V212 wireless tablet facilitated early evaluation of the touch interface by the individual, while an appropriate LCD touch screen was ordered and integrated into the application software running on a laptop computer running Windows XP, which acted as a "stand-in" for the embedded processor that will ultimately be integrated into the system. In other words, the LCD touch screen for the project acted as the user interface for the application that was running on the laptop computer, providing display, sound, and user input. This method of software development allowed simultaneous and parallel design and implementation of the enclosure for the LCD touch screen as well as the positioning assembly to occur.

Fig. 7.16. Final manufactured enclosure.

The interface enclosure, which is designed to hold a Caltron Industries 12.1" LCD touch screen (12V power, 800x600 pixels) that uses thermoformed ABS plastic (Figure 7.16). The thermoforming process enabled a case design that incorporates smooth and rounded features that results in an attractive and sleek appearance. The case is designed to be aesthetically appealing to the customer, using paint in the customer's favorite colors to increase her motivation to use the device. A pair of USB powered amplified speakers are mounted behind the LCD touch screen assembly in the enclosure (Figure 7.17). This enables the incorporation of a degree of fluid protection into the enclosure as the speaker baffles are rear facing and away from the most probable direction of accidental spills and fluid exposure. It also directs the sound from the device in the direction of the person(s) who would be facing the individual using the device.

The case containing the touch screen running the GUI is attached to the customer's wheelchair using a custom-designed mounting arm (Figure 7.17). The arm is made from 7/8" OD 4130 steel tubing with a 0.12" wall thickness and is designed to meet strength requirements, as well as to prevent excessive deflection under typical loading of both the device itself and the forces due to the individual interacting with the device. The mounting arm is connected to the individual's wheel chair using a custom designed adjustable and removable mounting clamp that provides adjustments for positioning of the overall system relative to the wheel chair. There is an adjustable angle elbow that allows positioning of the touch screen interface relative to the individual, and then an adjustable LCD mount that allows for optimal orientation of the touch screen interface. The touch screen interface is affixed to the mounting arm using a standard LCD quick connect VGA computer display adapter.

The individual commonly uses a tray attached to her wheel chair and the touch screen interface is meant to be able to rest on that tray at eye level and within easy reach. The bottom of the enclosure incorporates rubber "feet" meant to rest on the tray and provide an additional degree of stability when the individual is interacting with the touch display. Cabling between the display and the embedded processor and power supply (located under the seat of the wheel chair) will be implemented via a flexible cable enclosure attached to the mounting arm. The next phase of development will determine the optimal mounting system for the embedded processor and power supply.

The total cost of the project was $1,800.

More information is available at https://edge.rit.edu/content/P08005/public/Home

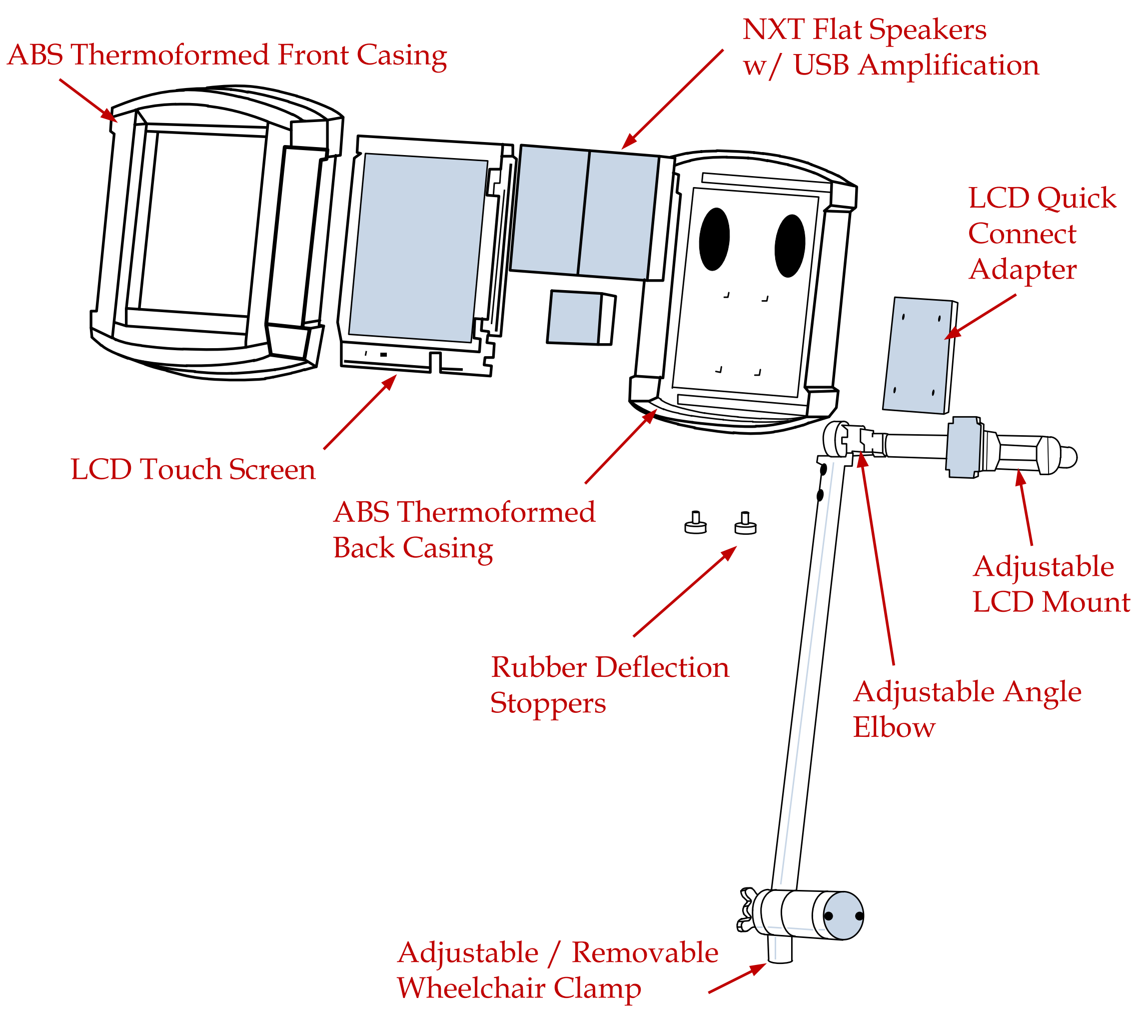

Fig. 7.17. Exploded view of the system allowing the communication board to mount to the user's wheelchair.

MOTION TRACKING SYSTEM

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Electrical Engineering Designers: Wade Daugherty, Brian Leigh, and Josemaria Mora (team leader)
Mechanical Engineering Designer: Jennifer Mallory
Client Coordinator: JJ. Mowder-Tinney, Nazareth College Physical Therapy Clinic
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INTRODUCTION

As a part of a typical physical therapy regime for patients recovering from strokes, a gait assessment is performed. Many of the clinic's clients have an irregular gait, and the clinic currently has several devices that measure such features as balance and weight distribution. However, they do not have a method for measuring the hip, knee, and ankle joint angles during walking. The clinic only has means of making a qualitative assessment of the patient's motion and progression, lending to an incomplete evaluation of each patient. If the clinic did want to obtain the measurements of the joint angles, they can only do so by using a goniometer while the patient is not moving. This measurement requires two therapists, and is both inefficient and inaccurate as it does not provide an accurate assessment of the patient's dynamic progress.

SUMMARY OF IMPACT

The resulting device is based on gyroscope output. Gyroscopes are enclosed and attached using an electrode-snap system to pre-identified anatomical reference points (Figure 7.18). Angular velocity data is sent from each gyroscope to a microcontroller, and then transmitted to a computer via Bluetooth. Angular displacement for the hip, knee, and ankle joints is then calculated and displayed on the computer. The data is stored for comparison in future therapy sessions. In the future, this system may be the basis for telemedicine work that the clinic is considering to enable them to work with patients who would otherwise be unable to undergo physical therapy.

TECHNICAL DESCRIPTION

The Motion Tracking System is based on data collected through eight Analog Devices ADXRS300 gyroscopes. The gyroscopes are enclosed in small plastic cases that are attached to the patient's skin using ECG electrodes. Data is transmitted to a MSP430 microcontroller worn on the patient's waist belt. Using a BlueSMiRF Bluetooth wireless modem, raw angular velocity data is transmitted to a laptop computer where it is processed, displayed, and saved using a Java script written by the design team.

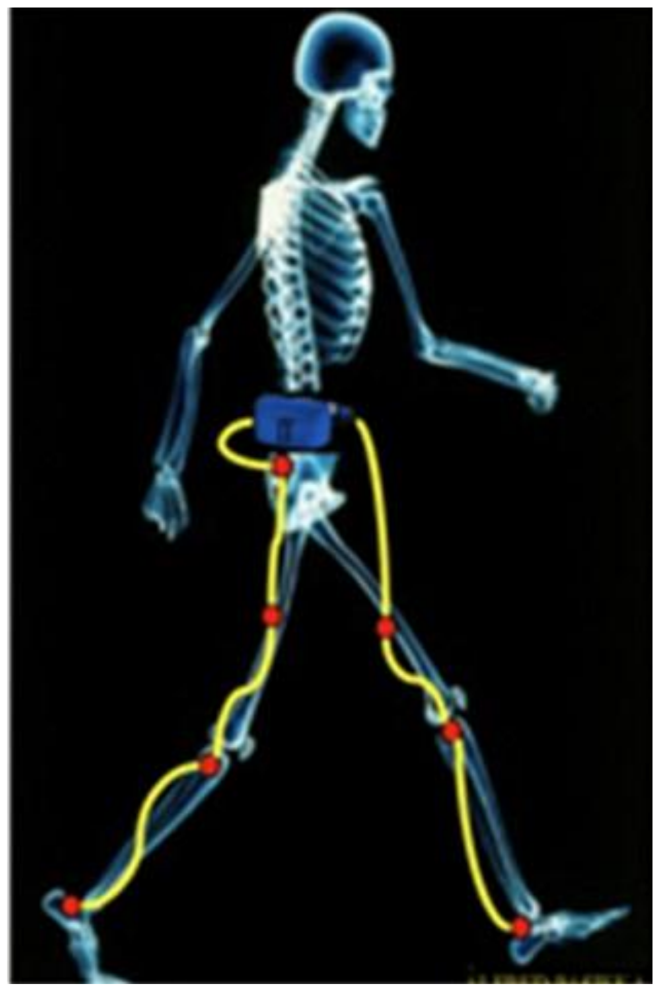

Fig. 7.18. Schematic showing locations of gyroscopes.

The raw angular velocity data is integrated to obtain angular displacement. A sample of the resulting user interface is shown in Figure 7.19.

As part of the team's testing procedures, data are collected for normal walking profiles, as well as for irregular walking to simulate the way a typical patient might walk, without flexing the knee. Evaluation of the device indicates that the system is functional, as shown in Figure 7.20. The system can detect different gait patterns as shown in Figure 7.21. For the hip angle, the clinic staff is only interested in documenting whether flexion occurred, and not the actual range of flexion. For the knee and ankle, the actual degree of flexion is needed.

Some difficulties were encountered with the design. For unexplained reasons, the system was unable to accurately collect and display more than one cycle of data without the error increasing drastically. Additionally, the data transfer rate between the microcontroller and laptop was slower than

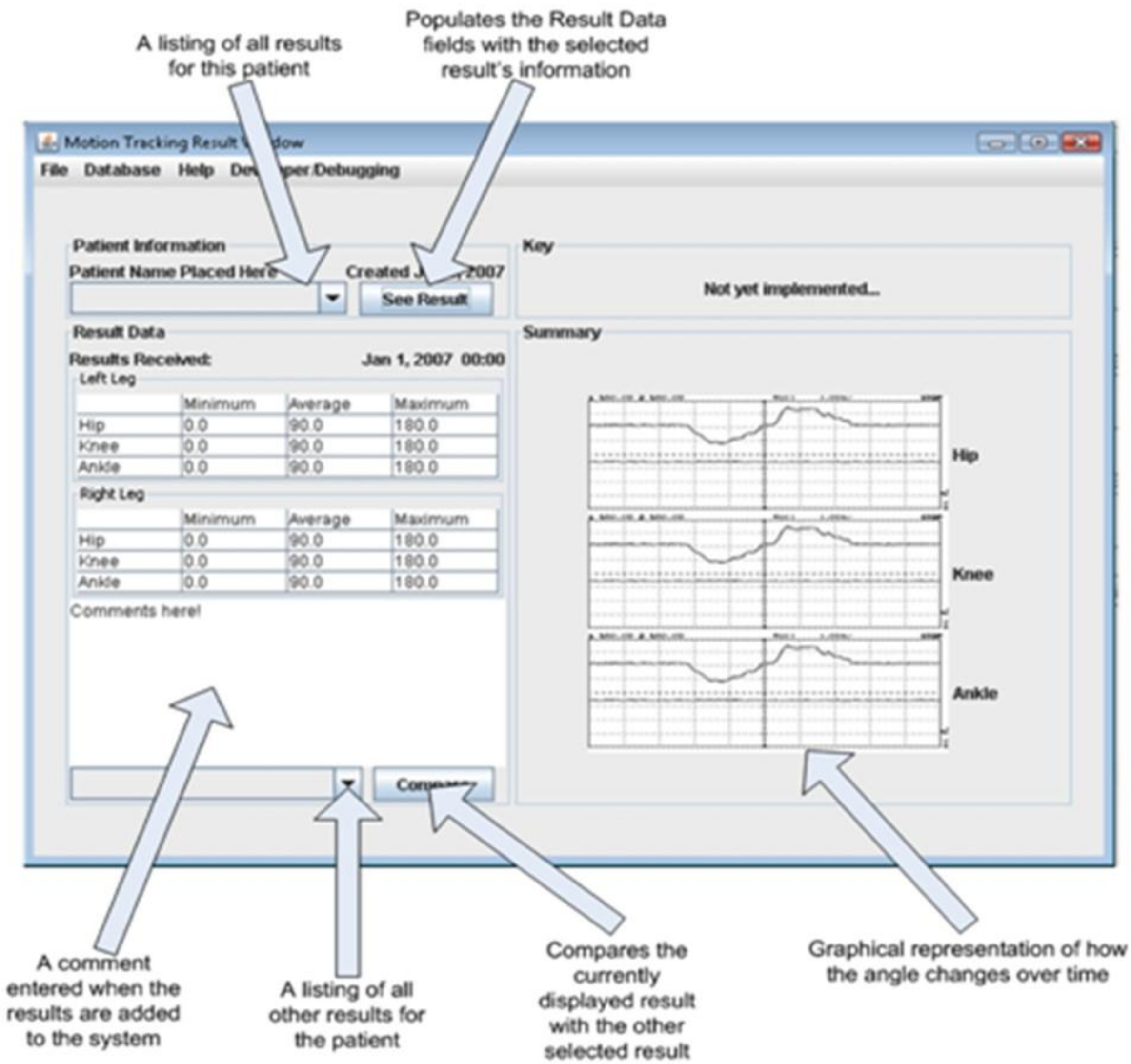

Fig. 7.19. User interface for motion tracking system.

anticipated. Overall, the project was a significant step toward creating an affordable motion tracking system for use in a physical therapy clinic.

The total cost of the project was $1,443.37.

More information is available at https://edge.rit.edu/content/P08006/public/Home

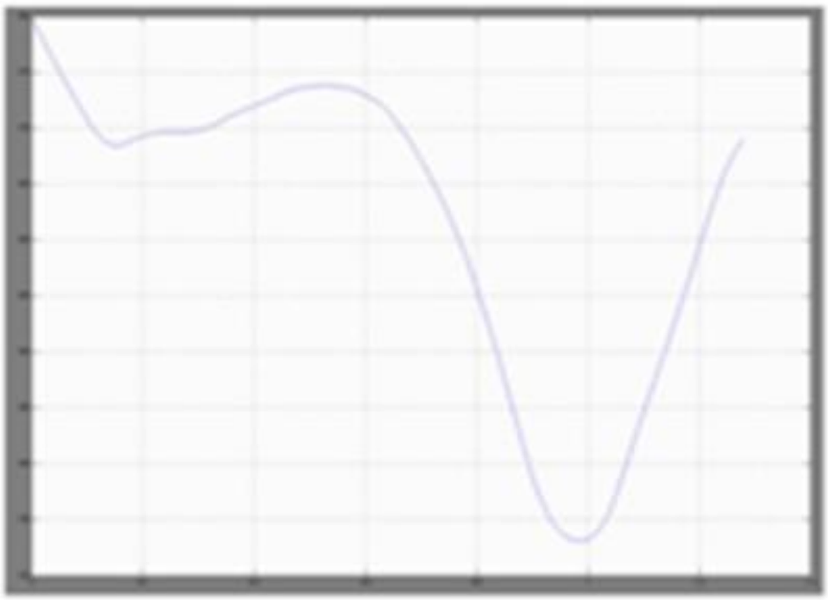

Fig. 7.20. Knee flexion, with a range of 130º-180º.

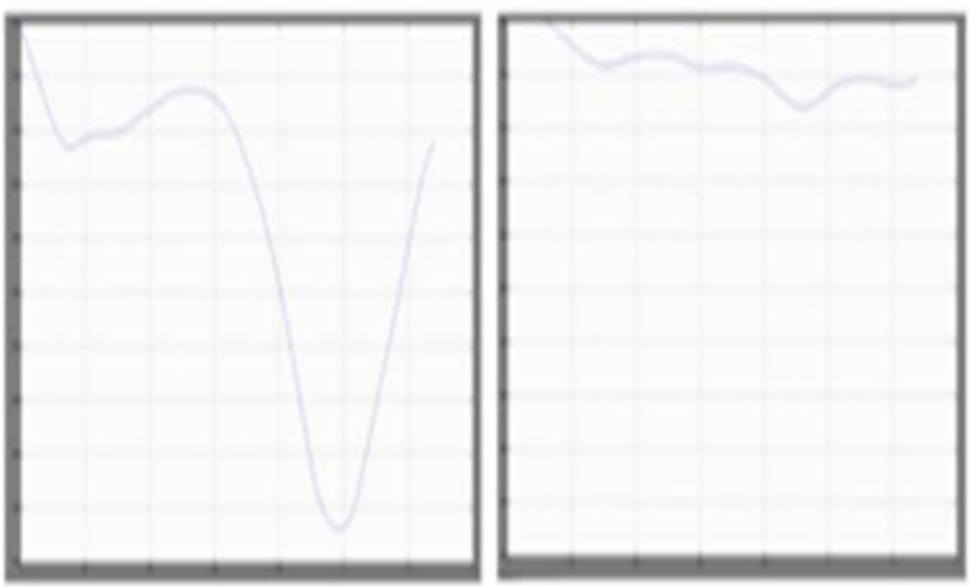

Fig. 7.21. Knee flexion in a normal gait pattern (left) compared with a simulated patient (right).

ARCWORKS MANUFACTURING PROCESS IMPROVEMENT

Industrial Engineering Designers: Eric Meinecke (team leader) and Stephen Morey
Mechanical Engineering Designers: Shawn O'Hern, David Perkins, and James Salerno
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INTRODUCTION

The purpose of this project is to design and build a machine that improves upon a manual process of assembling closure/straw adapter subassemblies that are used Nalgene wash bottles. Problems with the manual process that are addressed with the new design include a long assembly cycle time, a high force input requirement that caused long-term repetitive stresses for the operators, and a tedious loading procedure that is frequently completed incorrectly, resulting in a high part rejection rate. A secondary project objective is to redesign the floor layout of the entire wash bottle assembly cell at ArcWorks to streamline the flow of materials through the assembly process. Figure 7.22 shows the subassembly being created with this machine.

Fig. 7.22. Wash bottle subassembly.

SUMMARY OF IMPACT

A pneumatic device, capable of creating five closure/straw adapter subassemblies simultaneously and keeping an automatic tally of the number of subassemblies made, was successfully built (Figure 7.23). The machine is now being used by employees with a range of mental and physical disabilities at the ArcWorks manufacturing facility. ArcWorks has already expressed their satisfaction about the outcome of this project, making particular note of the ease of use for the employees. Since its installation at ArcWorks, the new assembly machine has replaced all the manual presses previously used to make closure/adapter subassemblies. While the manual presses will continue to be used for small specialty orders, the new machine has become ArcWorks' workhorse for making subassemblies. Additionally, the distance parts travel from raw material to finished product has been reduced from 90 feet to 45 feet through a redesign of the layout of the manufacturing floor (Figure 7.24). The new design also allows the supervisor to see at a glance the stage of assembly of any part, just from his position on the floor.

TECHNICAL DESCRIPTION

The pneumatic system consists of five double-acting cylinders plumbed in series. There is a slight delay between the first and last cylinder to fire, but the lag is insignificant relative to the total stroke time. When the pneumatic cylinders actuate and extend, a guide sleeve housed within a press fixture fits over the straw adapter, and bottoms out on the straw closure. As the cylinder continues to extend, the force presses the adapter into place. The inner core of the guide sleeve has a cavity composed of a series of concentric steps that mate with corresponding faces on the adapter. The concentric steps not only allow the inner core to interface with the adapter in any orientation, they also distribute the total assembly force on the adapter over the maximum possible area, reducing the likelihood of breaking the adapter during assembly. This system is the key to consistently successful subassemblies.

Upon the completion of the machine construction, testing, consisting of filling an order of 1400 closure/adapter subassemblies for ArcWorks, was completed. The objectives of this test were to test the robustness of the structure of the machine and the pneumatic fixtures, to test the pneumatic safety equipment (the two-hand anti-tie down control and emergency stop), to identify any usability issues with the machine, and to compile statistics on the performance of the machine. The 1,400 subassemblies completed had a rejection rate of 0.7% (10 parts). This is significantly better than the average rejection rate of 5% with the current manual assembly process. The cycle time has been reduced from six to four seconds and the force required to assemble the device has been reduced from 50-70 lb. to two ounces (the force required to activate the two-hand anti-tie down control).

The total cost of the project was $1,682.01.

More information is available at https://edge.rit.edu/content/P08008/public/Home

Fig. 7.23. Closure/straw adapter subassembly device in use.

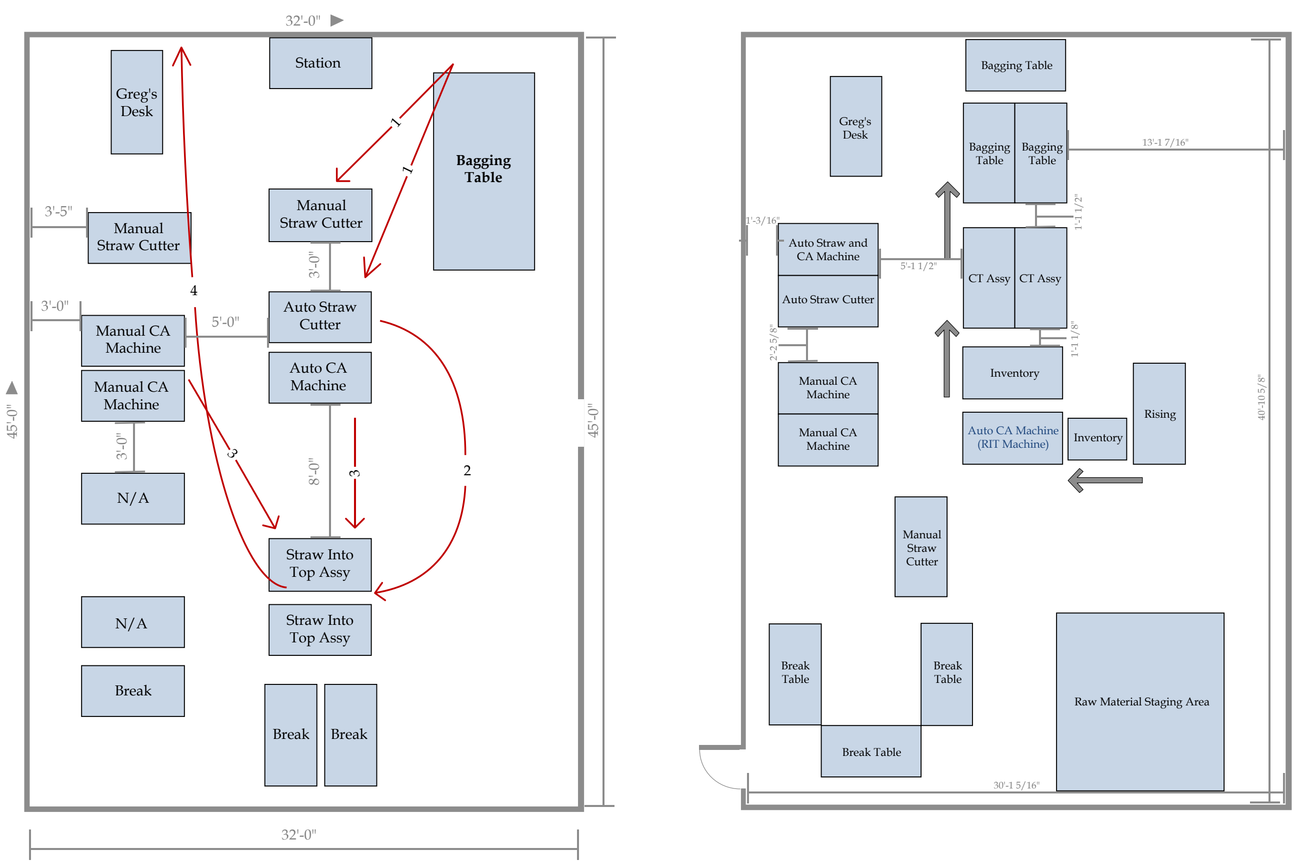

Fig. 7.24. Material flow diagram before (left) and after (right) floor layout redesign.

CHAPTER 8
STATE UNIVERSITY OF NEW YORK AT BUFFALO

School of Engineering and Applied Sciences
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ASSISTIVE LEG REST FOR A DESK CHAIR

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INTRODUCTION

The Assistive Leg Rest for a Desk Chair was designed to allow the client, who has suffered a stroke and could only use their right side, to easily elevate their legs while seated at their desk chair. This was necessary as the client had developed edema in their lower left leg. Typical desk chairs with leg rests have leg rests that are difficult to elevate. Other chairs with leg rests, such as recliners, are much too bulky. With that in mind, a regular desk chair shown in Figure 8.1 was modified to have leg rest which was easy to elevate and also compact.

SUMMARY OF IMPACT

Those who need to keep their legs elevated and find it difficult to use traditional means for doing this will find the Assistive Leg Rest for a Desk Chair very convenient.

TECHNICAL DESCRIPTION

This device had several design requirements. The requirements for the overall system had to have a mechanical advantage between 3:1 and 6:1. In addition, it must be able to lift the weight of legs (approximately 30 lbs.) with a lever arm of 16 inches, and to also have a factor of safety of 3. This allows the client to easily lift their legs up in a short amount of time, achieved by using a drive train that consists of bevel and worm gears with a crank handle (modified ratchet) connected onto the original leg rest design.

Since the leg rest moved through an angle of 120 degrees, an overall gear ratio around 3:1 was chosen. This would allow the leg rest to be elevated completely in 6 to 12 cranks if the user cranks the handle between 60 and 30 degrees. The gear ratio was achieved by using a set of bevel gears with a 1:3 ratio connected to a worm gear set with a 10:1 ratio. This gives an overall ratio of 3.33:1.

Fig. 8.1. Assistive leg rest in the down position.

Fig. 8.2. Assistive leg rest in the up position.

The worm gear set chosen had a lead angle of 9° 28′ with a double thread. This ensures that the worm can drive the worm gear, but not the other way around. At the same time it doesn't compromise the required strength or desired gear ratio.

The crank handle was designed to be 16 inches in length to equal the lever arm of the leg rest. This ensures that the gear ratio provided by the drive train is the mechanical advantage for the system. The handle also has an extension for the ratchet switch. It is a long lever hinged at the middle so the distance traveled at the user end of the lever is the same as that at the ratchet switch. This allows for the ratchet direction to be easily changed without having to be changed right at the base of the ratchet.

On the ratchet there is also a brake lever. This brake lever is attached by a brake cable to rods with springs on them. Springs push the rods into the middle of the leg rest shaft when the leg rest is in the elevated position. The leg rest is then lowered by pulling the brake lever and then cranking down the leg rest. This brake helps to alleviate the stress on drive train and also ensures that the worm gear will not back drive the worm and cause the leg rest to descend unexpectedly.

A gear guard was also designed to ensure that nobody would be hurt by the gears in the drive train during operation.

The total cost for this project was $456.00.

Fig. 8.3. Gear assembly.

Fig. 8.4. Rear of the gear assembly

PORTABLE ASSISTIVE ELEVATION SEAT

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INTRODUCTION

The portable assistive elevation seat provides persons with disabilities the ability to stand up from a sitting position to the standing position. With some input from the user, the seat manually lifts the person using a lever on the right side of the seat. The maximum weight of the person is three hundred pounds. The Portable Assistive Elevation Seat can be used by a wide range of persons with disabilities who otherwise would stress their upper body while trying to stand. The person also has to provide enough force to trigger the hydraulic jacks. The force is not enough to strain the user in any way because of the design of the lifting subsystem. The other part of the lifting subsystem is the release device, which allows the user to release the hydraulic jacks from the lifting position. The clamping subsystem is designed as a portable seat so the user is able to attach the portable elevated seat on an existing seat such as a bench or chair. There are also two levers on each side of the clamping subsystem, which allows the person with disabilities to easily detach the portable assistive elevation seat. The third part of the portable assistive elevation seat is the actual seat assembly. The person with disabilities sits on an existing orange seat, which is be connected to the Plexiglas base plate.

SUMMARY OF IMPACT

The portable assistive elevation seat will help people in any situation where he or she wants freedom to sit where ever he or she wants. The portable assistive elevation seat does not restrict the person from only seating in designated spot in a sports arena to a restaurant. The best feature of this product is that it never runs out of power, or is bulky or heavy because it is using mechanical advantage innovation.

TECHNICAL DESCRIPTION

The portable assistive elevation seat has three main assemblies: a lifting mechanism, a clamping mechanism, and seat assembly. The three main parts are attached to the top in three different sections of 15.63 inches by 11.75 inches Plexiglas base plate.

Fig. 8.5. The lifting mechanism.

The front section of the prototype has the lifting mechanism. This mechanism consists of the two aluminum jacks, the lifting ratchet and the release mechanism. The two aluminum hydraulic jacks are attached together by welding an aluminum plate to the hydraulic jacks with a length of 3.42 inches and fastening it to the Plexiglas. The two aluminum hydraulic jacks are also pinned together with an aluminum bar with two different diameter dimensions. When the bar is acting as a pin for the hydraulic jacks, it has a diameter of .295 inches and the larger diameter in between the hydraulic jacks is .375 inches. The larger diameter of the aluminum bar has a diameter of .985 inches and length of 3.42 inches. The nylon bar sits on top of the larger piece of aluminum bar so that it rotates the hinge of the seat assembly. While the rotation is simple in design, it is the most effective way to allow the lifting mechanism to raise the user off a seat.

The ratchet device for the lifting mechanism consists of a hexagonal bar with a length of 11 inches connected to a rotating aluminum bar. The rotating aluminum bar has two parts, which are an aluminum round bar with a diameter of .386 inches and a hexagonal bar with a length of 8 inches. The longer part of the aluminum round bar is connected to the hexagonal bars with screw pins on the 11 inch hexagonal bar and the 8 inch hexagonal bar. The smaller part of the aluminum round bar is also connected with a screw pin to the hexagonal bar. The smaller part of the round bar has a length of 1.25 inches. The larger part of the aluminum round bar is 5 inches in length. The large aluminum block is located in the front and left side corner of the Plexiglas base plate. The large aluminum block has a width of 1.06 inches, a length of 1.62 inches, and a height of 2.45 inches. The smaller aluminum block has a width and length of .725 inches and a height of 1.45 inches. The original design used the aluminum hydraulic jack to trigger the hydraulic pump. This was modified by screwing onto an 8 inch hexagonal bar. The two pieces are placed at the correct distance from the horizontal and vertical direction on the bar to allow the most effective action in hitting the hydraulic pump. This allowed a simple way to pump the hydraulic jack and not have to completely redesign an existing design.

The release is the final component of the lifting mechanism. It was the hardest part of the design of the lifting mechanism because of the difficulty in rotating both releases on the hydraulic jacks simultaneously. The design consists of an elevated platform above the two hydraulic jacks. The hydraulic jacks have a circular aluminum disk with

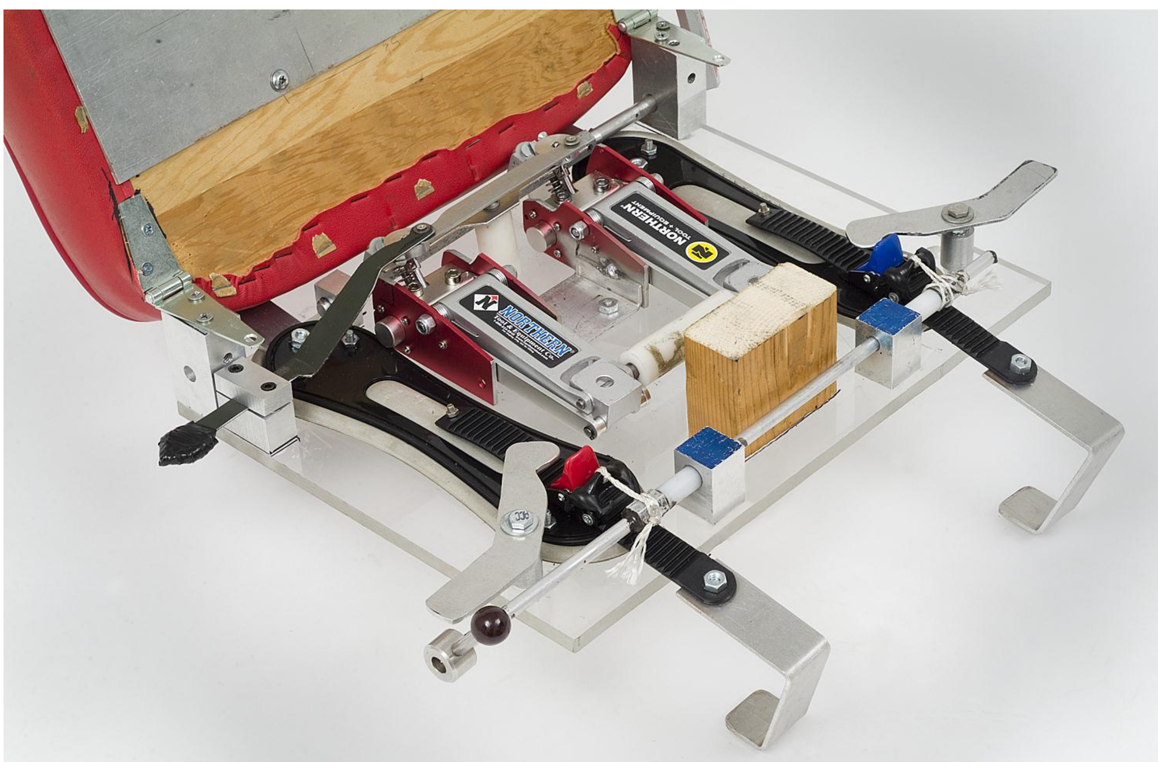

Fig. 8.6. The clamping mechanism.

a 1 inch diameter connected on the release mechanism. This allows both to turn to the right and left at the same time. The elevated platform has a rectangular aluminum plate with a length of 5 inches above the two circular aluminum disks, which allows both disks to rotate at the same time. There is also a rectangular aluminum plate with a length of 6.5 inches below the aluminum disks, which is screwed into the sides of the hydraulic jacks for support. The user pulls or pushes with a stainless steel lever, which has a length of 3.25 inches. The stainless steel lever and the rectangular aluminum plate are connected at the same point on the right circular disk. The stainless steel lever is supported by a small and large aluminum block. The design of the block has two separate blocks that allows the stainless steel lever to freely move in the horizontal direction, but not in the vertical direction. The large aluminum block has a width of 1.55 inches, a length of 8.23 inches, and a height of .92 inches. The small aluminum block also has a width of 1.55 inches and a length of 8.23 inches but a height of .460 inches.

In the back section of the prototype, there is the clamping mechanism. The clamping mechanism consists of the ratchet device and the release mechanism. The clamping mechanism uses a modified snowboard binding for the ratchet device and release mechanism. The ratchet device consists of a small steel bar with a knob that is connected to an aluminum round bar with a diameter of .32 inches and 17 inches in length. There are two hexagonal bars with a 1 inch length, which are inserted over the round bar diameter. The two hexagonal bars are also glued in place to only rotate with the round bar. The two hexagonal bars are the most important part because they are attached by a string to the snowboard bindings. When the user pulls back on the ratchet, the hexagonal bar rotates and pulls the snowboard binding tighter together. The hexagonal bars have a nylon bushing to allow it to rotate freely with minimum friction. The nylon bushing has a diameter of .475 inches. The round bar is supported by two aluminum blocks with a height of 1.38 inches, a width of 1.04 inches and a length of 1.04 inches.

The release mechanism is the easiest part of the prototype. The handle for each snowboard binding unit has a special handle that connects to the Plexiglas base plate. The handle is 1.32 inches above the base plate, which sits on an aluminum round bar with a diameter of .75 inches. The handle is located in front of the red or blue switch of the snowboard binding. The user easy rotates the handle to release the clamping mechanism.

The seat assembly is connected to the Plexiglas with two stainless steel hinges. The seat used in the prototype is an orange desk seat with a width of 16.875 inches and 12.75 inches in length. The seat rests on two aluminum blocks and a wooden block. The two aluminum blocks are in the front of the prototype with a height of 2.45 inches, a width of 1.06 inches, and a length of 1.62 inches. The wooden block is fastened to the Plexiglas base plate with a height of 2.75 inches, a width of 3.75 inches, and 1.635 inches.

Overall, the proof-of-concept adequately satisfied the design criteria. The total cost of the project was $133.00.

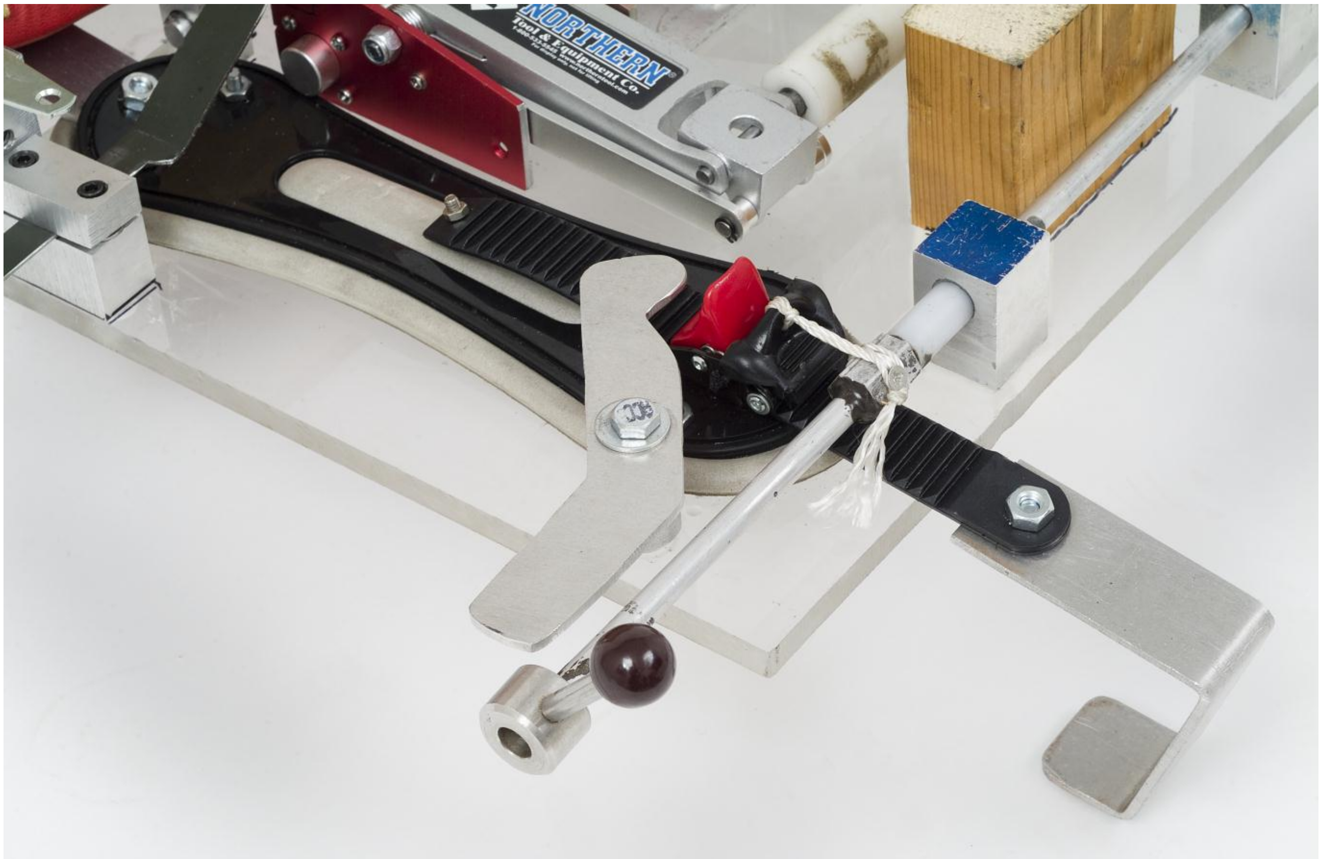

Fig. 8.7. The seat assembly.

AUTOMATIC RECLINER CHAIR

Student Designer: Christopher Bogdan
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Mechanical and Aerospace Engineering Department
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INTRODUCTION

The Automatic Recliner Chair addresses the needs of elderly persons or those with other joint or muscle conditions that make it difficult to move from the seated position to the standing position in a rocking recliner chair.

SUMMARY OF IMPACT

In using this device, the person is moved from a seated position to a position with a forward angle, reducing the necessary force to remove oneself from the chair.

TECHNICAL DESCRIPTION

This design is intended to be integrated into the design of recliner chairs to allow for a vertical lifting motion in the back of the chair that increases the angle of the seated position. To facilitate this process, a pneumatic system is designed that allows for a linear motion to occur via a pneumatic cylinder with only the opening of a three way solenoid valve.

As the person rocks forward in the chair, a pneumatic cylinder with a 1 in. bore and 1 in. stroke presses against a kick-plate, and forces water into a series of pressure chambers. A spring located on the shaft of the cylinder then causes the cylinder to extend upon a backward rocking motion, allowing the cylinder to draw water from a reservoir in preparation for the next pressure cycle. Two brass check valves located on either side of the inlet to this cylinder prevent backflow, and allows for sequential repetitions of the cycle to build pressure in the pressure chambers. When the system is fully pressurized to a level of approximately 110 psi, two springs located at the cylinder bracket prevent further pressurization of the system while still allowing for uninterrupted rocking motion.

A three-way solenoid valve is used to connect the high pressure cylinders to the linear actuator, and the linear actuator to the reservoir. In the off state, the linear actuator is connected to the reservoir tank.

Fig. 8.8. Automatic recliner chair.

When the person desires to stand, the use of a wireless transmitter triggers the solenoid to the on position. This connects the high pressure cylinder to the linear actuator and causes the actuator to extend and the system settles to a pressure of approximately 75 psi. Coupled with the 2-inch bore of the actuator, this applies an upwards force of approximately 235 lbs. The actuator itself applies its force to a hinged plate mechanism located in the chair that then allows for the tilting motion to occur.

When the solenoid is switched off, the system then returns the water to the reservoir and remains pressurized at approximately 70 psi.

With exception to the actuation equipment, the hinge and bracket materials were made of 10 ga. stainless steel. The actuation cylinders were made of cast steel, and the flow control valves were made of brass. Piping consisted of flexible plastic tubing rated for use at 200 psi.

This system in total cost approximately $200.

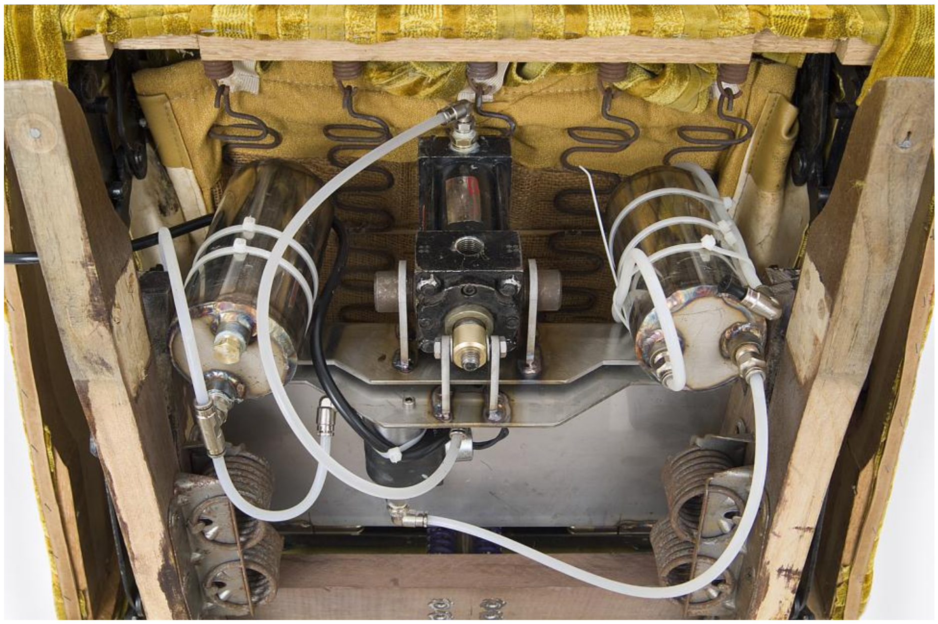

Fig. 8.9. Linear actuator and pressure chambers.

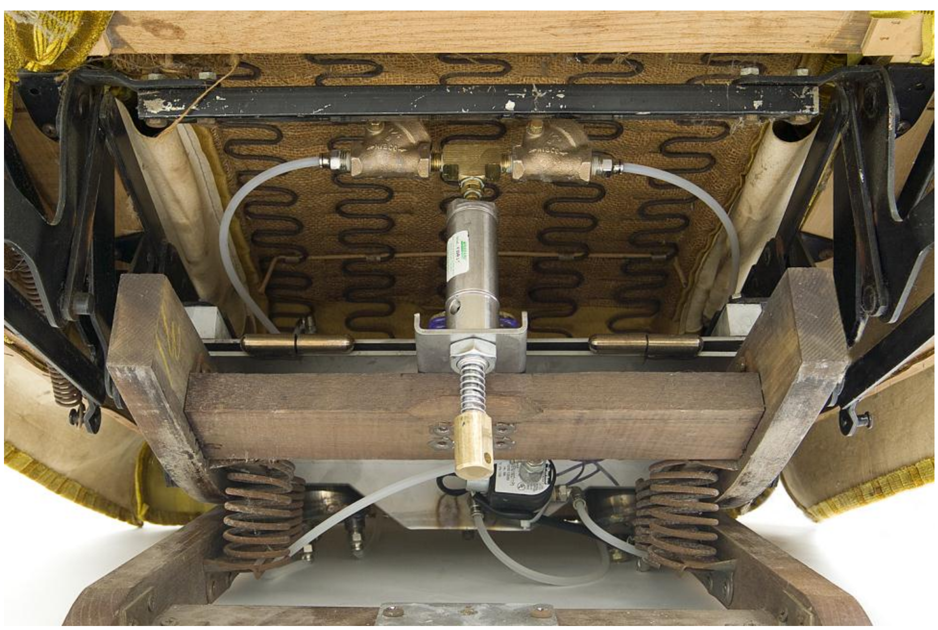

Fig. 8.10. Pneumatic cylinder.

ULTRALIGHT COMPACT WHEELCHAIR

Student Designer: Daniel Carr
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INTRODUCTION

This project's main concern was to create a wheelchair that is significantly lighter in weight and whose dimensions would be smaller than those of a conventional wheelchair design.

SUMMARY OF IMPACT

For wheelchair users, there exist various situations in which their wheelchairs are obtrusive or difficult to maneuver. Examples include smaller dorm rooms or living rooms, or in any building with tight corridors or limited space. The Ultralight Compact Wheelchair allows one to operate under these types of spatial constraints. Additionally, the light weight of the wheelchair aides in the ease of its transport for those with limited strength or agility.

TECHNICAL DESCRIPTION

Built for this course was a model of the Ultralight Compact Wheelchair, which differs from the actual product as it employs a different selection of materials. Inexpensive but sturdy PVC piping was used to build the frame of the wheelchair. The final product would actually be made from the extraordinary lightweight but strong carbon fiber tubes.

The wheelchair is 28 inches in height, 24 inches in width and 31 inches in overall length. It can safely

Fig. 8.11. Ultralight compact wheelchair.

support a 250 lb. person, with the availability to increase the load by increasing the diameter of the tubes of the frame, which are presently ¾ inch outer diameter. The model weighs 16.5 lbs., and the carbon fiber chair would be 2 lbs. heavier at 18.5 lbs.

Where the model's PVC piping is connected by manufactured joints, the carbon fiber tubes would be assembled together through the use of industrial strength epoxy. In addition to having a greater strength to weight ratio than steel, the carbon fiber tubes also have the benefit of being much more corrosive resistant to weather and other adverse conditions.

The specific design of this wheelchair eliminated the need for rear casters, which are usually included to prevent the chair tipping over backwards. The Ultralight Compact Wheelchair places the client's weight and center of gravity closer to the front of the chair and lower to the ground to provide additional security and a steadfast hold to stay upright in the face of opposing forces or momentum.

The cost of this project was $53.

Fig. 8.12. Rear of the ultralight compact wheelchair.

OUTDOOR STAND-UP/SIT DOWN LIGHT-IMPACT PEDDLING WHEEL CART

Student Designers: Daniel Cimino, Adrianna Kwiecinski, Raghu Seetharaman
Supervising Professor: Dr. Joseph C. Mollendorf
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INTRODUCTION

The Peddling Wheel Cart provides an easy way for a person with disabilities to move around outdoors. This is a new kind of design equipment for people who can't walk due to a certain disability they might have. This allows for a safer transition between a wheelchair and a walker. It is basically a cart that provides easy transportation from one place to another place. The Wheel Cart consists of: four wheels used for moving around; a seat, front frame with handle bars, and peddling system. The peddles are regular bicycle peddles, two wooden boards are attached on top of each peddle for a foot rest. The four wheels used are small bicycle wheels. The tubing used to make the chart is aluminum tubing, which is all welded together at each intersection. Brakes are used for the two back wheels, which locks them when the person comes to a stop. Sprockets are used to attach the chain to the front and back axles. The chain is covered with wooden box. Our main goal is that the rotational speed of peddles will be the rotational speed of the system.

SUMMARY OF IMPACT

Our main goal is to make the steering as efficient as possible so that it is easy to control. The peddling system is also another important part, since it is attached to the steering mechanism where both move simultaneously. The aluminum bars of the Front frame allow the person to steady himself. Most importantly, this allows the person to be in a standing position and imitate walking. This device is for outdoor use only.

TECHNICAL DESCRIPTION

The Peddling Wheel Cart's main mechanisms are the steering, and the peddling system. The peddling system is at the front of wheel cart. The primary propulsion system includes the peddles that are attached to a rotating axle, which has a main drive gear on it. This drive gear drives a roller chain that drives the secondary drive gear. This secondary drive gear is attached to the rear drive axle, which drives the rear wheels. Thus, this system propels the cart forward. The peddles are in an ergonomically pleasing position for the user.

Fig. 8.13. Light Impact peddling wheel cart sitting.

Fig. 8.14. Light impact peddling wheel cart standing.

The other main system of the cart is the steering system that allows the user to maneuver the cart, which is necessary for any moving vehicle. The steering system consists of the front wheels that are attached to the front steering spindles, which pivot at the front of the main frame. These pivot freely due to the bearings at the top and the bottom of the front steering pivot spindles. The left and the right steering spindles are linked together with a cross link. This cross link ensures that the left and right steering spindles turn together at the same rate. This steering mechanism is basically a rudder system of an airplane, but you move it with your right arm. You either push or pull on a lever to turn left or right.

*The overall price of the Peddling wheel cart is $590.00.

Fig. 8.15. The peddling and steering mechanism.

AUTOMATIC LOWER KITCHEN CABINET

Designers: James E Fischette Jr. and Michael Petrosino
Supervising Professor: Dr. Joseph C. Mollendorf
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INTRODUCTION

The device shown in the picture is designed to fix a problem for the elderly and those with lower back and leg problems. This particular group of people has a hard time bending down to reach items in the bottom shelves, especially those items that are stored in the back of those shelves. This product solves that problem by bringing the items stored to you so that bending down is not required. This was designed assuming that the cabinet has one shelf, in addition to the bottom floor of the cabinet. To bring the items to a easier to reach place, the top shelf slides out on drawer slide and the bottom shelf slides out on an identical set of drawer slides. It also lifts up to meet or exceed the level of the top shelf.

Fig. 8.16. Automatic lower kitchen cabinet.

SUMMARY OF THE IMPACT

The device will allow the user to utilize this storage space without assistance or risking pain or injury.

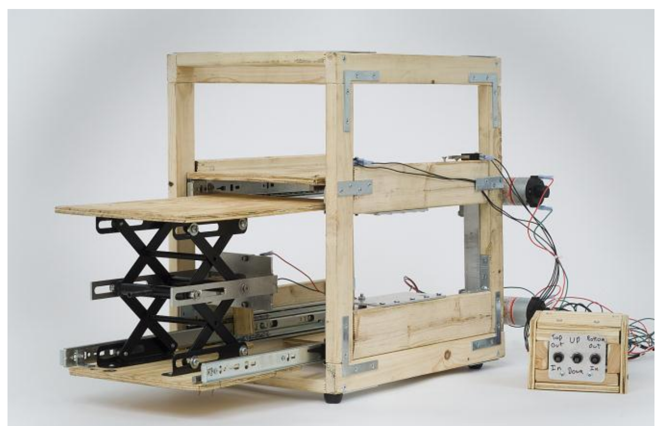

Fig. 8.17. Shelf extended and raised.

TECHNICAL DESCIPTION

This is built to approximately a two-thirds scale as it is only a proof of concept design. The frame is made from 1″ x 2″ furring strips, and put together with aluminum flat and 90 degree angled brackets. The drawer slides are industrial strength and can hold a load of up to 100 pounds. Each shelf is designed to extend beyond the front plane of the system, and is extended with a rack and pinion system. A cog on the motor attaches to a cog on the pinion gear axle via a rubber cog belt. Attached to each shelf is a gear rack that lines up with pinion gear, and when rotated, the pinion gear pushes on the gear rack to extend and retract the shelf.

The lower shelf is equipped with a scissor jack system. The scissor jack is modified to house a hopper with an attached motor. The hopper is attached to the center pivot point, allowing the scissor jack to extend and compress, while keeping the motor stationary. The motor is attached to the drive screw of the scissor jack. This lifts the lower shelf up to meet or exceed the level of the upper shelf. There are three motors on the machine: one for each shelf and one for the scissor jack. All three motors are identical direct current gear motors. They are 12 volt motors that draw approximately 3 amperes and spin at 50 rpms at the maximum voltage. Supplying the power the motors is a 12 volt, 5 amperes power supply that is sufficient enough to power all three motors. The machine is only meant to run one motor at a time. Limit switches are attached to each shelf to stop the drawer extension and compression when needed.

Controlling the motors and the operation of the machine is a remote box that contains three double pole-double throw switches, one for each motor. The final product will not have this control box but will have the three switches mounted on the piece of wood that is found above the cabinets but underneath the counter. One drawback to this design is that it takes away from the actual storage space in the cabinet. This problem will be lessened on the full-sized model because a lot of the hardware on the scale model is the same hardware that will be used on the full-size. In proportion to the overall size of the larger model, the frame, motors, power supply and scissor jack will take up less space and leave more storage.

The total cost of the design was approximately $ 325.

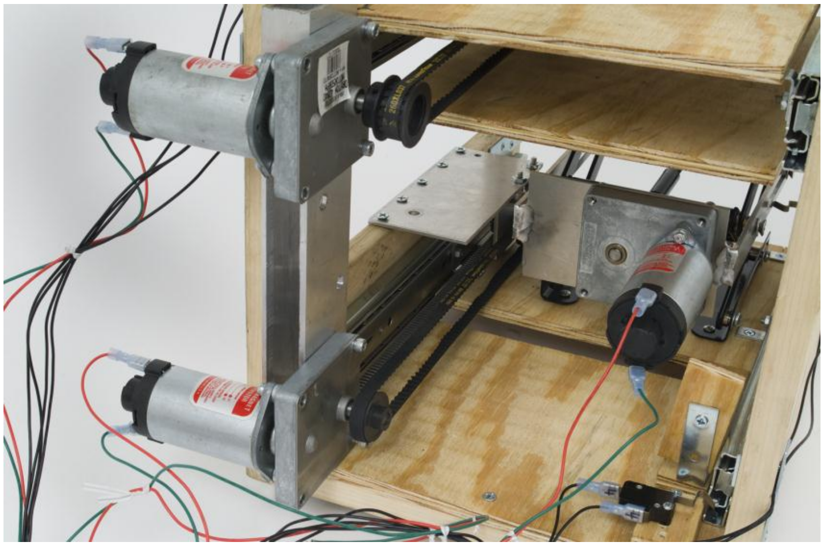

Fig. 8.18. Motors used to drive the system.

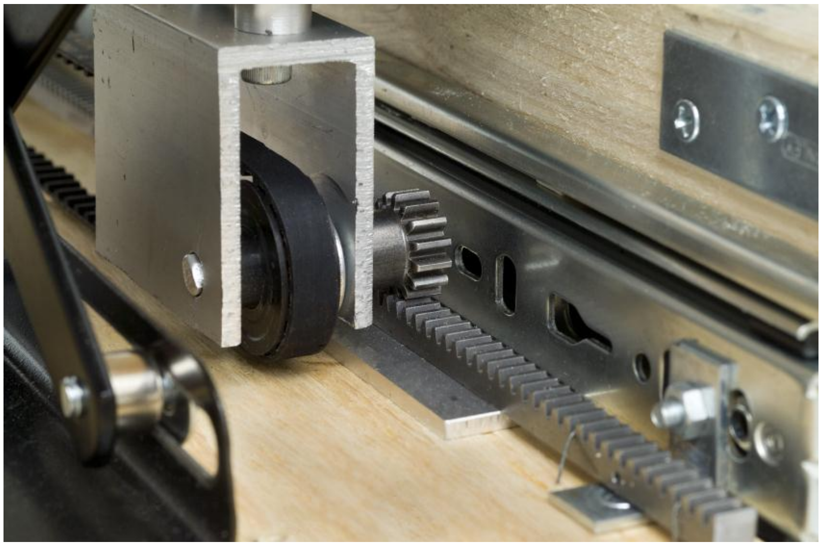

Fig. 8.19. Gear used to move a shelf.

PORTABLE HOME BASED LIFT FOR INACCESSIBLE AREAS

Designers: Ancy Alexander and Ronald George
Supervising Professor: Dr. Joseph C. Mollendorf
Mechanical and Aerospace Engineering Department
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INTRODUCTION

Lifts for people are only found in specialized areas such as hospitals. Other heavy duty lifts are found in factories. These devices are not practical enough to be used within a home setting. A 1:2 scale prototype of a portable lift was created to assist people at home to access areas at heights.

SUMMARY OF IMPACT

The target audience is people who have trouble climbing chairs and stools due to knee and muscle pain. The design is simple and portable, so that a user can move it and position it wherever he or she wants.

TECHNICAL DESCRIPTION

The device consists of a wide supporting base at the bottom and a moving car on top. A pair of ½ inch guide rods run through each end of the car, with the lower end attached to the base. The guide bearings sit in two holes in the car as shown.

The guide provides a low friction guide path for the lifting operation. A motor drives a system of two pulleys and steel cables that attach to the car through a pair of eye bolts. The drive system sits on a supporting platform above the base and car. Two non-marking wheels are provided at the lower back end of the frame, and two handles on each side of the motor and pulley casing, for tilting and moving the device. There are two support railings on the sides of the car for safety. A user operated switch actuates the motor is attached on one of the railings. Finally, four steel supports connect the base with the motor platform.

The base of the full scale design is 26 x 36”, the car is 20x32” and the total height of the device from the floor to the top end of the motor is about 20”. These dimensions were realized after considering comfort,

Fig. 8.20. Portable home based Lift.

size and portability issues. The total lifting height capability is about 30 inches.

A coupling connects the motor shaft with a rotary shaft onto which are placed two pulleys with setscrew type attachment. The motor is a 3 RPM, 250 lb.-in device that can lift a weight of 70-100 lbs. for purposes of a demonstration. The actual device is designed for a maximum load of 300 lbs. which includes a factor of safety of 2. This will necessitate the need for more powerful motor. The motor needs to be custom built so that it is compact enough for assembly.

The device has not been optimized for commercial use. The designers suggest: 1) improvement of the design of the frameworks more in terms of ease of manufacture and assembly, 2) the top ends of the two guide rods have to be limited in their lateral movement by clamping them to the supports or by having the ends sit in appropriate clearances in the platform, 3) a hemispherical casing for the motor assembly that can be opened and closed for protection and maintenance purposes, 4) two limit switches in the actual model to provide the top and lower end limits for motor operation, 5) a four way channeled system of pulleys to hold the car from the front and rear ends of the car rather than the middle section, 6) a counterweight to offset chances of the front end of the loaded car acting as a cantilever 7) more ergonomic handles and support railings and 8) a non-slip rubber surface for the loading end of the car.

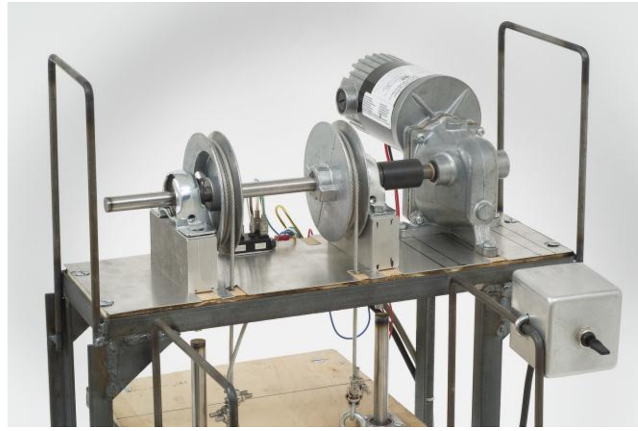

Fig. 8.21. Motor and pulleys.

Figure 8.20 is a pictorial representation of how the device will be used.

The total cost of this project was $40.

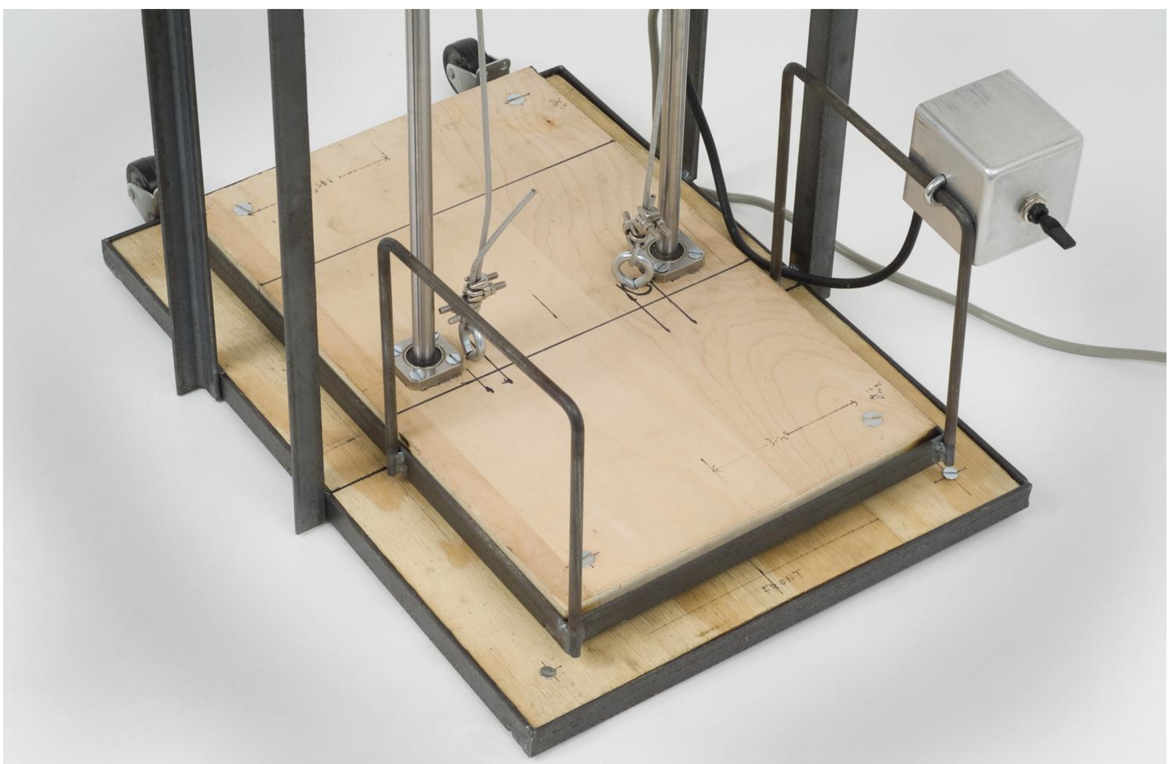

Fig. 8.22. Lifting platform and connections.

PLANTAR FOOT SELF INSPECTION SYSTEM

Designers: James R. Harris, and Tushar T. Patel
Client Coordinator: James R. Harris
Supervising Professor: Dr. Joseph C. Mollendorf
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INTRODUCTION

Diabetes is a leading cause of foot problems related to poor circulation in the extremities. These foot problems include gangrene, foot ulcers and poor healing of wounds. This is currently the leading cause of non-traumatic amputations in adults. With proper foot education and increased observation, severe foot problems can be reduced. Elderly and overweight people in particular have difficulty examining the plantar foot. The plantar foot self-inspection system, shown in Figure 8.23, provides a way to examine the plantar foot by reproducing the image onto a computer.

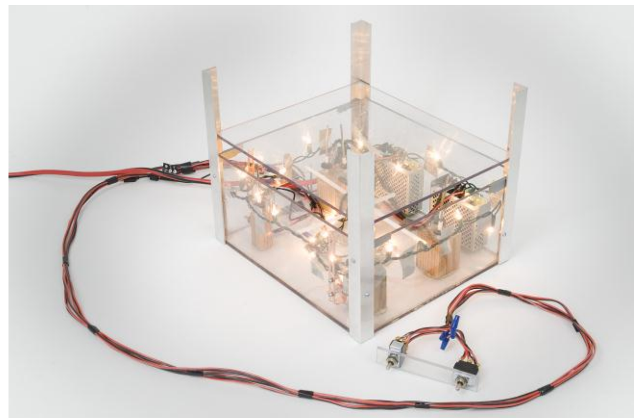

Fig. 8.23. Plantar foot self-inspection system.

SUMMARY OF IMPACT

This device will allow people an easier method to examine their plantar feet. This will increase observation of their feet, which will allow for prevention of the foot problem mentioned earlier. Overall, this will help to reduce the number of non-traumatic foot amputations.

This device will also be a benefit to medical personal in several ways which is a result of the need to be connected to a computer. The first method is the patient at home can complete a check of their foot and email the video and images of their self-examination to the doctor. The doctor can then examine the files and make recommendations. The second method is the doctor can use the device in his office to produce video documentation which can be used to track symptoms.

TECHNICAL DESCRIPTION

The Planter Foot Self Inspection System allows a patient to obtain video and pictures of the planter foot for self-inspection. It consists of a camera that looks at the bottom of a person's foot. This camera is then able to be moved in the x-y plane via a controller that is attached to the system. It is operated by placing either foot onto the top of the device and then moving the camera using the attached controller. The camera should automatically focus on your foot.

The outer shell of the device is a 12.5 inch wide, 14 inch long, and 8 inch high box that is made of ¼ inch Lexan. The camera that was used was a Logitech QuickCam Pro for Notebooks. The camera is connected to a pulley system that provides its movement. There was also a strain of 20 white mini Christmas lights that was added to enhance the lighting.

The motion is produced by two 12 VDC 30 RPM high torque gear motors. These motors will help move the camera up, down, left, and right. The motors and the pulley system can be seen in Figure 8.24. The motors are activated by moving either one of two toggle switches that are located on the controller the way you would like the camera to move. The camera can be seen in Figure 8.25. The power was provided by an AC to DC Transformer that had a 12 VDC output.

The approximate cost of this project was $350.

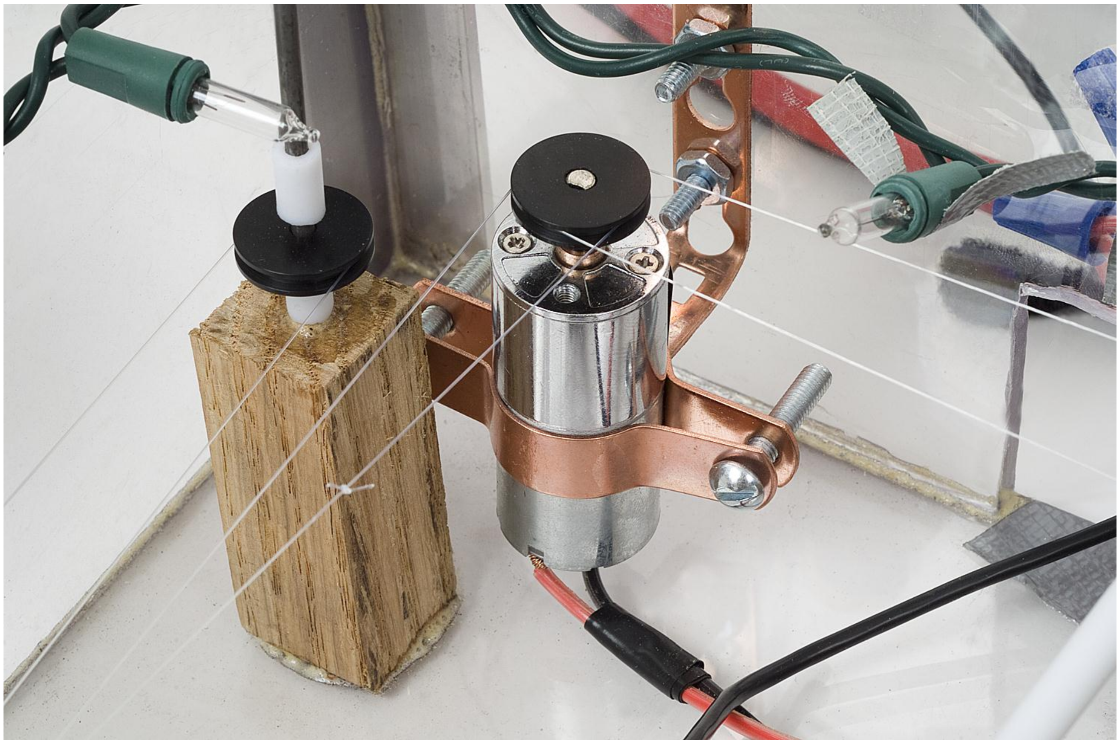

Fig. 8.24. Motors and pulley system.

Fig. 8.25. Camera.

SWIVEL SLIDE SHOWER CHAIR

Student Designers: Ryan M. Orzell and Ian Smith
Supervising Professor: Joseph C. Mollendorf
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INTRODUCTION

The Swivel-Slide Shower Chair is designed to assist the elderly, temporarily and/or permanently disabled in accessing the shower. It is a universally customized bath chair. This device allows for the seat to be displaced from the center and then swivel providing easier access to the shower/tub than other conventional bath chairs.

SUMMARY OF IMPACT

The device is highly adaptable fitting most conventional tubs. The Swivel-Slide Shower Chair is constructed from noncorrosive materials to assure minimal maintenance and a long product life.

This product has been designed to be a better alternative to transfer bench shower chairs and typical bath seats. It allows for greater ease while bathing.

TECHNICAL DESCRIPTION

The key design objective of the Swivel-Slide Shower Chair was to reduce the chance of an injury taking place while entering or exiting the shower or tub. At the same time we wanted to design a chair that allowed for greater mobility while bathing. It was fabricated to withstand a force of 400 pounds at the base and 300 pounds at the axle.

This light weight product is constructed in three major sections for easy storage and portability. The first section consists of the seat and bushing. The second section is composed of a lift arm assembly that is held in place with a spring loaded push pin. Both of these sections can be easily removed from the base, which is the final section.

The sections of the chair are dismantled with such ease that it is a major advantage over other standard transfer benches and shower chairs that do not disassemble as readily.

The seat is constructed from extremely resilient blow molded plastic. The anchor plate and axle, which

Fig. 8.26. Swivel slide shower chair.

not only house the bushing but also supply the rigidity to the movable portion of the product, are made from machined aluminum. The bushing is machined Teflon. This material was chosen over ball bearings because of its low friction characteristics without lubrication, its high durability, and the small likelihood of corrosion.

The base is made from lightweight aluminum tubing so that it can be effortlessly lifted and positioned as needed. The aluminum is also corrosive resistant, which is a highly favorable attribute for extended use in a partially submerged environment.

The seat slides which are made of galvanized steel allow the seat to glide easily from side to side. The lift arm attachment is connected to the slides. This placement permits it to travel with the seat and keep the arm in a position where it has little contact with the other items in or on the shower or tub. The bends in the arm keep it away from the individual once seated on the chair. The arm is centered when entering or exiting the seat and thus the torque on the assembly is minimized. This prevents any part of the product from lifting or moving.

The adjustability of the legs allows the chair to fit the height of several different sized tubs and each user's leg length. Additionally, the legs are fitted with high performance latex suction cups at the bottom to provide further stability to the chair.

The total cost of the project was $126.

Fig. 8.27. Shower chair turned and extended.

Fig. 8.28. Swivel chair slides.

REMOTE FAUCET ADJUSTER

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INTRODUCTION

People constantly use faucets without thinking about it. This device was created to assist people that have trouble using a faucet in its normal setup. People in a wheelchair or of short stature may have trouble reaching the controls of a normal faucet. Also, people who have arthritis may have trouble with a normal faucet. The remote faucet adjuster shown in Figure 8.29 is available to assist people in both of these situations.

SUMMARY OF IMPACT

The remote faucet adjuster will give people with disabilities the ability to sustain themselves without help from others. The remote allows people to adjust the faucet without having to reach the controls. The controls on the faucet are easy to adjust which allows people with arthritis to set the temperature and flow rate as they would like without causing them pain.

TECHNICAL DESCRIPTION

The remote faucet adjuster has two separate components. The main component is the faucet itself, which is attached to a normal faucet. The second piece of the remote faucet adjuster is the remote portion of the product.

The remote consists of a box made out of acrylic, the remote electronics, and the dials. The electronics for the system were taken from a remote control car. The case consists of a front plate of acrylic with two holes drilled in it for the dials, four clear walls cut from an acrylic sheet and then glued together and a back panel. The back plate is actually made of two pieces that interlock so that half of the back can be pulled off to replace the batteries. The two dials control the two handles. This allows the user to control the flow rate and temperature.

The base of the faucet is the part that actually controls the water. To build the faucet controller, a faucet was purchased and then partially

Fig. 8.29. Remote faucet adjuster.

disassembled. A box was build out of aluminum that holds the servos. When mounted, the countertop is located between the box and the top portion of the faucet. Crank arms replace the handles. There is one crank arm located on top of each valve. A rod from the servo to the crank arm allows the user to control the faucet. In addition to transferring the servo force to the valve, it also allows a normal person to use the use the faucet.

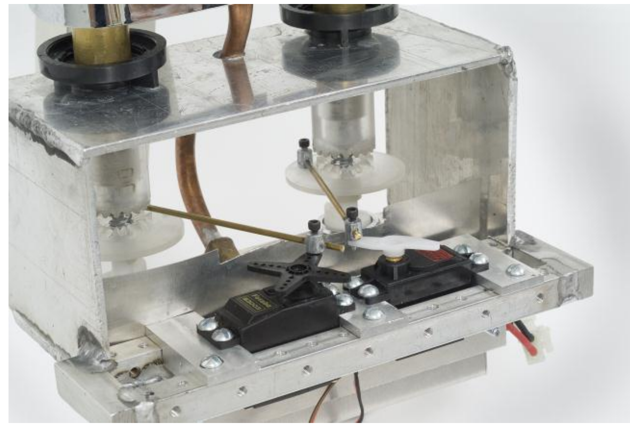

Fig. 8.30. Crank arm, handle shaft teeth, and electronic servos.

The handle engages and disengages the crank arm. This is done by having teeth on both the crank arm and the handle shaft, as shown in Figure 8.30. A spring located in the center disengages the teeth from each other there is. When someone uses the handles, they simply push down slightly and turn. There are brass pipes that connect the top faucet to the aluminum box. This brass pipe is adjustable to fit countertops of different thicknesses. Inside this pipe is a rod that connects the handles to the teeth that engage the crank arms. This rod is allowed to spin and move vertically. The servos are placed outside the aluminum box so that water has less of a chance of reaching them. The receiver was placed under the aluminum box for the same reason.

Fig. 8.31. Remote faucet adjuster.

For this build, batteries are used instead of using a wall outlet. For testing the faucet, which lasted a few hours, the batteries were never replaced. In production the remote would use batteries but not the faucet itself.

The total cost for this project was $125.

ONE TOUCH EASY OPEN DOOR

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INTRODUCTION

Disabilities, such as carpal tunnel and arthritis, have a great impact on a person's life at home. This makes it more difficult to use everyday objects and perform common functions, such as opening a door. The one touch easy open door is designed to attach to an existing interior door with some modifications. By simply pushing or pulling on one of the sensors it actuates the latch. This eliminates the grasping and rotating motion, which would cause pain and discomfort to people with the above disabilities.

SUMMARY OF IMPACT

This device, when implemented, allows the user to easily open interior doors in their home without assistance from another person. This is important because a person should not have to sacrifice privacy just because they have a disability. Being able to easily open doors to a bedroom or a bathroom restores privacy and mobility.

TECHNICAL DESCRIPTION

To use the device, special handles are used that sends a signal to the switches. This is accomplished by adding two devices to the exterior surfaces of the door. A grab handle with switches is installed on the inside of the door. This handle is U shaped. Located at the outmost portion of the handle are switches with an additional moveable surface, so that when pressure is applied to this surface, it activates the switches. This handle also gives a means for the user to apply forces to open the door. Secondly, a panel switch is placed on the outside of the door. This portion contains a base, switch, and moveable face. The base attaches directly to the door and houses the switching mechanism. Then, by pushing on the face, the switch activates. The final component is the internal electro-mechanical for opening the door. This includes an electrical to mechanical transducer, a timer circuit, as well as a power source. The timer circuit is intended to receive the activation signal from the switches on the exteriors of the door. It then activates the transducer through a relay so the latching mechanism, as well as the door knob is rotated to the open position, allowing for the door to be pulled or pushed open. The transducer holds the latch in the open position for a short duration to allow the user to enter/exit the room. This circuit is easily accomplished using a 555 timer IC, and a few other external components.

Fig. 8.32. One touch easy open door.

The power source consists of two 9 Volt batteries. The transducer for this prototype is a small direct current motor with a planetary gear system from a

Fig. 8.33. Grab handle and motors.

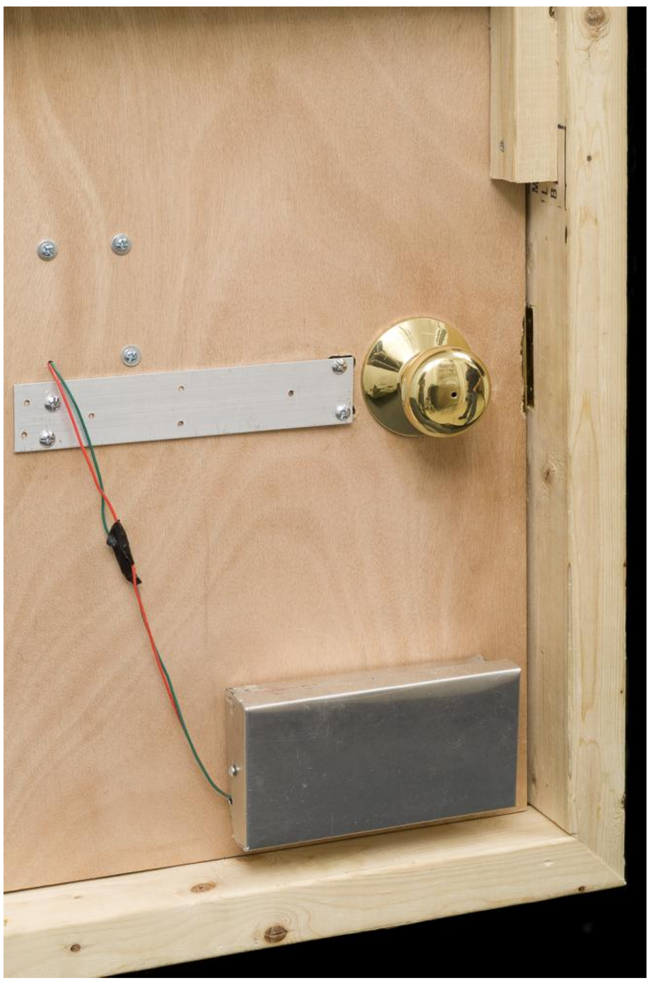

Fig. 8.34. Panel switch box.

small electric screwdriver. This is then coupled to the door knob via a bevel gear as well as three spur gears. The 555 timer is set up to hold the door in the latched position for approximately 10 seconds. A common reed relay is used to allow for a larger current be transmitted to the transducer.

The overall cost of this project was around $30.

MED-AIDE EZ-OPEN

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INTRODUCTION

The Med-Aide EZ-Open enables individuals to open medicine bottles. It was designed to allow someone, with weak hand strength, in particular someone with arthritis, to open child safe medicine bottles. People with arthritis find it hard to grip small bottle tops, push down, and twist all at the same time. The medicine in the bottles helps to relieve pain and discomfort caused by arthritis. If the individual cannot even open the bottles because of their disabilities, the medicine becomes useless. The aim of the Med-Aide EZ-Open is to give people the ability to easily open medicine bottles.

SUMMARY OF IMPACT

The Med-Aide EZ-Open gives someone of limited strength the ability to open medicine bottles. The Med-Aide EZ-Open turns the twisting motion into a much easier linear motion, and it has a large design, which makes holding it more comfortable.

TECHNICAL DESCRIPTION

The Med-Aide EZ-Open has a length of 20 inches and a main handle diameter of 1 ½ inches. The main handle is made of Polyvinyl chloride (PVC) tubing. The large diameter and lightweight PVC make the Med-Aide comfortable to use for people with arthritis.

The Med-Aide has the ability to open bottles with a lid diameter between 3 ¼ inches and ¾ of an inch. The Med-Aide has a conical shell design. This allows any diameter bottle lid to fit inside the limits previously stated. The conical shell is made of a plastic funnel. The funnel is lined with silicone rubber. The rubber lining is 1/16 of an inch thick. The silicon provides enough deformation so that the bottle lid can be gripped. The combination of the plastic funnel and silicon lining helps keep the device lightweight.

Fig. 8.35. The Med-Aide EZ-Open.

A bolt runs through the middle of the main handle and through its diameter. It connects the cone to the main handle. Inside the main handle, and attached to the bolt joining the cone, is a nylon gear. It has a 1 inch diameter. Next to the gear, and running parallel to the length of the main handle, is a nylon rack. The rack has the same pitch as the gear enabling them to engage smoothly. The rack is attached at one end of the main handle via a spring. The spring, in turn, is attached to a rubber stopper at the end of the main handle. The other end of the rack attaches to another piece of PVC tubing. This piece of tubing has a 1 ¼ inch diameter allowing it to slide in and out of the main handle. The end of this second piece of tubing has a 90 degree bend. This prevents it from sliding inside the main handle. Pulling this secondary handle outward pulls the rack over the gear. This turns the gear counterclockwise. Since the gear and the cone are on the same bolt, the cone rotates in the same direction. If a medicine bottle were underneath the cone, the lid would be spun and thus would be removable.

Just placing the medicine bottle on a countertop and using the Med-Aide in this fashion does remove lids. However, the bottle tends to spin at the same time and the top does not always spin off. In order to resolve this issue a sheet of the silicon used to line the funnel is placed under the medicine bottle. This provides enough friction and stability for successful removal of medicine bottle lids every time.

The total cost of the project was $30.

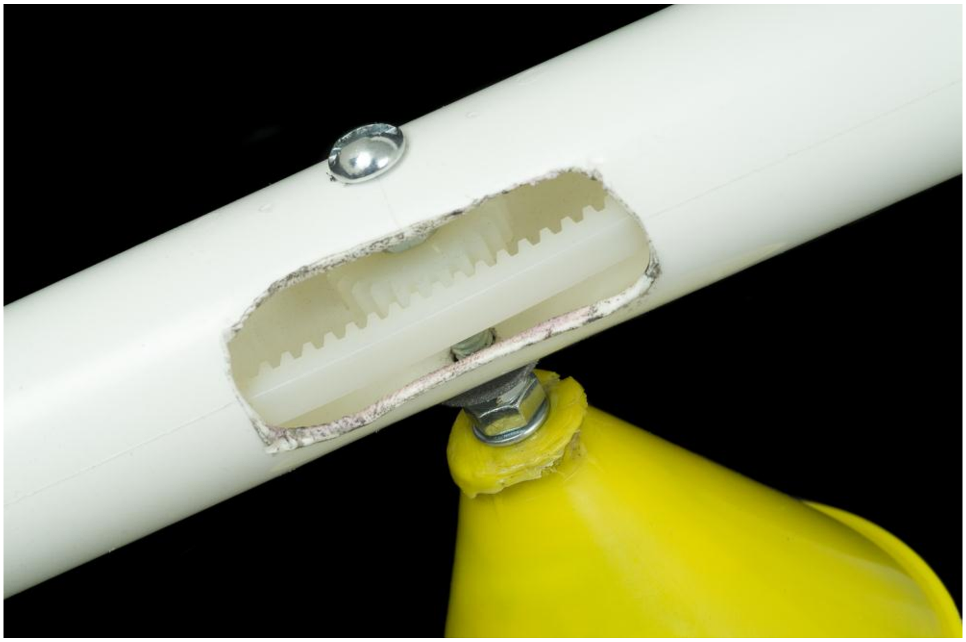

Fig. 8.36. Close up of gear assembly.

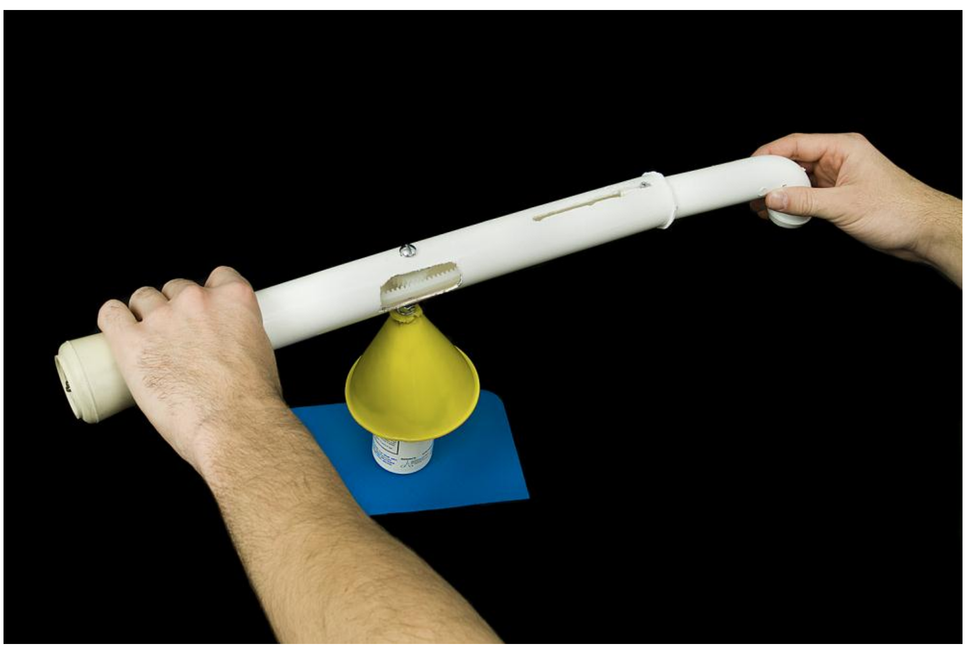

Fig. 8.37. Med-Aide Easy Open with bottle.

ASSISTIVE FEEDING DEVICE

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INTRODUCTION

There are individuals with mental or physical disabilities that have trouble feeding themselves. They rely on personal assistants for meal preparation and feeding. The assistive feeding device is designed to give the user independence to feed themselves, without relying completely on an assistant.

SUMMARY OF IMPACT

This portable, battery operated device, brings small and solid pieces of food to the user's mouth with the push of a button. When it is filled by an assistant, a user will simply have to approach the device and push a single button to use it.

TECHNICAL DESCRIPTION

This device uses two main components, a rotating Lazy Susan and a conveyor belt. The Lazy Susan rotates by using a rotating wheel attached at its base. The Lazy Susan has a 1" by 1" hole along its circumference. As it rotates, this hole aligns with the conveyor belt that sits directly below the holes. When the conveyor and the hole are aligned, one or more food pieces will fall onto the conveyor belt. The food pieces are then deposited onto a receptacle at the end of the conveyor. The upper part, the Lazy Susan, is angled during operation and lies flat on the base when being moved or stored. This device uses 4 AA batteries. The conveyor belt and the rotating wheel are made from plywood and parts salvaged from a toy tractor.

The total cost of this project was $50.

Fig. 8.38. The assistive feeding device

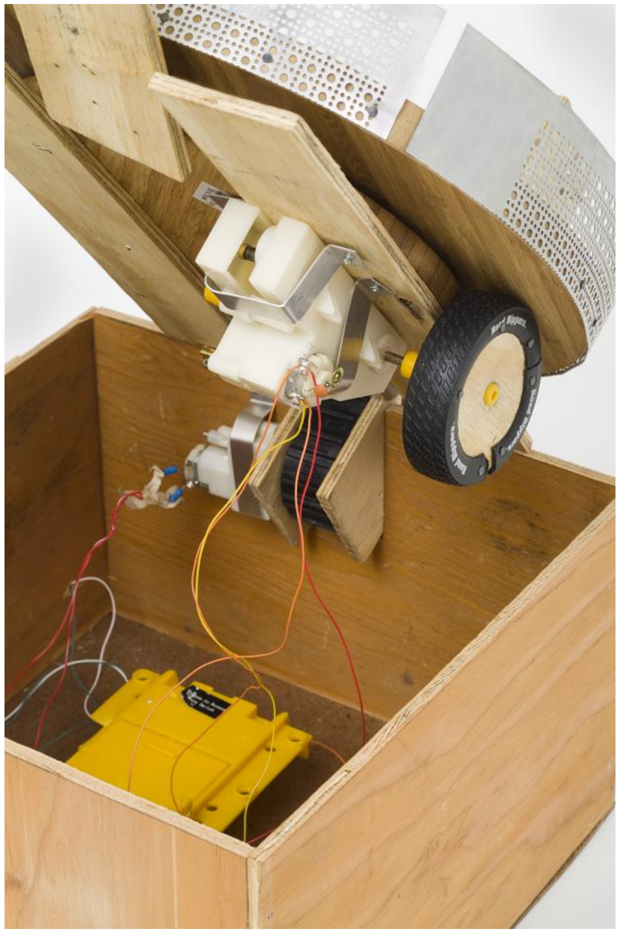

Fig. 8.39. The motor and method of rotating the Lazy Susan.

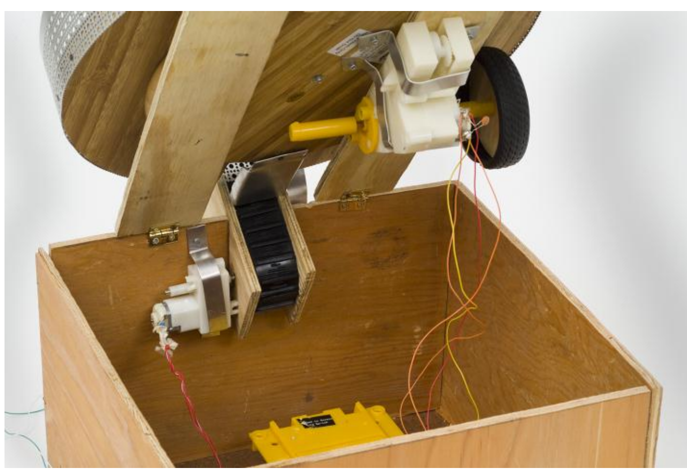

Fig. 8.40. The motor and conveyor belt.

OFF-ROAD WHEELCHAIR

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INTRODUCTION

The Off-Road Wheelchair is designed to cover rough terrains such as gravel, light snow, broken cement and dirt paths comfortably. This is an attendant propelled (requires a person to push) device for people who use a wheelchair. Standard wheelchairs have small front caster wheels and lack a suspension system which restricts the user's mobility. Other transportation devices have a high center of gravity and can easily tip over. The Off-Road Wheelchair addresses these issues by using 12 and 16 inch mountain bike tires, an individual wheel suspension system, and a lowered seat for stability. Additionally, the Off-Road Wheelchair is collapsible for easy transportation.

This device was designed to accommodate a specific client; if it were to be mass produced, specific components would need to be changed. These changes are noted throughout the report.

SUMMARY OF IMPACT

The Off-Road Wheelchair allows wheelchair users to participate in outdoor daily activities with ease; these activities may have been restricted due to lightly snow covered pathways, broken sidewalks, or lack of a solid, smooth path to travel on. It also allows wheelchair users to participate in recreational activities such as taking a ride through the woods.

TECHNICAL DESCRIPTION

The suspension system lays the foundation for the entire wheelchair. The left and right hand side are treated individually, but are identical in design. Each side has a central base which is made of 1-inch steel square tubing welded together. Square tubing is used for ease of manufacturing and to increase the strength of the welds that are used for the brackets. Square tubing is used for suspension components because it is easier to manufacture certain parts than with round tubing. Extending towards the front of the chair, from the lower front bracket, is a lever arm. This is attached to the bracket using a bolt and washer. This allows the arm to pivot.

Fig. 8.41. Off-road wheelchair.

The lever arm is welded to a wheel fork, which allows the front wheel to turn. For this preliminary design, the forks from two mountain bikes are used with slight adjustments. A steel bracket is welded to the fork to increase the trail of the wheel. This allows for easier turning of the wheelchair. If this were to be manufactured, the forks would be designed and built specific for the Off-Road Wheelchair.

Extending towards the back of the chair, from the lower back bracket, is another lever arm. This is attached in the same fashion as the front one. However, this lever arm is directly attached to the rear wheel.

For this preliminary design, both the front and rear wheels are from mountain bikes, and use the bolts and screws that are already attached to mount them to the wheelchair. If this were to be manufactured, machined wheels would be used to increase the strength and stability.

The front wheels are 12-inches in diameter. This size allows for wheel clearance when turning, and leg clearance when sitting. They are also large enough to overcome stepped objects. The rear wheels are 16-inches in diameter. This is also large enough to overcome stepped objects and to provide stability, but small enough for easy turning and maneuvering. The treads on the mountain bike wheels also help to increase control.

Each lever arm is connected to a 750 pound-force-per-inch bicycle shock. This shock is in turn, mounted to the central base. These mounting locations were chosen to maximize the cushion and travel of the spring. If this wheelchair is to be manufactured, a spring with a larger force-per-inch needs to be used to allow shock absorption for users of all sizes.

This suspension system allows for the free vertical movement of each wheel. This allows the Off-Road Wheelchair to overcome stepped objects with ease. The shocks absorb the forces from the terrain that provides a more comfortable ride for the user. Also, the wheelchair is designed to have a lower center of gravity, increasing the wheelchair's stability, while still maintaining better than average ground clearance.

The Off-Road Wheelchair uses a cross bar design for collapsibility. This design is similar to that found on manual wheelchairs. Two pieces of 1-inch square tubing are attached at the middle by a bolt and washers. This allows the cross beams to pivot with ease. The bottoms of these parts are welded perpendicularly to 1-inch steel round collars. This collar is bolted to the suspension base using brackets. This collar helps to increase the rigidity of the frame by preventing the two halves from twisting with respect to each other.

The top of the cross beams are welded to the seat rail. This is a piece of 1-inch round steel tubing. When the wheelchair is being used, these rails sit in steel catches. These catches are made from 1¼ inch steel round tubing cut in half, and welded to the suspension base. They are lined with padding which helps to absorb some force when opening the wheelchair. To help secure the seat rails into the catch, pins are used to hold the two together. If this device is to be manufactured, the catch needs to be designed to lock the seat rails in and would have a release mechanism when collapsing. Also, a four bar design should be used, instead of a simple cross-bar, to increase stability.

Riveted to the seat rail is the nylon seat. Nylon is used since it is lightweight, cheap, provides some give for shock absorption and it is waterproof. This is also used for the back of the seat, which is riveted to two pieces of 1-inch steel round tubing. This tubing is welded to the suspensions base and supports the back of the seat. The tops of these tubes have handles welded to them. The handles have rubber bicycle grips at either end. This is to allow the attendant to have a good hold on the wheelchair.

In order to allow the user to get in and out of the wheelchair easily, removable leg rests are used. Actual leg rests with calf pads from a manual wheelchair are used. New mounting joints are created out of steel and welded to the seat rail. When attached, the user's legs sticks out in front of them. The leg rests are adjustable so that they can range from 0 to 30 degrees below the horizontal. They are capable of going lower than this; however, they would interfere with the front wheels as they turn. This sitting position is similar to that of sitting in a lounge chair. It keeps the feet up and out of the way of stepped debris. The calf pads provide support for the legs so that the force is distributed over the entire leg, rather than just your feet. If this were to be manufactured, new leg rests should be designed. The calf pads on the current leg rests do not fold up out of the way. This should be changed, and the length of the leg rests should be adjustable to fit all users.

Arm rails are welded from 1-inch square steel tubing and attached to the suspension base. To provide comfort, they are wrapped in foam. If this were to be manufactured, there should be a cover over the foam and anchored down.

The wheelchair was spray painted to help prevent rust and for aesthetics. If this were to be manufactured, the parts would either be nickel plated or powder coated to ensure that the wheelchair would not rust.

The total cost of the Off-Road Wheelchair is $250, not including the donated leg rests.

Fig. 8.42. Suspension.

MOTORIZED WHEELCHAIR TABLET COMPUTER MOUNT

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Client: David Jauch
Client Coordinator: Kris D. Schindler
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INTRODUCTION

This project (shown in Figure 8.43) is designed to address a mounting need for a tablet style laptop computer. The computer allows someone without the ability to speak to communicate audibly through the use of talking software. The mount has an arm that allows the computer to rotate away from the user when the computer is not needed through the use of an electric motor. The motor is powered through the wheelchair's battery system, eliminating the need for an additional power source.

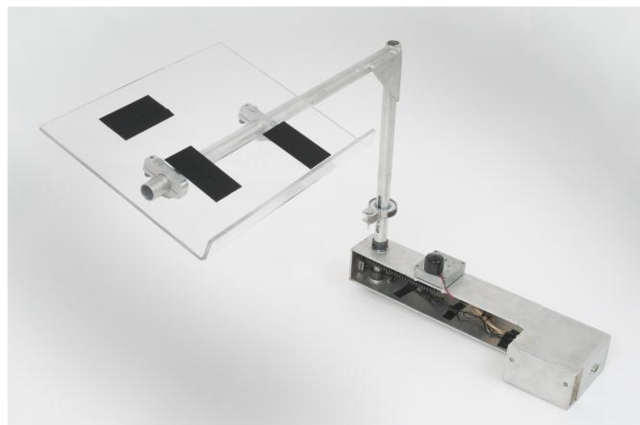

Fig. 8.43. Motorized wheelchair tablet computer mount.

SUMMARY OF IMPACT

This project was designed for a stroke patient with limited mobility and muscle strength in his arms. The present mounting systems available to mount his talking device are unsuitable for use because they all required manual force to move the device into position. The addition of a motor allows the patient to push a toggle switch and move the computer towards or away from himself without the assistance of an aide. This allows for increased independence, and having the computer easily accessible improves his communication.

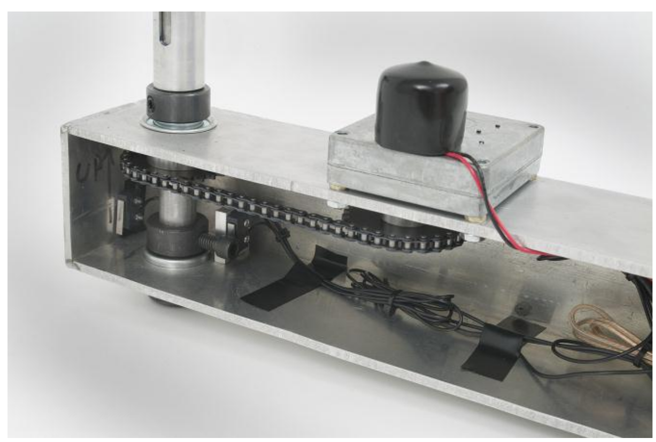

Fig. 8.44. Detail of the transmission setup for the arm.

TECHNICAL DESCRIPTION

The key components of the computer mount consist of an aluminum mounting base, an aluminum rotating arm, a motor, and an acrylic computer tray. The mounting base attaches to the wheelchair through the use of bolts and t-slot nuts installed in a channel on the right side of the wheelchair seat. The mounting base serves as a structural support for the rotating arm, and houses the motor, sprockets, and the chain connecting the motor to the rotating arm. The rotating arm is able to swivel approximately 180 degrees to allow the patient to be lifted from the wheelchair through the use of a vertical jack. Ball bearings installed in the mounting base ensure a smooth action. The arm is adjustable in height to allow a proper clearance between the armrest and the tray. The motor is a 12 volt DC geared type, with a speed of 1.5 RPM. This is linked to the rotating arm by two same sized sprockets and a chain. A detail of the transmission setup is shown in Figure 8.44.

The slow speed of the motor was chosen to keep the user and surrounding people from being hurt by the swinging arm. Limit switches mounted in the base, which are activated by a lever mounted on the arm shaft, prevent the arm from rotating too far in either direction. The toggle switch that actuates the motor is a double throw, momentary type to allow the motor to operate in both directions. The wiring from the switch and the battery to the mount is easily detachable from the base through the use of a serial port style connector. This allows for easy removal of the device without having to disconnect the wiring. The computer tray is made from bent acrylic, which can also be used to hold books, papers, and other items for convenience. The computer is held to the tray with self-adhesive hook and loop fasteners so that it does not fall off when the wheelchair is driven. To provide additional support and decrease deflections of the rotating arm while in use, a bracket containing a ball bearing attaches to the existing tray on the wheelchair and surrounds the arm.

The total cost of the project was $175.

Fig. 8.45. Mount attached to wheelchair.

Fig. 8.46. Tablet mount swiveled out of the way of the user.

ASSISTIVE TENNIS BALL LAUNCHER

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INTRODUCTION

The assistive tennis ball thrower is used to help wheelchair confined children, with limited hand movements, throw a ball with the pull of a lever. This device is designed to fit most wheelchairs on the arm and to accommodate both left and right handed children.

SUMMARY OF IMPACT

The intent of this device is to allow children with disabilities participate in outdoor activities with other children. Children love this device and find it very entertaining as they are now able to engage in outdoor activity with the other children. The glossy colors and designs on the device grab the attention of any child as they enjoy the look and functionality of the tennis ball launcher.

Along with using the device for playing with other children, the child can also use the assistive ball launcher to play with "catch" with their dog as well.

TECHNICAL DESCRIPTION

The device was designed with a strictly mechanical perspective, with no electronics. The concept is simple, yet, very effective. Following the release mechanism of a pinball machine, the assistive ball thrower is a spring loaded shaft attached to a smooth handle. The device is a 3'' diameter, 16'' length, plastic tube attachment to a wheelchair. Within the tube is a spring loaded apparatus that operates to push a ball out of the tube. The spring loaded apparatus consists of: spring, steel rod, two aluminum disks and a handle.

The spring is compressed against one of the aluminum disks that are bolted to the tube on top and bottom. A steel rod, with both ends threaded, lies in the center of both disks; one side of the rod is

Fig. 8.47. Assistive tennis ball launcher.

attached to an aluminum disk which moves within the tube, freely and pushes the ball out of the tube. Attached to the other end of the rod is a smooth, transparent plastic handle which is pulled back. Once the handle is pulled back, the spring is compressed and loaded. Then, once the spring is released the ball is launched. While there does exist devices such as these on the market, the uniqueness of this device is the attachment to a wheelchair. The attachment is on the side of the wheelchair, near the armrest, allowing clearance for operating the wheel and resting of the arm. The tube is held within a "horseshoe" clamp which is bolted to one of two "sandwich" plates and rest on top of a horizontal bar. One side of the clamp attaches a bar near the armrest of the wheelchair to the horizontal bar. The other side of the "horseshoe" clamp bolts the tube to the other side of the horizontal bar such that the horizontal bar provides a launching pad for the device.

The total cost of this project was $30.

Fig. 8.48. Tennis ball launcher mounted to a wheelchair.

GUITAR ASSISTIVE DEVICE

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INTRODUCTION

The goal of the guitar assistive device, shown in Figure 8.49, is to provide a user with little or no fine motor control, or mildly impaired gross motor skills, a device to assist them in playing guitar. More specifically, the user is able to play commonly used chords so that the user would have a large variety of music to choose from. The two major distinguishing factors of the device include the power chord shape and the easy-to-use handle. The device also allows for the power chord shape to be modified to another shape, for example a minor chord or a seventh chord.

Fig. 8.49. Guitar assistive device.

Fig. 8.50. Assistive device in power chord shape.

SUMMARY OF IMPACT

Adaptive equipment for the person with disabilities has traditionally encompassed basic living needs, such as mobility, activities of daily living, and other practical activities. These individuals, however, are limited in their ability to participate in the arts and other forms of entertainment. It is only recently that technology began to address these issues. This device creates a new avenue, whereby a person with disabilities is able to actively engage in the display of fine arts.

This device addresses psychological and spiritual needs by creating an avenue for a disabled individual to express themselves through music. An individual with a disability, such as cerebral palsy or mental disabilities has decreased fine and gross motors skills; however, they often have emotional and spiritual needs that remain unmet. Music has proven to be vital in opening up avenues of expression. Allowing an individual to create music has a huge impact by improving their quality of life.

TECHNICAL DESCRIPTION

There are three major parts of the design. The mask in the front holds the positioning of the rubber used to hold down the strings. It is displayed in Figure 8.50 in a power chord shape, but allows for variant configurations.

The second part is the back brace and springs. The springs were originally designed as stiff bars. The reason it was modified is because too much strength was required to slide the device up and down the neck. The spring design allows some give, yet it retains a tight enough fit not to dampen the vibrations on the string. The back brace axis contains a rubber piece that is shaped to the neck of the guitar. Ideally, this piece should be larger to allow for better tracking on the neck of the guitar. Also, a desirable modification to the design is to put tracking rollers inside the springs to keep the mask from coming off-center.

The third major part of the device is the handle. This handle is designed to be easily held by someone with low grip strength. It ideally has a cylindrical cushion with a 1.5 inch diameter around the handle for easier gripping. It is wide enough so that most people should have no problem fitting their hand inside the handle.

When tested a total of 11 unique chords were able to be played including: E, E#/F, F#/Gb, G, G#/Ab, A, A#/Bb, B/Cb, B#/C, C#/Db, and D. Songs such as "Promises" by Eric Clapton or "Smoke on the Water" by Deep Purple can be played using only the aforementioned chords.

To get the device on the guitar, a screw is removed on one end of the back brace axis and the end of the spring is slid off. The device is then placed around the neck of the guitar and the spring is stretched and put back on the back brace axis. The screw is replaced and the mask is positioned properly on the strings. This process requires some help with the installation.

Most of the parts are machined from stainless steel or aluminum, depending on strength requirements. For example, the whole handle is aluminum to minimize weight but the back brace axis is stainless steel to maximize strength. There are 4 rubber pieces which are the sole points of contact between the device and the guitar. This helps to minimize wear on the guitar.

The total cost of the project was about $30.

Fig. 8.51. The guitar assistive device attached to a guitar.

HEIGHT ADJUSTING CHILD BATH SEAT

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Client Coordinator: Rose Godwin
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INTRODUCTION

The Height Adjusting Child Bath Seat was designed for children with little or no muscle control. The purpose of the seat is to provide a support system for the child in order to make it easier for the parent/caregiver to bathe them. The height adjusting aspect allows the parent/caregiver to raise the seat, set the child down, lower it into the tub, bathe them and raise it back up when finished. The ability to raise and lower the seat acts as a preventative measure to reduce back and muscle injuries, a common result of repetitive lifting for the parent/caregiver.

The seat also helps keep the child a safe distance away from the water, preventing the possibility of water getting into their eyes, nose, or mouth. It allows the bath to be given by one person, eliminating the need to have one person support the child's body safely while the other gives them the bath. Reducing the efforts of one person allows for a more stress free environment, and in the case where the child is in a group home, it allows caregivers to take on other responsibilities.

Fig. 8.52. Height adjusting child bath seat.

SUMMARY OF IMPACT

Taking care of a child with little or no muscle control is very physically demanding. It often requires heavy lifting, low to the ground movements and severe strain on the upper and lower back. This bath seat tackles each of these problems. The height adjusting feature prevents the parent/caregiver from overextending their back from reaching over the edge of a bath tub. It also promotes correct lifting procedures by avoiding low to the ground movement.

The seat alone provides a secure and more comfortable place for the child to sit, as opposed to sitting on the hard bottom of a bath tub. It will help to release pressure that may have previously existed on the spine or neck from the lack of support. It also prevents the child from sliding in the tub and keeps their head in an upright position. It makes daily tasks go by faster, and with much more ease and convenience for both the child and parent/caregiver.

TECHNICAL DESCRIPTION

The child bath seat was designed to hold children weighing from 30 to 100 pounds. At its lowest position, the seat is approximately 10 inches off the ground and when fully extended can reach a height of 16 inches. This height could be made larger by adjusting the cylinder lengths. It can be operated by one person using a foot pump to pump it up and a simple shut-off valve to release the pressure and lower it down into the bath tub.

The bath seat is made of a PVC pipe frame with a strong mesh material. Attached via PVC reducers are four air cylinders also made of PVC piping. PVC piping is chosen because it is readily available and had a relatively low cost. It is also chosen due to the fact that the chair needed to be able to withstand a very wet environment, with varying temperature ranges. Also, sharp edges are eliminated that could have been a potential danger to the child.

There are two cylinders under the leg portion of the chair (the front cylinders) and two cylinders under the back portion of the chair (the back cylinders). The inside pipes to the cylinder are cemented at one end to the reducer which comes off of the frame via a tee and are sealed at the other end. This piece has an O-ring groove and O-ring near the sealed end. The outside pipes of the cylinder, made of the next larger size PVC than the inside pipes, are open at one end where they slide over the inside pipe and capped off at the other end.

The pipes are cut to a specific length so that when in the lowest position, the outside pipes are in contact with the reducers, leaving about a one inch high area inside to be pressurized. In order to get air into these areas, small holes were drilled and tapped into each cylinder. With the use of barbed connections and check valves, hoses are connected to all four cylinders. The hose is then connected to two bicycle foot pumps (the air source), attached together by a piece of wood, for simultaneous pumping. One pump provides air to the back cylinders and the other pump provides air to the front cylinders.

This system does not have to be powered using foot pumps. An electric pump is a viable option; however, it must be kept a safe distance away from the water. Another power source could have even been the water coming out of the faucet. The water could have been channeled into the frame to raise the chair with the use of water pressure.

Equal pressurization of the tubes was somewhat difficult to achieve. At first, there was only one pump that controlled the air input to all four cylinders. However, the back cylinders need to be made larger to support more weight. After sewing the material to the frame, the actual seat portion was slightly closer to the front cylinders, thus the center of gravity of the chair had changed, putting more weight acting on the front cylinders. This caused the cylinders to rise at different rates. This was the main reason for adding another pump so that the front and back cylinders were controlled separately.

Stability was also an issue with the chair. The chair originally only had barbed connections, and no check valves. If for some reason the chair went down on one side, the air pressure would just be transferred to another tube allowing the instability. This was the main reason for the check valves to be added to the system. This allowed air to enter into each cylinder separately and not transfer into the other cylinders.

The air exits through another set of check valves which are connected by hose to a single shut-off valve. The user can simply reach down and open the valve to release the pressure in the system and close it again when they want to pump it back up. It is important to note that the springs inside of the check valves are adjustable for persons of various weights to ensure that the chair descends in a uniform motion.

Another way to address the stability issue was the addition of braces that connected the cylinders. This meant that if one cylinder went up, then the other cylinder goes up as well. The braces are made from donated aluminum tubing. A more child-friendly and water resistant material could be used.

Holes just matching the outside diameter of the cylinders were put in the aluminum tubing, allowing it to slide over the cylinders with a tight fit. These braces connected the two front cylinders and the two back cylinders together. This greatly helped the stability of the system. Another addition is to connect the front and back braces via a strip of tubing down the middle.

A somewhat difficult task was to find the exact correct size for the O-rings that went inside the cylinders. This normally is a simple task; however, the insides of PVC pipes are not exactly smooth, making it difficult to create a good seal. The cheapest solution was to use a honing tool to take out small imperfections and use the O-rings. A more efficient solution might be to find prefabricated cylinders that are water resistant.

The last part of the seat is the safety strap that provides extra support to the upper half of the body. Here, an elastic band is sewn with Velcro on each end that stretches around the frame and the child. The strap is not sewn to the frame so that it is easily adjusted to the specific height of each user. It is also desirable to have additional head support and safety straps to go around the legs as well.

The total cost of this project was $110, not including the cost of the check valves or strips of aluminum tubing, which were donated.

Fig. 8.53. Child seat with a child in it and raised.

BOTTOM PANTRY CUPBOARD WITH ROTATING SHELVES INSERT

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INTRODUCTION

The purpose of this product is to make items commonly found in a pantry cupboard more accessible to someone in a wheel chair or with limited mobility. Often, people with such restrictions find it difficult to retrieve items in the back of a cupboard, or have trouble bending down to the level of the cupboard; this limits the usable overall area of the cupboard.

SUMMARY OF IMPACT

The bottom pantry cupboard with rotating shelves insert mitigates the problem of accessibility by rotating the items around inside of the cupboard and bringing them to the user, rather than the user having to reach for them. Other important features of this product are its ability to be inserted into a preexisting cupboard, its simple operation, and its ability to operate even when loaded improperly.

TECHNICAL DESCRIPTION

The Bottom Pantry Cupboard with Rotating Shelves Insert was designed to fit most standard residential cabinetry. The dimensions for the insert are 25″ x 25″ x 32″

These dimensions comprise the main exterior of the product and allow the entire insert to slip inside a conventional bottom cupboard with only a few modifications.

The Bottom Pantry Cupboard Insert is separated into two general compartments. The top compartment is where the shelves are located. The bottom compartment, which is just 6″ high, holds the motor and electrical components.

The products that the user puts in the cupboard sit on 4 shelves. Each shelf has a usable area of 6.5″ x 17″. These shelves are suspended beneath a cross rod. This arrangement allows the shelves to freely

Fig. 8.54. Bottom pantry cupboard.

rotate on the cross rod as both the shelves and the cross rod rotate around a center axis. This configuration keeps the shelves always level so the product placed on them does not move as the shelves are rotating.

The cross rods are connected to two hubs on each side. Each of these hubs are interconnected and then connected again to a center hub that is welded to the center axis. This is the center of rotation. The center axis sits 15.5″ from the bottom of this compartment. It is supported by two triangular supports that have center hubs, which contain brass bushings as to allow the center rod to rotate freely inside of them. One end of the center rod has a sprocket attached by spring pins. This sprocket, when combined with the chain and motor, make up the drive system for this device.

The motor, which is housed in the lower motor compartment, is bolted to the exterior frame using counter-sunk 5/8″ carriage bolts. The motor is a 90V DC motor with 250 in-lbs. of torque. This motor consists of a worm gear transmission that gears down the speed of the motor to 3 rpms. The motor is connected via a 400 Volt 4 Amp bridge rectifier to a moment push button switch. This switch activates the motor when the user pushes it, and stops the motor when the user releases it. The switch and motor are connected to a fuse and then to a conventional 120 Volt three prong outlet.

This design has been tested and has performed well in both balanced and unbalanced loading conditions, as well as maximum loading conditions.

It has been determined that for the best operation of the rotational system, the shelves should always be loaded as evenly as possible. Also, no more than 15 lbs. should be placed on one single shelf at any given time.

Total cost of this project was $170.00.

Fig. 8.55. Shelves loaded with items.

AN INEXPENSIVE RECLINABLE WHEELCHAIR

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INTRODUCTION

The Inexpensive Reclinable Wheelchair enables persons with disabilities to have a relaxing experience in their own wheelchairs. This design allows people to recline the back of the wheelchair and move into a more comfortable position. The current models are expensive and putting the reclining position is done by someone other than the person using the wheelchair. Here, an existing wheelchair is modified so that it is reclinable. The Inexpensive Reclinable Wheelchair consists of incremental position hinges (turned into free moving hinges), gas springs, metal tubes (some with predrilled holes, some without), snap buttons, an aluminum bar, and anti-tippers. Using these items, any regular wheelchair can be modified to not only allow the user to be more comfortable but to also do the reclining themselves.

SUMMARY OF IMPACT

Two main concerns of the Inexpensive Reclinable Wheelchair are to make comfort more affordable and to help persons with disabilities avoid the associated health risks that come from spending long periods of time in a wheelchair. Current models of reclinable wheelchairs cost anywhere from four hundred dollars to one thousand dollars. The second concern is the health risks. Most people cannot sit in one spot very long and being unable to shift position makes it that much more uncomfortable. Using a reclinable wheelchair alleviates the uncomfortable factor, aides in avoiding bed sores and helps circulation.

TECHNICAL DESCRIPTION

The largest component of the Inexpensive Reclinable Wheelchair is the wheelchair. Modifications made to the frame allow the user to adjust the back of the seat. One of these modifications is the addition of hinges to the wheelchair frame. As mentioned above, the incremental position hinges are turned into free moving hinges by removing the springs inside that allows a smoother recline. Also the

Fig. 8.56. Reclinable wheelchair in the upright position.

Fig. 8.57. Reclinable wheelchair in reclined position.

wheelchair's frame is cut apart and the hinges are placed over the end of the now open tubing. Once that is done, the hinge arms are bolted onto the frame.

The next modification is the addition of gas springs. These help control the speed of reclining. They are bolted onto the back of the wheelchair frame and to the anti-tippers. The anti-tippers function as a safety feature to prevent the wheelchair from tipping

Fig. 8.58. Position control tubes.

Fig. 8.59. Anti-tippers and back of the wheelchair.

backwards. Steel tubes are added to the end of the anti-tippers to ensure that the ability of the wheelchair to tip backwards is minimal (an inch or two at most). Another safety feature is the aluminum bar added to the back of the wheelchair near the handles to ensure that the back of the seat stays rigid enough to prevent buckling but not too rigid as to be uncomfortable.

After adding these items, the last modification is the addition of walker legs that contain predrilled holes and some steel tubes. The steel tubes are placed inside the walker legs and the snap buttons inside of those tubes. The entire assembly is then bolted to the side of the arm rests and the side of the back part of the wheelchair seat. Pressing the snap buttons down allows the user to push back on the wheelchair's back and move through all the predrilled holes (this creates an incremental recline).

The total cost of the design was $271.40.

TOURING TRICYCLE

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INTRODUCTION

Many people do not have the ability to use their legs have a restricted number of exercise options available to them, and even fewer choices in the sport of cycling. Of the options that are available, many follow the conventional hand-crank design and lack the superior maneuverability that exists in many mountain bikes. The goal of the Touring Tricycle, as shown in Figure 8.60, is to provide a fun and unique approach to traditional cycling for persons with disabilities, along with a dual suspension for additional riding comfort.

SUMMARY OF IMPACT

Once in the tricycle, the bike moves forward by pushing and pulling on two lever arms. This allows the person to engage in physical outdoor activity while enjoying a sense of independence. The main muscles worked include the biceps, triceps, chest, shoulder, and core muscles. The dual suspension of the bike also allows the rider to ride on rougher terrain than other human powered vehicles in its class.

Fig. 8.60. Touring tricycle.

TECHNICAL DESCRIPTION

There are three major components that allow the Touring Tricycle to move forward: the lever arms, steering system, and brakes. All these systems are designed around a dual suspension mountain bike frame.

The lever arms are the source of propulsion of the bike and take the place of an individual's use of legs. The lever arms rotate about an axle that extends through the frame of the bike, just in front of the seat through the use of ball bearings. The arms extend down below the axis of rotation and connect by way of a steel pin to another metal bar that attaches to the front sprocket of the tricycle as seen in Figure 8.61.

Ball bearings surround the connecting pins to provide for smooth movement in both the pushing and pulling directions of the arms. A simple fixed gear chain is used to help propel the tricycle as well.

The second major technical component of the Touring Tricycle is the steering assembly. Steering the bike is done by a system of conventional brake cables with housings that are typically used on most two wheeled bicycles. A throttle tube is placed on the top of each lever arms where the hands would be placed so that it is free to rotate by use of the wrists. One end of the cable secures into the throttle tube and the other end crosses the frame of bike and wraps around an aluminum steering disk before the cable is clamped to the front of the disk as shown in Figure 8.62. With this setup, rotating the right wrist inward turns the bike to the left, and rotating the left wrist inward turns the bike to the right.

Sufficient slack is given on the cables to allow for free movement in the full forward and back positions of the lever arms. The steering disk is an aluminum circular plate that clamps around the steering column of the bike to help guide the tricycle either way.

Fig. 8.61. Lever arm assembly.

Fig. 8.62. Steering disk with cables.

Keeping the cables taut is imperative to the proper operation of the bike. To make sure this always occurs; one cable tensioner for each lever arm is installed adjacent to the throttle tube handles as shown in Figure 8.63. The tensioner is a simple mechanism that holds the cable housing in place while providing overall adjustability by allowing the rider to tighten a screw that pulls the cable tighter if need be. A metal plate with two tapped holes secure the cable housing directly in back of the steering disk to keep the other end of the cable system taut as well.

The last major component of the device is the braking system. This system uses the existing brake handle from a mountain bike mounted on the right lever arm so that at any time, the user can grab it immediately without moving their hand away from their steering responsibilities. The brakes themselves are mounted on the front wheel of the bike. The fixed gear feature of the bike also provides a means of braking. By simply switching the direction of movement of the arms, the bike shifts its momentum in the opposite direction and brings the tricycle to a halt.

Some other details help make the bike more ergonomically pleasing to the user. A fully supported seat with side panels secures the user to provide maximum comfort and stability. To ease the user entering and exiting the device, the left lever arm can be removed by pushing in a push pin button and replaced in the same manner. Also, leg straps attach to the side of the seat so that a person may secure his/her legs by placing them over the lever arm axle and pulling the ankles backward to be secured in the leg straps, as shown in the overall view of the bike with user in position (Figure 8.64).

The total cost of the project is $172. It should be noted that the bike frame, seat, front wheel, and brake handle were all donated.

Fig. 8.63. Brake handle and cable tensioner.

Fig. 8.64. Overall view of the touring tricycle with rider.

FISHING ROD FOREARM SUPPORT

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INTRODUCTION

The fishing rod forearm support is designed to aid people suffering from Carpal Tunnel Syndrome. Traditionally while fishing, the forces endured from the use of a fishing rod are resisted by the hand and forearm muscles. This support transfers the force from the hand and forearm to the elbow and shoulder. The user simply fits their hand and forearm into the support and secures the strap over the forearm.

SUMMARY OF IMPACT

This device redistributes the forces associated with fishing from the hand and forearm, to the elbow and shoulder. The result is less pain and irritation, more control over the fishing rod, and a longer fishing experience due to less fatigue.

TECHNICAL DESCRIPTION

Two prototypes were made, one from aluminum sheet metal and one from carbon fiber for weight reduction. Both prototypes are identical in form and function, the only difference is that connections with the aluminum prototype were welded, and the carbon fiber prototype was glued.

The device consists of three main sections. The first section is the one that the fishing rod lays in. It is created from cutting a 1.375 inch tube in half-length wise. A section of pipe insulation foam is then cut and glued inside of the section to protect the cork on a fishing rod from damage.

The second section is the one that the forearm rests in. It is a 4 inch inner diameter section of rolled aluminum sheet metal. This section for the aluminum prototype is also used as a mold to wet lay the section for the carbon fiber prototype. The wet lay is done by impregnating layers of bidirectional twill carbon fiber fabric in the mold with epoxy. This section is covered with ¼ inch thick foam padding to provide comfort.

Fig. 8.65. Fishing rod forearm support attached to a fishing rod.

Fig. 8.66. Fishing rod support in use.

The last section is a ½ inch inner diameter tube that is connected perpendicular to the first section. The purpose of this tube is to provide structural support between the first and second sections. The tube is milled or "fish mouthed" at one end to the outer radius of the first section. This enables a proper weld or glue joint. The other end of the tube is cut to the angle of the second section which also enables a proper weld or glue joint.

Lastly an elastic strap is riveted on to hold the forearm into the support and attached with Velcro to the other side. Rivets also attach hose clamps that hold the rod into the device.

The cost of this device was $120.

Fig. 8.67. Rod forearm support without a fishing rod.

Fig. 8.68. Fishing rod forearm support.

ARM-MOUNTED CARRY ASSISTANT

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INTRODUCTION

The reason for designing and building this project is to make an individual's arm a useable platform if they lack adequate upper body strength or have lost use of an arm due to a stroke. A key feature to this design is that much of the weight of carried items is transferred to the hips and shoulders, allowing the equipped arm to exert little or no effort.

SUMMARY OF IMPACT

For an individual who has lost use of an arm resulting from a stroke, this device provides support for their weak arm. It does so by using the disabled arm as a foundation for the system, allowing them to carry items instead of performing all tasks with the strong arm. It has been found that many stroke patients tend to tuck their weak arm close to their body. By providing the arm with a task or function and requiring it to be moved away from the body, the system provides some therapeutic value to the patient.

TECHNICAL DESCRIPTION

The arm-mounted carry assistant consists of a cuff made out of Schedule-40 PVC for durability, which envelopes the patient's forearm and continues up the back of the elbow. It is split into semicircles and hinged on one side, allowing it to be easily equipped. The inside of the cuff has been lined with soft foam for comfort. The prototype has been equipped with a pair of steel hooks allowing the user to carry various items such as grocery bags, buckets or baskets, etc. If a load is too great, it may result in a large moment because the mass of the carried item is located away from the elbow. If this occurs, the hook attachment may be reversed by unscrewing the pair of wing nuts from the ¼"-20 x 1" carriage bolts and rotating the piece 180°, thus situating the load closer to the elbow. For production purposes, the product offers numerous attachments for a variety of situations that arise where a pair of hooks is not the best tool.

Fig. 8.69. Arm-mounted carry assistant.

Fig. 8.70. Arm mount with hooks.

The arm is not supposed to support the majority of the load; therefore the device has been designed to transfer it to the user's shoulders and hips. The patient wears a support belt that aids the load distribution. A strap from the opposite shoulder goes through a loop on the cuff to bear some of the load on the shoulder and also prevents the arm from swinging to the outside of the body under the weight. A female end located on the hip of the belt mates with a male feature found near the elbow on the cuff disbursing some of the weight to the hips. This feature also provides control of the arm, preventing it from moving aimlessly. There is also a post that goes from the cuff to the stomach of the belt to prevent the arm from swinging inwards.

Velcro is chosen as the closing feature for the cuff because it is simple, requires little effort as compared to a complex locking mechanism. With a load applied, it is highly unlikely that the Velcro will release because it has been applied over a radius. This means that when there is a force pulling downwards on the sleeve, the Velcro straps are being pulled in various directions over the top of the cuff rather than in one direction.

Fig. 8.71. The carry assistant attached to the body.

Fig. 8.72. The carry assistant in use.

SPRING LOADED, EXTENDING COUNTERTOP

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INTRODUCTION

Often times, the reach of those who are confined to wheel chairs or use walkers is limited when approaching a counter top because of the protrusion of their assistive equipment in front of them. The goal of this project is to create a mechanical system which allows for the extension of a counter top with relative ease to provide those individuals described above more working space in kitchens, bathrooms and any other areas in the house where counter tops are used.

SUMMARY OF IMPACT

This project utilizes compressed spring tension and a locking mechanism to propel the extending countertop section outward for the initial 3 inches of movement, allowing for easy access to the extending section by providing a large area for gripping during the full extension. It allows people to increase their productivity and greater organization while performing tasks that require countertop space.

TECHNICAL DESCRIPTION

This system utilizes 3 sub-systems in its operation.

The first subsystem is a pair of sliding rails on which the countertop slides. The rails are mounted to the sides of a section of counter top that is selected for extension (of any width, and with sliding rails of varying lengths as per the customer's wishes), and is connected to the sections of countertop which are to remain stationary; thus, creating an extendible working surface area.

The second subsystem is a spring located to the rear of the extending section. This spring is anchored to the wall, and when the counter is in the retracted position, the spring is compressed between the counter top and wall. There is a guide rail in place within the inner diameter of the spring in order to prevent the spring from bending out of position when a compressive force is applied to it. The guide rail inserts into a hole drilled horizontally into the extending section, as to not hinder the movement of the counter top inward and outward.

Fig. 8.73. Extending countertop retracted.

The third and most complex subsystem is a locking mechanism that prevents the counter top from extending when not in use. The lock is positioned at the front of the counter on the stationary section lock. The main body of the locking mechanism consists of a rectangular block of aluminum, with a square pocket milled on one side, and a handle mounted to the top. A square wedge (similar to a door knob wedge) is placed in the pocket of the main body. The purpose of this wedge is to protrude from the main body to intersect a striker plate that is in place on the sliding section when in the retracted position, thus preventing the extension of the countertop due to the spring. On the side of the body/wedge assembly is a plate anchored to the stationary counter, preventing the wedge from falling out of the body, and with a slanted cut on one side, contacts the wedge during retraction of the lock, sending the wedge into the body, and freeing the counter top to extend. The wedge is then forced back to the out position via a compression spring positioned between the wedge and the inner wall of the pocket, so that when the counter top is pushed back to the retracted position, the wedge will once again contact the striker plate and hold the countertop in position.

Essentially all that is required for operation of the countertop from the user is a pulling motion of the handle. This moves the locking mechanism forward about one inch, allowing for the countertop to be extended out via spring tension for the first 3 inches of extension. The user then pulls the countertop out the rest of the way, allowing them to use the space more effectively.

Thanks to many donations, the cost of the project was under 30 dollars.

Fig. 8.74. Extending countertop extended.

THE ASSIST IN STANDING CAR SEAT

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INTRODUCTION

The Assist in Standing Car Seat is created for those who have trouble exiting an automobile. Most automobiles are designed to cause as little wind resistance as possible. This means that when manufacturers are designing cars, they try to make them sit as very low to the ground. When the cars are made to sit low, it creates a very low entry and exit point for people. It is this point that causes many problems for people when they try to exit.

SUMMARY OF IMPACT

This device allows a person with a disability who owns a vehicle easier exit. If they already own a car that is too low to the ground, the seat provides an alternative choice to buying a new car. Since the seat has replaceable installation rails, the seat can be swapped in and out of cars as the owner bought different models.

TECHNICAL DESCRIPTION

This device is a compilation of three main components. The first component is a normal car seat with basic functions. This means that the seat still has the ability to slide back and forth and it maintains its tilt function to allow the seat to adapt

Fig. 8.75. Assist in standing car seat.

Fig. 8.76. Assist in standing car seat assisting the user.

to different comfort levels of passengers. The second component is a pneumatic device that fills an expandable container with air and then releases the air when the device is no longer in use. The third component is a plate system which is attached at one end, via hinge, to allow the plates to separate in an angular fashion.

The pneumatic system uses a 12 volt air compressor that is attached to a ball through a system of hoses. The hoses that connect the ball and the compressor are bisected by a release valve that allows the air to leave the ball. The ball of the pneumatic system is placed between two ¼ inch aluminum plates of the plate system. The plate and pneumatic system are both attached to the slightly modified car seat.

The system works by the user turning the pump on with a switch that has been installed in the upper part of the chair. When the pump is turned on, the ball expands and separates the two plates. This causes the seat the user is sitting on to tilt. This tilting motion allows the user to straighten their legs as well as raises their center of gravity, making it easier to stand. Once they are standing, they simply turn the system off, using the same switch, and the device readies itself for its next use.

With the sale of different sliders, which attach the seat to the car, the seat has the ability to be installed in a wide spectrum of vehicles.

The total cost of this device was $119.86.

Fig. 8.77. Air compressor and hoses.

Fig. 8.78. Ball inflated lifting the seat.

COMFORTABLE COLLAPSIBLE SAFETY CRUTCH

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INTRODUCTION

The Comfortable Collapsible Safety Crutch is a remodel of the standard crutch currently on the market by making it more stable and comfortable. Storage and transport are also recurring problems with the current models and are also considered in this device. Overall, this crutch encompasses multiple traits that benefit the user in comfort, convenience, and safety.

SUMMARY OF IMPACT

This product benefits anyone who uses crutches for any type of injury. It encompasses nearly all beneficial characteristics that a crutch entails. It is easier on the joints of the wrists and shoulders because it dampens the force of the pivoting which in turn allows a longer durations of use. It also creates a more stable crutch in case of slipping. The crutch also collapses for easier transport when in public areas or in areas of limited space.

TECHNICAL DESCRIPTION

This product is designed to improve the stability and comfort of a standard crutch. To address the problem with the safety, the rocking base was created. Most crutches just have the single pivot point. The broad rocking base is like walking with a wheel. If the crutch slips, it regains traction with a different part of the crutch. The base is constructed out of 5/8th steel tubing and bent with a 6-inch radius. It is also designed so that the base telescopes inside the original frame of the crutch. This structure is depicted in Figure 8.79.

The center pole is a guide for the spring and a place where the bottom collar clamp is placed. The collar clamp can be adjusted to different lengths to change the strength of the spring, or the spring can be completely changed. The spring compresses against another plate located at the bottom of the crutch frame. It consists of 2 collar clamps welded to an aluminum plate. There is a tension pin that goes through the center guide pole for the spring that

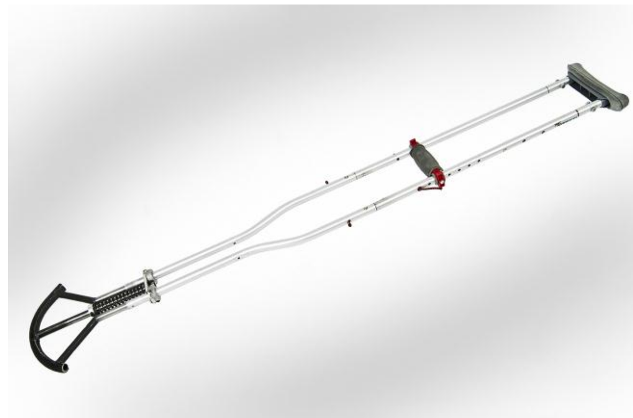

Fig. 8.79. Comfortable collapsible safety crutch.

Fig. 8.80. Crutch in collapsed position.

passes through this plate to keep the base from falling off.

The collapsibility was accomplished by cutting the original crutch frame in half and welding 5/8th aluminum tubing inside with an inch and a half protruding from the cut. Holes are then drilled and pushpins inserted as a means to keep the crutch structurally sound, while maintaining the ability to be broken down. Bungee cord was also strung through the crutch frame to help re-assemble and keep the pieces together, even when disassembled.

Lastly, since the adjustability is usually done at the bottom of the crutch where the springs and the rocking base are now, the adjustability aspect is moved to the top of the crutch. To begin with, the crutch frame is cut a couple inches below where the underarm support attaches. It was constructed using 2 lengths of 1 foot long 5/8th steel tubing. There are holes drilled through either end and pushpins are inserted in one end of each one and then inserted into the crutch frame. The crutch frame also had holes for the pushpin to lock into drilled out. The other ends of the tubing are bolted into the crutch. The following photo depicts the overall structure.

The overall cost of this project cost $60.

Fig. 8.81. Crutch in use.

Fig. 8.82. Crutch in use with springs compressed due to applied force.

HOSPITAL BED WATER DISPENSER

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INTRODUCTION

The Hospital Bed Water Dispenser is a device designed to provide water to people in a hospital or nursing home beds. The Hospital Bed Water Dispenser uses a pressure transducer that triggers the motor to pump when the patient applies a vacuum pressure to the end of the water tube. The controls located on the top of the water tank provide the doctors or nurses with the ability to control and monitor how much water a patient intakes. The goals of the water dispenser are to provide hospital or nursing home patients' easy access to water whenever they desire and to help doctors monitor a patient's water intake.

SUMMARY OF IMPACT

The Hospital Bed Water Dispenser gives patients easy access to a water supply and eliminates the need for a nurse to provide water to a patient whenever they are thirsty. The water dispenser also helps doctors to monitor the amount of water a certain patient drinks. The water dispenser helps patients consume water whenever they are thirsty and also limits the amount of time nurses spend providing water to their patients.

TECHNICAL DESCRIPTION

The Hospital Bed Water Dispenser is designed to be mounted onto a wall or hung on the rails of a bed. The total dimensions of the water dispenser are 12in x 9 in x 9 in. The approximate weight of the tank with water inside is 32 lb.

The water dispenser tank is made out of hard sterile plastic. The water tank also contains a Brita water filter to help purify the water. The top of the tank has a removable lid for easy access.

The hospital bed water dispenser pump is attached to the side of the plastic tank and enclosed inside the hanger of the water dispenser.

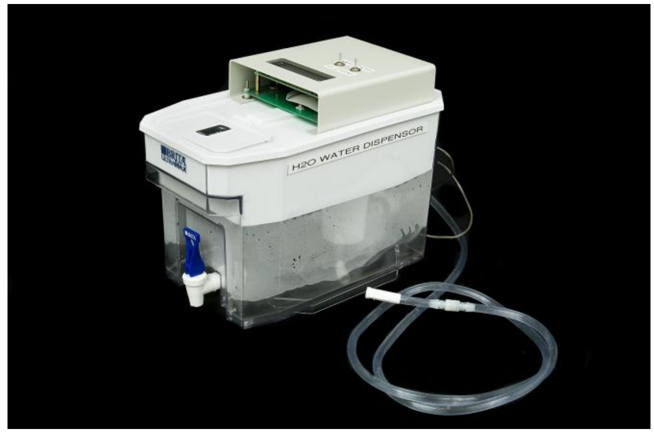

Fig. 8.83. Hospital bed water dispenser.

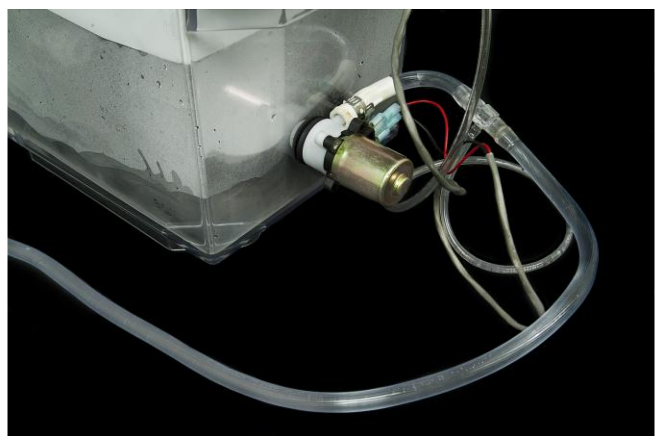

Fig. 8.84. Water pump with feeding tube.

Connected to the pump is a 6 ft. feeding tube with a nozzle on the end and power cords.

The circuit for the hospital bed water dispenser sits on the top of the tank. The control circuit consists of a circuit board with one 2 x 16 character display screen and 2 switches. The switches are used to select the amount of water that should be dispersed in units of mL. The circuit is programmed to display how much water has been dispensed and how much water left to be dispensed. When the amount dispensed reaches the limit amount, the display blinks. The display screen also has a sleep mode that can be activated that turns off the display.

The pump and pressure transducer are also connected to the circuit board. The pump is calibrated to pump in 50 ml increments and is activated by the pressure transducer. A small tube (1/8") connects the pressure transducer to the feeding tube (1/4"). When a patient applies a vacuum pressure to the end of the feeding tube, it triggers the pressure transducer to activate the motor to flow water.

The total cost of the prototype project is $ 310.54. If mass produced, projected price is in the $150 range.

Fig. 8.85. Display panel for the water dispenser.

Fig. 8.86. Hospital bed water dispenser .

Fig. 8.87. Water dispenser in use.

SECURITY STORAGE ATTACHMENT FOR WHEELCHAIR

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INTRODUCTION

The goal of the security storage attachment is to build a security based storage compartment that can be attached onto a wheelchair. The purpose of building this attachment is to help wheelchair users secure their belongings while in motion. Traditionally, storage attachments for wheelchairs come with a lot of restrictions that makes it very difficult for wheelchair users. Also, many of these storage attachments are flimsy and not very safe. The security storage attachment for wheelchairs was built to eliminate these problems by providing easy accessibility that is secure and safe.

SUMMARY OF IMPACT

The security storage attachment is built to be attached to the space underneath the wheelchair seat. The storage slides out between the person legs. Once done removing or storing items, the storage can then be pushed back underneath the seat for safe storing. This design allows only the wheelchair user to have access to the storage compartment making it safe and also easily accessible.

TECHNICAL DESCRIPTION

The design of the wheelchair is based on a discussion with a local store dealing with wheelchairs. The storage attachment is designed to the specification of the store's most popular and best-selling wheelchair. The empty space underneath the wheelchair's seat is chosen as the best place to attach this storage. The storage is built using wood and is shaped like a box.

The dimensions of the storage attachment device are 10 inches long, 6.5 inches wide and 9.5 inches deep. These dimensions are calculated based on a few criteria. The width is calculated based on the distance of the foot pegs. This is so that when the storage slides out, it is not restricted by the user's legs. Next, the length is calculated to use up all the empty space and at the same time not stick out underneath the seat too much when stored. The depth of the storage attachment is based on two important restrictions: the front wheel of the wheelchair having a 360 degrees clearance and also an allowance space between the seat and the storage

Fig. 8.88. Security storage attachment for wheelchair attached to a chair.

Fig. 8.89. Storage attachment in extended position.

lid to avoid the user's bottom hitting the box when he or she sits down. Even with many restrictions, the dimension of the storage allows the user to keep multiple items in the storage such as wallets, cell phones, passports, medicines and many other things all at the same time. The storage is attached to the wheelchair via a platform that is attached to the stabilizing bars in between the wheels of the wheelchair. The platform is built using aluminum tubing. The storage compartment and the platform are connected by the two sliders that slide the storage in and out. Unlike traditional sliders that can remove the box from the platform, the sliders used for this storage attachment are commonly known as t-tracks. These sliders are much more stable than conventional sliders. Also, it comes with a stopping mechanism so the storage will not hit the wheelchair bars if accidentally pushed back too fast. In total the system weight is only 12.3 pounds and can carry up to 20 pounds safely.

The total cost of the project was $50.

Fig. 8.90. Rails used to extend the attachment.

Fig. 8.91. Storage attachment opened and in use.

TRI-BRID

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INTRODUCTION

The Tri-Brid offers users with limited use of their legs the ability to travel quickly in a recreational or professional sports setting using this a relatively inexpensive device. The Tri-Brid utilizes a pedal crank mechanism mounted where the handlebars are normally positioned, with the chain directed to a single geared freewheel mounted on the front wheel. A rear positioned seat is placed slightly over the rear wheels, with a chest-pad mounted to reduce weight transferred into the arms.

SUMMARY OF IMPACT

The sleek design is aesthetically pleasing, while providing a very ergonomic position for users who are serious about riding long distances or professional racing. The design allows users to travel farther and faster than traditional wheelchairs, keeping a bicycle-level height for traveling with regular bicycles, while keeping costs substantially lower than other hand powered tricycles.

TECHNICAL DESCRIPTION

The design is the modification of a traditional 26" bicycle and a 24" tricycle conversion kit. The bottom bracket for foot pedaling is removed and placed where the handlebars are traditionally located. The frame is reinforced where the bottom bracket was removed by replacing it with a square steel bracket. Moving the bottom bracket to the handlebar position enables the user to pedal using their hands, while still being able to safely and securely steer the Tri-Brid at higher speeds. A removable chain guard was mounted over the sprocket of the hand crank system to protect the user from unintentional contact with the metal teeth of the sprocket.

The braking mechanism is a traditional "v-brake" for bicycles mounted on the front wheel in the reverse position to allow room for the chain to transfer motion un-obstructed to the front wheel. The hand-brake is mounted just behind the front

Fig. 8.92. Tri-Brid.

fork and directly below the user's arms, allowing for effortless accessibility at speed.

Two small steel plates are added to the bicycle where it connects to the tricycle conversion kit that prevents any loosening of the connection between the two, which in turn prevents it from disconnecting after continuous use.

Utilizing the mounting points for the rear brake on the bicycle, the seat was installed using aluminum bars and plate. The forward tilting position of the seat promoted a leaning forward body position to assist in keeping an efficient power transfer to the drive train.

The chest pad is placed using the opening intended for traditional 'saddle' seats on bicycles. Without this chest pad, a user carries the weight of their upper body through the arms, drastically limiting turning ability and the user's ability to remove one hand to brake while traveling. The chest pad provides weight transfer that allows the user to put as much or as little force into pedaling, and enabling them to brake comfortably.

The square bracket that replaced the bottom bracket is used to mount the foot platform, while the bolt holes traditionally used for a water bottle holder are used to mount ankle straps intended to hold the limited use legs of the user in place while in motion.

The total cost for the project was $183.24.

Fig. 8.93. Hand crank system with chain guard.

Fig. 8.94. Tri-Brid with a rider.

STANDING ASSISTANT / WALKER

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INTRODUCTION

From a sitting position, it is very difficult for individuals who suffer from back pain to stand up. Described here is a standing assistant that gradually aids a person to stand. The device also serves as a walker.

SUMMARY OF IMPACT

The final project consists of a standard aluminum walker with a set of handlebars connected to an electric lift. Ergonomically located where the right-hand thumb is positioned, the control switch is pressed up to move the lift up, and vice-versa. For someone using the device, they would simply situate the walker in front of the chair, grab the handlebars, lean slightly forward and press the control to be raised to the standing position.

TECHNICAL DESCRIPTION

The walker's lifting mechanism is a dual mounted linear actuator, with a maximum load capacity of 250 pounds. This is mounted on the front legs of the walker and is fully adaptable to be taken off or installed on another walker. Connected to the top of

Fig. 8.95. Standing assistant/walker.

Fig. 8.96. Handles retracted.

Fig. 8.97. Handle bars and controls.

the actuator is a set of aluminum handlebars clamped by a bicycle head stem that actually lifts the individual. The control for the actuator lift is mounted on the right side handle. With the use of an "on, off, on" switch, the actuator can be extended or retracted. The only other addition is the rear leg stabilizers for extra support when a load is applied.

Since the motor requires a 12V- 2 A power source, a rechargeable battery pack supplied. For weight restrictions, there are 10 AA batteries connected in series within this power supply that allows the device to run for about an hour with a load.

The total cost of the project is $62, which does not include the cost of the walker, or linear actuator. Without donations this project costs approximately $300.

Fig. 8.98. User sitting preparing to use the assistant/walker to stand.

Fig. 8.99. User standing with help from the assistant/walker.

VERSATILE GRIP ASSISTOR

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INTRODUCTION

The Versatile Grip Assistor is a device for use by persons who lack grip strength or grip traction. The device is light weight and durable. It is designed to easily fit in a purse, pocket, or hand bag. The goal of the grip assistor is to allow those who lack grip strength or grip traction to open jars, doors, and hold onto objects with finer motor skills than before. It needs to be light weight, easy to use, multifunctional, and aesthetically pleasing.

SUMMARY OF IMPACT

The object provides aid to those who need to open bottles, jars, and/or doors on their own without outside assistance. The device is able to adjust to fit objects from close to 0 inch diameter up to objects of diameters of 3 ½ inches. This range covers most household jars and bottles and fits over most doorknobs. In this way a person with limited grip strength has more leverage and grip when opening jars or bottles.

TECHNICAL DESCRIPTION

The device is primarily made from polycarbonate clear material. This material is very strong and durable. Also, when broken, the plastic does not

Fig. 8.100. Versatile grip assistor.

shatter or break into many shards.

It is equally used by right and left handed people. The entire device weighs less than one pound so it can easily be placed in a pocket or purse without burdening the carrier.

There are two main components to the device which are separated but will not fall apart unaided. The lower jaw can be adjusted to fit around the object to be gripped and then squeezed so the teeth lock into place. From here the user has more leverage on the object to be opened/moved/turned.

The lower and upper jaws each contain a grip material attached to them. This material can be any plastic or rubber that has a high friction surface. Superglue is used to secure rubber strips onto the jaws. This gave the device additional grip to assure no slipping when attempting to open/turn objects.

The shape of the inner jaws has two parts. The inner part, which makes up most of the jaw, is concave inwards on both jaws. This allows 4 points of contact when gripping a circular object as opposed to two points of contact with a straight surface. On the tips of each jaw is a flat section. This section allows for more precise grip on smaller objects such as socks, nails, electrical plugs.

The total cost of the project was $49.

Fig. 8.101. Grip assistor being used to open a bottle.

CHAPTER 9
TULANE UNIVERSITY

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PATIENT-NURSE SUPPLEMENTAL CALL SYSTEM

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Client Coordinators: Margot Ballina, Denise Chetta
Supervising Professor: David A. Rice
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INTRODUCTION

Current commercially available nurse call devices have limitations when used by patients with various disabilities. Call and control buttons are typically small and difficult to read, rendering them prone to incorrect selection, particularly for the elderly or for patients with motor impairment. Further, call systems typically require a verbal response from the patient, which can slow care for those with speech impairment, either pathologic or iatrogenic as with patients experiencing tracheotomy. The purpose of this project is to develop a supplemental communication system to augment the ability of patients to communicate with nursing staff. The device consists of a sealed plastic housing with eight large buttons on the display panel, each associated with a specific audible request (Figure 9.1). Easily visible icons and large text fonts are printed on the button faces. The assembly includes a caddy for the existing hand-held call control, and is rigidly mounted to a fully adjustable bedside stand.

Fig. 9.1. The front view of the patient-nurse supplemental call system showing the large button display and hand-held call control caddy.

SUMMARY OF IMPACT

The Patient-Nurse Supplemental Call System enables patients with a reduced ability to talk over typical hospital room intercoms to communicate effectively with nursing staff by selecting custom, pre-recorded responses and requests. It works seamlessly with the existing call system. Assessment by the clients is positive. They believe that the device will facilitate more effective care, and further evaluation is currently underway to develop this device, with the goal of producing a number of units for delivery.

TECHNICAL DESCRIPTION

The Patient-Nurse Supplemental Call System consists of a "voice box" made of a 14" x 6" x 3" plastic case with eight large push buttons and a speaker. The buttons are labeled with large-type words or symbols representing customized pre-recorded audible responses. In the current configuration, the responses are: Food/Water, Need Medication, Pain, Breathing Problems, Emergency, Bathroom, Yes, and No. The buttons consist of a single custom-molded silicone elastomer sheet mounted under the front panel of the case with eight 1.5" diameter disks (overlying eight momentary contact switches) protruding through the box. Each button/switch circuit plays a separate phrase. An aluminum caddy is fixed to the side of the voice box and serves as a holder for a standard commercial Executone nurse call device. The entire assembly is attached to a bedside stand modified to enhance stability in order to minimize motion of the assembly when the response buttons are pressed.

All electronics are powered by a 9VDC wall adaptor power supply, internally regulated to 5VDC. The voice box contains an Arduino Diecimila microcontroller board connected to a vinculum VMusic2 player (Figure 9.2). The Arduino board is programmed in C, via a USB connection, to permit the VMusic2 module to locate and play a MP3 file when one of the momentary switches fixed to a response button is closed. Each switch activates one of the pre-recorded tracks stored as separate files on a USB flash drive that is inserted into the VMusic2 module. An audio cable connects the VMusic player to a RadioShack speaker located in close proximity to the microphone of the Executone nurse call device placed in the caddy.

A two-way switch is mounted on the side of the voice box and is connected to the Arduino input to permit selection of the gender of the pre-recorded voice. A nurse can reset the device using a momentary switch that is mounted into the back of the box. A cover protects the switch and seals everything but the Executone device. Two hinges hold an acrylic bar in place above the Executone nurse call button and the voice box on/off switch so that both systems activate simultaneously when the patient presses the bar.

Total project cost: $698.00.

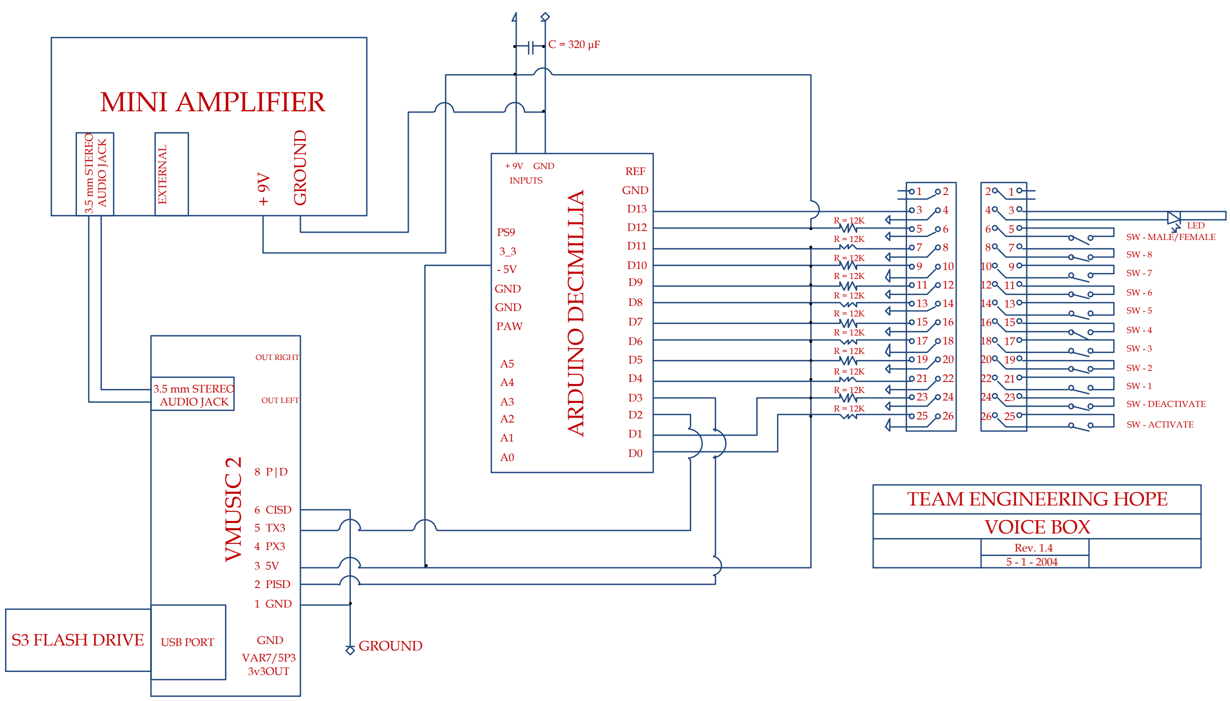

Fig. 9.2. The circuit diagram of the patient-nurse supplemental emergency call system.

CONVERTING GAIT TRAINER

Designers: Taylor Moss, Anne Marie Norman, Molly Oehmichen, Noel Schexnayder
Client Coordinators: Kimberly B. Pizzo
Supervising Professor: David A. Rice
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INTRODUCTION

Our client is a four year old (and his family). He has frequent atonic seizures, reduced muscle tone, and limited spatial perception. He is able to walk unaided only for short distances. His parents prefer to transport him in a standard child's stroller rather than in a wheelchair. In order to encourage independence and to develop ambulatory strength, the goal of this project is to create a gait trainer/walker that can convert to a stroller as needed. It is capable of accommodating our client's growth. The Converting Gait Trainer (Figure 9.3) consists of a commercially available gait trainer to which forearm supports and anti-tipping bars are attached for use as a walker, and to which adjustable head and foot rests, and a fold-away, padded handle bar are attached for use as a stroller.

SUMMARY OF IMPACT

The versatility of the Converting Gait Trainer significantly reduces the difficulties of managing multiple pieces of large equipment associated with the client's day-to-day family activities. The client is able to walk and play independently (Figure 9.4), yet his parents can transport him when necessary. The client's occupational therapist believes this device can significantly improve his ability to maintain balance and posture while learning to walk, and she says the client enjoys using the device and is eager to use it on a regular basis. She also expresses interest in developing similar devices with the other children at the rehabilitation center who could benefit from its design.

TECHNICAL DESCRIPTION

The Converting Gait Trainer is designed with high safety standards and adaptability as primary criteria. The Nurmi Neo child size gait trainer from Otto Bock serves as the base, along with an adjustable sling seat, anti-reverse wheel locks, and friction breaks. It includes the following

Fig. 9.3. The Converting Gait Trainer configured for use as a stroller.

modifications: a headrest, a removable footrest, a fold-down stroller handlebar, walker grips with forearm supports, anti-tip bars, and additional safety features. The headrest, footrest, and stroller handlebar are components that are used during stroller mode. In the walker mode, the main components utilized are the anti-tip bars, forearm supports, and a protective barrier designed to keep the client from falling forward. Each of the modifications is customized for our client and this Nurmi Neo design. These modifications do not compromise the integrity of the original structure.

The headrest consists of two laminated ¼″ sheets of birch plywood creating a rigid curved surface conforming to the frame of the gait trainer. Cushioning is added to the headrest with a ½″ piece of memory foam, upholstered using marine grade vinyl. The headrest is attached to the frame of the gait trainer using U-bolts and acorn nuts that prevent injury from exposed screw threads. This method of attachment permits easy removal for cleaning purposes.

The footrest also consists of laminated ¼″ birch plywood, which is painted and rubberized using Plasti-Dip. A steel piano hinge allows the footrest to fold open to approximately 120 degrees. The footrest is attached to the bottom of the gait trainer using industrial strength hook-and-loop material. When not in use, the footrest is stored along the lower bars of the stroller handlebar. Hook-and-loop is used to mount the footrest in this storage position.

The stroller handlebar is made of ½″ electrical metallic tubing (EMT) formed into a 'U' shape with a pipe bender. Connecting hinges salvaged from a child's stroller create the fold-down mechanism. PVC tee connectors and hose clamps create the lower inserts for the vertical support bars of the handlebar. These support bars, also made of EMT, are secured with epoxy into the hinges and lower braces using EMT pipe connectors. A cross-support made of 1/16″ stainless steel wire rope is secured between each vertical support bar to maintain the structural rigidity of the stroller handlebar assembly. Hose clamps secure the handlebar assembly to the original frame of the gait trainer. The handlebar can be snapped into one of several upright positions, depending on the height of the user. The EMT is covered with polyethylene foam.

The anti-tip bars are made of ½″ aluminum tubing formed at a 90° angle and capped with rubber stoppers. The tubing fastens above the rear wheels of the device, and can be pinned in an upward or downward orientation. When in the downward position, the anti-tip bars prevent the device from tipping backwards while the client is walking.

Forearm supports allow the client to walk comfortably without having to hold himself upright. The forearm supports are made of 4″ ABS pipe cut in half, covered with ¼″ foam, and upholstered with marine grade vinyl. Half-inch PVC tubing connects the forearm supports to the base of the gait trainer.

Fig. 9.4. Model showing gait trainer configuration. Safety equipment is not shown.

The grips on the forearm supports are rubberized for maximum comfort.

The client frequently fell forward while walking, so a protective barrier is added as a safety precaution. Strips of 90% polyester stretch material are sewn into a 35% polyester- 55% cotton blend poplin to create a fabric barrier that holds the client upright, permitting only minimal forward motion and thereby preventing injury. The protective barrier snaps onto the frame of the gait trainer.

Additional safety features on the Converting Gait Trainer include rubber coating on all metal parts that the client may contact. This is an important addition to the design because the client has frequent seizures.

The device is lightweight and folds for storage.

Total project cost: $950.00.

THE REMOTE SNAKE

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Client Coordinators: Craig Michel
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INTRODUCTION

Our client is an adult with muscular dystrophy. He has limited hand strength and motor control. He has difficulty grasping and manipulating the multiple remote controls required to operate his home entertainment system, and often needs his attendant to intercede. The objective of this project is to develop a bedside station to hold and position a universal remote control such that the force required to press the buttons is minimized, while the need to handle the control is eliminated. The Remote Snake (Figure 9.5) consists of a universal remote control selected for ease-of-use and the ability to control multiple devices with one unit. This remote is mounted on a flexible conduit extension (the "snake") mounted to a plywood base, providing continuously adjustable positioning while maintaining rigid support.

SUMMARY OF IMPACT

Muscular Dystrophy is a genetic, hereditary family of diseases that cause progressive muscle weakness and degeneration. Due to reduced muscular capacity, our client has difficulty controlling his home entertainment system and often relies on his attendant to change settings for him. He also has difficulty alternating the use of various other electronic devices. The Remote Snake satisfies the client's stated performance criteria. It gives him independence and the ability to consolidate and fully control his home entertainment electronics. Additional field test results indicate that the simplicity, ease-of-use, and convenience of this design make it an effective solution for a large range of clientele.

TECHNICAL DESCRIPTION

The primary design criteria developed in concert with the client are that the device must be: controllable with one finger, compatible with most home-entertainment systems, useable in bed, inexpensive, and easy to maintain.

The Remote Snake consists of three main components: the base, a flexible mounting extension, and the remote control. The base is made of cabinet grade ½" plywood. The bottom portion of the 1′ x 2′ base fits between the client's mattress and box spring. No fasteners are required to fix the platform to any bed frame. Corner brackets fasten a mounting shelf to the base. A universally adjustable flexible steel conduit is adapted to act as an extension arm and is attached to the shelf portion of the base. It serves to permit the remote control to be rigidly positioned in any orientation, while resisting the applied force necessary to operate the controls. A ¼" acrylic plate supports the remote control. Its dimensions are just undersized relative to the "footprint" of the remote in order to maximize stability and strength of attachment. The remote control is secured to the plate using hook-and-loop material. The entire apparatus is coated with Plasti-Dip to prevent the client's exposure to any bare metal protrusions.

The remote control chosen for our client is the One-For-All Kameleon URC-9964 Remote Control. It is capable of controlling all of the client's home entertainment components. Additionally, the remote has a motion sensitive back-lit screen which dims when not being used. This reduces annoyance, while prolonging battery life. The remote control operates at the low force levels the client can easily generate.

Total project cost: $200.00.

Fig. 9.5. The Remote Snake showing the basic configuration of remote, flexible extension, mounting, and base.

EXERCISE INCENTIVE MACHINE FOR CHILDREN WITH AUTISM

Designers: Brooke Lovett, David Ladd, Gina Sequeira, Samantha Warren
Client Coordinators: Carrie Cassimere, MSW
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INTRODUCTION

Our clients are four students with autism. As a group, they have a wide range of verbal communication, attention, and physical ability. Their teacher believes that including a component of independent physical exercise in their classroom will promote their developmental progression. However, their classroom has space limitations. The goal of this project is to design a space-saving exercise apparatus that encourages self-motivated usage by providing visual and auditory incentives coupled to the amount and quality of exercise. The Exercise Incentive Machine (Figure 9.6) is a modified exercise bicycle fitted with an adjustable, conforming seat with safety harnessing, and equipped with a stoplight visual cue and a CD-player incentive function (children with autism often enjoy music) activated by threshold peddle motion. It is capable of being programmed to prescribe and monitor simple exercise regimens.

SUMMARY OF IMPACT

Students with autism demonstrate a wide range in development of their levels of independence, attention and communication ability. They also have a variety of physical activity requirements that include the need to release built-up energy and strengthen muscle groups in the leg. The Exercise Incentive Machine provides the capability to incorporate physical and mental activity in a relatively small space suitable for a classroom. It permits safe, independent operation by students in a way that encourages their desire to exercise while maintaining their attention. Teachers are able to customize an exercise regime for each student. They are also able to indirectly monitor progress, freeing them to conduct simultaneous classroom activities.

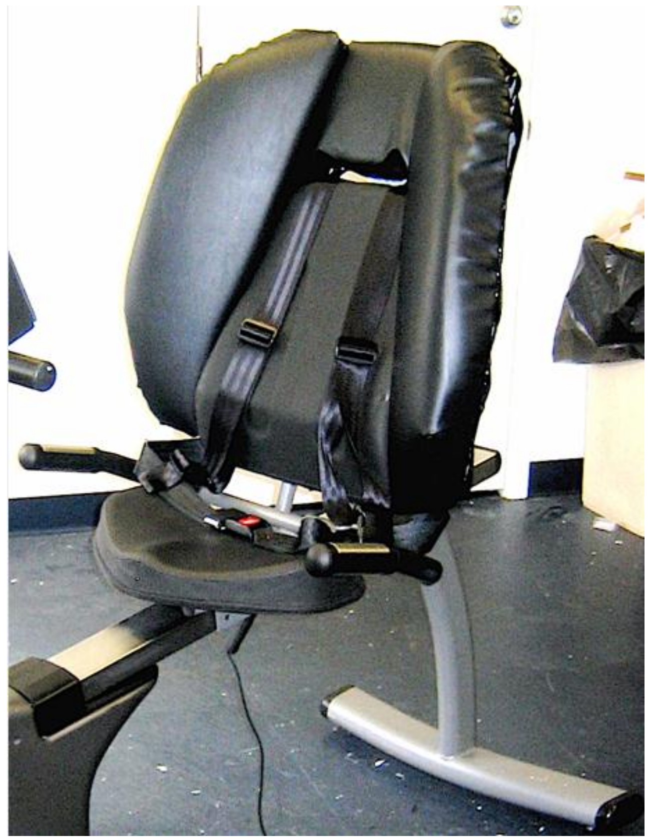

Fig. 9.6. The exercise incentive machine seating system.

TECHNICAL DESCRIPTION

The Exercise Incentive Machine is a modified version of a Vision Fitness R2000 recumbent exercise bicycle. It was chosen for its robustness and its quietness, since its use must not distract other students in the classroom. Two side supports (27″ x 8″) are fixed to the original seat back with steel brackets angled to give a 135° lateral contour. A vertical in-line headrest (approximately 10″ x 10″) is also bracketed to the original seat to provide additional support. All seating additions consist of a plywood base under 2″ –3″ foam padding upholstered with marine grade vinyl. Polyester seat and seat back slip covers fit over the entire seat assembly to facilitate cleaning. A storage pouch for a CD player and CDs is added to the back of the seat. A lap belt and adjustable harness, made of automotive grade 2″ nylon seatbelt material, are securely mounted to the seat to provide augmented support if necessary. The harness is designed to be optional, whereby 2″ buckles can be detached from permanently mounted tongue slides. The Exercise Incentive Machine weighs approximately 130 pounds and fits in a 62″ x 30″ x 50″ space.

A 18.25′′x 6.25′′ x 3.75′′ plastic stoplight replaces the original LCD console (Figure 9.7). The stoplight circuitry is powered by a 10V, 1.2A AC/DC transformer. A 2A fuse is used to limit current. The stoplight contains three holiday lights inserted into a piece of ¼′′ plywood (18′′ x 6′′) within the console. They are situated directly behind each of the three red, yellow, and green translucent plastic plates. An 18.25′′ x 6.25′′ mount for the console is made of 3/16′′ plywood. Two 2′′ brass brackets and two pieces of ¼′′ aluminum secure the stoplight to the wood console back.

A parallax BASIC stamp is used as the main controller of the device. A lighted ON/OFF switch enables the operator to monitor status. A 1 kΩ potentiometer and an onboard analog-to-digital converter allow the operator to enter the desired workout time. A momentary contact switch allows the user to start the programmed exercise regimen. During exercise, 5 LEDs, corresponding to 20% increments of regimen, allow teachers in the room to determine the student's progress in the set program. The LEDs, potentiometer, and start switch are located in the middle of the left panel of the console, above the ON/OFF switch.

A 12V relay is located beneath the user's seat and is used to control whether or not music is played for the user based on peddling activity. The CD player provides audio input that passes through the relay and into the user's headphones.

Total project cost: $850.00.

Fig. 9.7. The stoplight feedback unit. The five LEDs and the timer controller for the teacher is located above the left hand.

AN AUTOMATED SMART MEDICATION DISPENSER

Designers: Ben Wheatley, Will Sprott, Peter Navarro, Jesse Compo
Client Coordinators: Linda Ann Brown, Denise Chetta
Supervising Professor: David A. Rice
Department of Biomedical Engineering
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New Orleans, LA 70118

INTRODUCTION

A large client population comprised of patients disabled by chronic pain requires strong medication. Treatment is often compromised by patient non-compliance and drug overuse. The client coordinator of this project hopes to implement in-home technologies that regulate and monitor the medications prescribed for pain management. This project aims to develop a prototype dispenser that accomplishes these goals (Figure 9.8). The current design consists of a keyed, tamper-resistant housing containing a programmable motor controller capable of providing timed dispensing of medication. The multi-compartmented foil punch-out disc is filled in the pharmacy according to a physician's prescription. The disk rotates one compartment for each programmed dispensing event. The digital display shows timing and other information for the user. The operational history of the dispenser is stored in on-board memory, and can be recalled as a means of monitoring compliance. The prototype provides a proof of concept for further development of the product.

SUMMARY OF IMPACT

Approximately one in five Americans lives with chronic pain. The treatment for chronic pain is an area of significant interest in the medical field due to the propensity for non-compliance or abuse by these patients. The design goals of this project that have been achieved are to develop a prototype medication dispenser demonstrating portability, tamper-resistance, and prescriptive dispensing. The client coordinators are now able to demonstrate how such a dispenser will work and are able to provide input for second-generation designs. The prototype shows the need to incorporate new technologies, such as medication packaging in accordance with prescription. This design demonstrates that the administration of pain medication can be controlled on an hourly, daily, or weekly rather than monthly basis, thereby potentially reducing many of the ancillary problems associated with narcotics used to treat chronic pain.

Fig. 9.8. Dispensing unit prototype showing carrying handle, pill punch control, output chute, and digital display.

TECHINCAL DESCRIPTION

The housing consists of a 9″ x 9″ x 9″ box made of half-inch cabinet grade plywood to which a carrying handle is attached. The top access panel is key-locked to permit loading medications by only qualified personnel. A "gumball-type" dispensing chute delivers pills through the front panel. A spring-loaded plunger passes through the top panel and is used to manually punch-out individual pills through a customized foil "blister-pack." An LCD display indicating dispensing cycle timing and is mounted in the front panel.

The principal component of the design consists of two circular metal plates, approximately 8″ in diameter, between which a blister-pack of individual pills is sandwiched (Figure 9.9). The plates and foil blister-pack are intended to be specific to a given prescription. These would be loaded in the pharmacy. Each plate has a central hole that fits on a drive shaft. Twenty-four, ¾″ diameter holes are arranged along the perimeter, each capturing a foil blister containing one or more pills or capsules. Just interior to each of the 24 holes is a small alignment hole that allows an infrared sensor to determine when a new compartment is in the correct position following plate rotation. The central hole is coupled to a 200:1 gearhead DC motor, resulting in a nominal disc rotation speed of 10 rpm. The rotation of the plate-blister-pack assembly is controlled by a programmable motor controller. When the internal timer countdown reaches zero, the motor switches on until the infrared sensor detects the LED at the next alignment hole, at which time the motor is switched off. Once the motor has rotated, the current dose is in line with the manual plunger that is then depressed through the foil blister-pack to drop its contents into the dispensing chute. Simultaneously, the LCD timer is reset to indicate the time remaining until the next pill is to be dispensed. The device is battery powered, with a battery charger access port through the back panel. The next phase of this project includes adding reporting and reprogramming access through telephone dialup data exchange.

Total project cost to date: $150.00.

Fig. 9.9. Pill wheel showing 24 compartments and optical indexing holes.

A WHEELCHAIR-ACCESSIBLE SINK FOR A SPECIAL NEEDS CLASSROOM

Designers: Elaine Horn, Raeanna Poplus, Jesse Ranney, and Brent Smith
Client Coordinators: Victoria Pickering
Supervising Professor: David A. Rice
Department of Biomedical Engineering
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New Orleans, LA 70118

INTRODUCTION

Our clients are students in the special education program at a local high school. Many use wheelchairs. Their teacher uses a sink in her classroom to teach hygiene and other skills. Access to the existing sink and faucet was limited. Many students couldn't get their wheelchair close enough. Some couldn't reach far enough to operate the faucet. Splashing was a problem. The goal of this project is to select and install a sink and fixtures that permit wheelchair accessibility and independent operation by the students. Project goals are accomplished by redesigning the counter space and height, the sink location, under-sink plumbing, and faucet position, as well as by selecting a more easily operated faucet with an aerator and a basin shape that minimizes splashing (Figure 9.10).

SUMMARY OF IMPACT

Accessibility remains a significant problem for people who use wheel chairs, particularly when dated facilities are to be used. The use of an existing sink in the clients' classroom presented such a situation; only one student could use the existing sink on his own, and many students could not fit their wheelchairs under the countertop. A number of students had difficulty reaching the faucet and lacked the arm strength to use the handle. The current design of the sink, faucet, and counter space permits all students to access and use the sink without the assistance of the teacher. The proper selection of the basin shape prevents excessive splashing. Faucet selection and placement facilitates easy operation. The teacher is now much more able to teach hygiene skills as part of her classroom effort and has expressed great satisfaction with this solution.

TECHNICAL DESCRIPTION

The Wheelchair-Accessible Sink is a rectangular, drop-in, self-rimming stainless steel sink. The basin shape and shallow depth reduces splashing, but still permits all wheelchairs to fit beneath. The sink is placed forward in the countertop with the drain to the rear in order to facilitate accessibility. A single-handle, ADA-approved mixing faucet with a swivel spigot is also installed forward and on the right side of the basin to permit access. This side-mounted faucet is easily operated and is within reach of all students including those using wheelchairs. A removable lanyard that snaps onto the surface of the countertop limits the range of motion of the spigot so that the faucet cannot be positioned outside the basin and spill into a student's lap or onto the floor. A flow restricting aerator further controls splashing.

The counter top is raised approximately two inches to meet ADA standards. A new 40" section of Corian countertop replaces a portion of the original countertop. Pressure-treated wooden legs provide mechanical support. The Corian countertop is secured to the original countertop using Corian-specific epoxy. A metal cleat fastened to the wall supports the free end of the new Corian section. The counter is also supported along its length with wooden cross-braces. The new countertop is cut to be flush with the front edge of the original countertop, and a Corian backsplash completes the counter installation.

Total project cost: $700.00.

Fig. 9.10. Illustration of the installed sink configuration. Not shown is the stop that keeps the spout over the basin.

WORLD OUTSIDE MY WINDOW

Designers: DéJeune Antoine, Laurin Buettner, Scott Jennings, Ashok Manepalli
Client Coordinators: Hank Klimitas
Supervising Professor: David A. Rice
Department of Biomedical Engineering
Tulane University
New Orleans, LA 70118

INTRODUCTION

Our client has Type III Osteogenesis Imperfecta, a disease resulting in fragile bones and weakened musculature. Even with the support and safety restraint provided by commercially available car seats, moderate decelerations risk inflicting significant musculoskeletal injury. Consequently, the client cannot sit upright safely in her family's vehicle during car trips. Instead, she lies on the floor behind the driver's seat, which allows her to roll and gently accommodate normal vehicular motion. However, in this position she is unable to see out the windows, which can lead to disorientation and reduce the pleasures of travel. The goal of this project was to design a closed-circuit television system to permit the client to monitor the view outside her vehicle. The Video Window Viewer (VWV) consists of three cameras and monitors providing views through the left, right, and front windows while not obstructing the driver's lines of sight (Figure 9.11). The system is designed for portability and allows the client to easily transfer the system to other vehicles.

SUMMARY OF IMPACT

The VWV uses a closed-circuit television system to provide views from the side windows and through the front windshield. The client is now able to partake of the view as she travels, having real-time images through a 270° field of view from within her family's vehicle. Together, the three perspectives provide her with enhanced navigational abilities and a more enjoyable ride. She comments, "Your device gives me a new outlook on the world around me. I am able to see what is going on outside of my car. I am once again able to see the happenings of the city, the new buildings, and the true culture that surrounds me every day. It may not be looking out the real window, but it is sure close!"

TECHNICAL DESCRIPTION

The main structural component of the system is a folding tray (Axius® auto expressions™ Backseat Travel Tray, part# 142403) that can be secured to the back of any standard car bucket seat with a network of nylon straps. Originally designed for use as a dining and writing surface, this tray provides a horizontal support surface for the monitors and other components of the system. A steel 10" x 15" cookie sheet is secured to the underside of the horizontal surface of the tray using hook-and-loop material and wire bent into staple-like fasteners. The steel sheet extends 10" from the edge of the tray towards the middle of the vehicle, providing a horizontal surface directly over the client's head.

Three liquid crystal display monitors, two Emerson Mobile MT-1564R monitors and one Road Theater RT-500 monitor, are attached to the underside of the steel sheet using machine screws. This allows the client to view all three monitors simultaneously, and allows each monitor to be removed and examined individually if service is required. A thick plastic sheet is used to cover the upper surface of the steel sheet in order to conceal the fasteners while providing a usable horizontal surface.

Each of the three monitors is connected to a PC213XS closed-circuit microvideo color security camera by means of a standard video input connection. One camera is mounted on the dashboard, looking through the windshield, while the other two are mounted on the left and right C-pillars and look through the windows of the left and right sliding doors. These cameras are fixed in position using 3M Command™ mounting adhesive. All monitors and cameras are powered by the vehicle's 12VDC power supply. The power lines for each monitor and camera are separately fused. They all feed from a single cigarette lighter-style 12VDC plug.

Total project cost: $400.00.

Fig. 9.11. The Video Window Viewer as installed in the client's family vehicle. The monitors are attached to the underside of the fold-down tray.

STAND ASSIST WHEELCHAIR

Designers: Shoib Bajaj, Chaitanya Nandipati, Stephanie Roberts, Samantha Weil
Client Coordinators: Salvador Paz
Supervising Professor: David A. Rice
Department of Biomedical Engineering
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New Orleans, LA 70118

INTRODUCTION

Our client is paralyzed from the waist down and uses a wheelchair. With full use of his upper body, he used a device that allowed him to transition to a standing position, but this device was lost during Hurricane Katrina. The goal of this project is to restore the client's ability to work in a standing posture, with consequent functional and therapeutic benefit. This is accomplished by modifying a wheelchair to include nitrogen gas struts to actuate a hinged chair frame such that the footrest, seat and seat back align in the standing configuration (Figure 9.12). The client is able to use his body weight and upper body strength to compress the gas struts and return the chair to the wheelchair configuration, thus eliminating the need for an outside active power source.

SUMMARY OF IMPACT

For people who are paralyzed, the use of a standing system has several benefits. Pressure relief reduces the occurrence of skin ulceration, trunk strength and balance are improved, organ alignment improves renal and bowel function, and spasticity is decreased. Prior to Hurricane Katrina, the client used a device that allowed him to transition to a standing position from his wheelchair. The Stand Assist Wheelchair returns this capability to the client in one integrated system. In addition, it makes it easier for him to complete therapeutic stretching exercises. Standing allows him to enjoy typical daily activities. Importantly, the client has a renewed sense of independence.

TECHNICAL DESCRIPTION

The Stand Assist Wheelchair replaces the seat, back, and leg supports with three main plywood sections. These are hinged together and bolted onto a standard wheelchair frame. Throughout the sitting and standing movement, the seat back and leg support maintain a vertical position by following a four-bar linkage mechanism to which the sections

Fig. 9.12. The standing wheelchair. Top: wheelchair configuration. Bottom: standing configuration, rear view showing gas springs and 4-bar mechanism.

are attached. The frame of the linkage consists of 1″ square steel tubes pinned at each end with ¼″ bolts. The leg-support and footplate are fixed to the wheelchair frame with U-bolt fasteners. Two casters are attached to the underside of the footplate to prevent tipping and increase stability.

To operate the chair, the client first removes the armrest of the device and transfers himself from his wheelchair. The client uses his other hand to push on the armrest and relieve some of his weight on the seat. As the load on the seat lessens, two 130 lbs. capacity nitrogen gas spring struts mounted at an angle underneath the seat extend and the chair moves to a standing position. The opposing ends of the struts are fixed with brackets to a plywood support panel. To return to the seated position, the client reaches back and pulls up on the armrest. The additional force on the struts causes them to compress. Once in the seated position, two spring-loaded pins snap-fit into the wheelchair frame and lock the linkage mechanism. Bicycle brake cabling is used to disengage the locking pins when the chair again converts to the standing position.

Four-inch condensed batting is used to cushion the seat, and the rest of the chair is padded with two-inch thick fiber batting. The front and back of the chair are upholstered with 100% cotton fabric. In addition to a knee abduction and restraint system, three safety straps secure the client. One holds his feet in position, and two support his torso. Each is elastic, adjustable, and secured with hook-and-loop fasteners.

Total project cost: $520.00.

THE TOUCHCOM: AN INTEGRATED ENTERTAINMENT AND COMMUNICATION SYSTEM

Designers: Eric Franca, William Kethman, Westbrook Weaver, and Lee White
Client Coordinators: Scott Songy
Supervising Professor: David A. Rice
Department of Biomedical Engineering
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New Orleans, LA 70118

INTRODUCTION

Our client has a spinal cord injury at the cervical level, but retains some use of his right arm. It is difficult for him to operate various audio devices including an MP3 player, cell phone, and voice amplifier, and it is especially difficult for him to alternate using these devices. The goal of this project is to design a single touch-screen interface that permits the facilitated operation of multiple audio devices using minimal applied force. The TouchCom (Figure 9.13) consists of large touch-screen LCD and embedded programmable interface controller housed in a custom fabricated ABS housing mounted to the client's wheelchair with a continuously adjustable ball-joint arm. Additional functionality includes the remote control of a television and an automatic door opener.

SUMMARY OF IMPACT

The design goal of the TouchCom, to facilitate the use and control of multiple peripheral audio devices for a client with restricted use of one arm, was achieved early in the project. The client can now easily switch between his MP3 player, cell phone, and voice amplifier microphone. The further developed final design surpasses his expectations by including the added functionality of TV and automatic door opening control. Touch-screen technologies offer highly effective solutions for applications where the use of multiple devices needs to be simplified, and where device control requires low operating force.

TECHNICAL DESCRIPTION

The TouchCom housing was custom fabricated using a 3-D printer in order to minimize the size required to contain electronics and support a large touch-screen graphical user interface (GUI). The housing is made of acrylonitrile-butadiene-styrene (ABS) plastic. To meet the design criteria of large screen size, color display, low power consumption, and serial connectivity, we selected the ezDISPLAY 2.0 serial graphic touch-screen LCD module. The GUI consists of menu screens and buttons that send serial x and y-coordinate input to a dzPIC30F4011 embedded microchip programmable integrated controller (PIC). The PIC coordinates the various functions of the device using 5 volt logic to activate latching relays that consume power only while switching. Latching relays are also advantageous because they retain their last switch state when power to the device is turned off. Power at 5 VDC is drawn from the 24 volt wheelchair supply through a DC-DC converter. When fully active, the TouchCom draws approximately 1 A, but when screen sleep mode is initiated after 45 seconds of inactivity, the device draws only 170 mA.

In addition to controlling multiple audio input/output devices, the TouchCom can be configured to amplify voice input. This public address (PA) function permits alerting traffic and hailing friends. An infrared LED is mounted within the housing to permit the PIC and touch-screen GUI to function as a typical TV remote control. Also an in-board radio frequency electronic key fob was incorporated such that the TouchCom can operate the client's automatic door opener control.

The TouchCom is rigidly, but reversibly, mounted to the client's wheelchair using U-bolts.

Total project cost: $725.00.

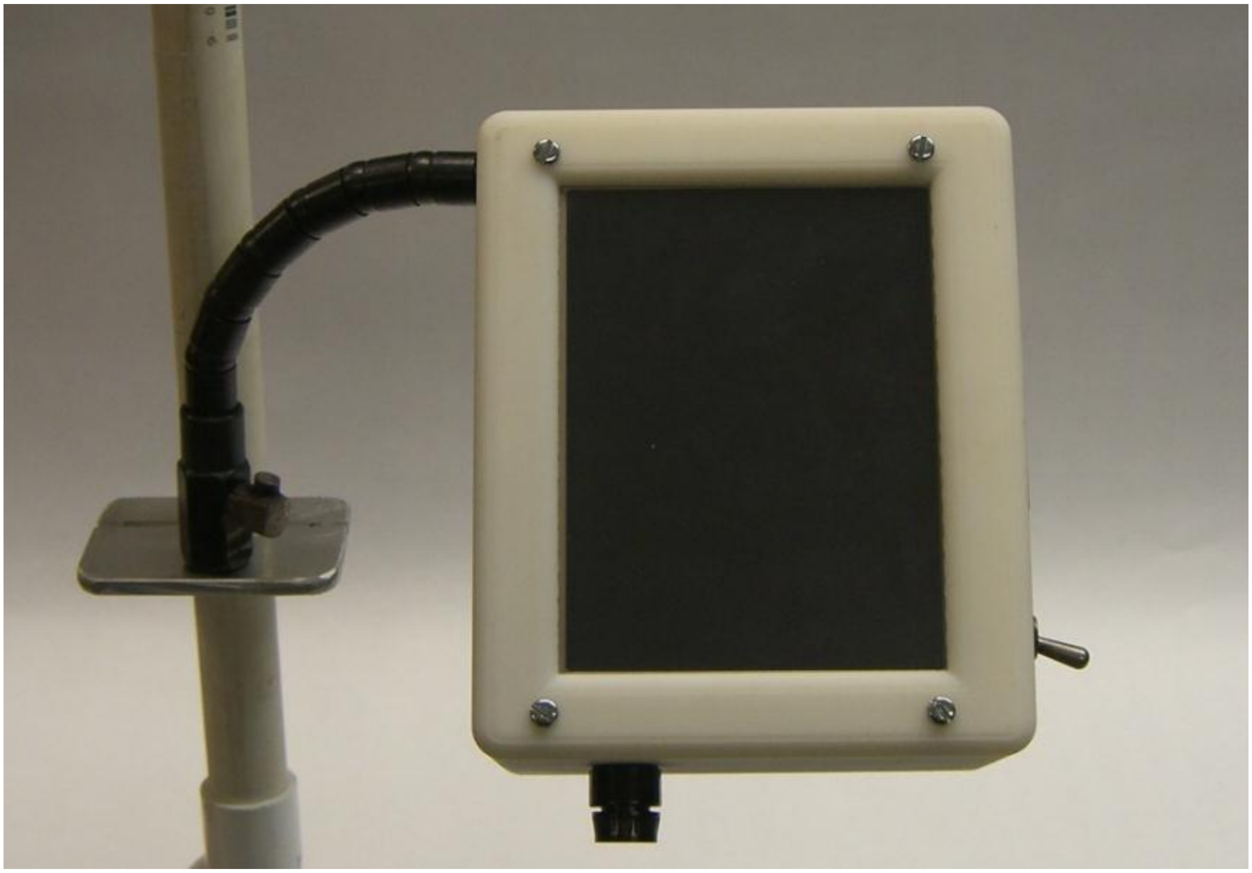

Fig. 9.13. The TouchCom touch-screen interface and flexible mounting arm.

CHAPTER 10
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THE E-RACER: A GO-KART FOR A CHILD WITH CEREBRAL PALSY

Designers: Kevin Arpin, Michael Marquis, Allison Meisner, Travis Ward
Client Contact: Gregg and Laura McClement, Calgary, AB, Canada
Supervising Professor: Dr. John D. Enderle
Biomedical Engineering Department
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Storrs, CT 06269-2247

INTRODUCTION

The E-Racer, shown in Figure 10.1, is a modified electric go-kart which was designed for a child with cerebral palsy who wanted a go-kart that he could use safely with his friends. The client has no use of his legs and very limited use of his left arm, so the controls had to rely solely on his right arm. Also, the client currently uses a wheel chair controlled by a joystick, so the E-Racer has joystick control. Additionally, the client requested that the go-kart be able to be controlled by a steering wheel. Thus, the E-Racer has two modes of operation, steering wheel and joystick, which is unique to this go-kart. The E-Racer also offers several safety features not found on standard go-karts, including those designed for children with disabilities.

Fig. 10.1. The E-Racer.

SUMMARY OF IMPACT

The E-Racer is designed based on criteria given by the client, the client's parents, and the client's physical therapist. The client requested a go-kart which allows him to have fun with his peers. The client's parents further requested that the go-kart have certain safety features. The client's parents wanted the go-kart to have an adequate safety harness, a seat that provides lateral support and a way to support the client's head while riding. The E-Racer allows the client to enjoy recreational time just as he would if he did not have cerebral palsy. The E-Racer provides the client with a fun vehicle, as well as increased self-confidence and a feeling of independence.

Fig. 10.2. Modified steering wheel.

TECHNICAL DESCRIPTION

Per request of the client, the E-Racer has two modes of operation. The switch between the two modes is at the rear of the go-kart to ensure that the rider does not accidentally hit it during operation. The steering wheel is the steering wheel from the stock go-kart, but has modifications. The modified steering wheel is shown in Figure 10.2, and included switches between forward/reverse, training/normal modes, and the braking/acceleration control for when the joystick is in steering wheel mode.

A joystick is located on the right side of the stock go-kart. The joystick controls acceleration, braking and steering when the go-kart is in joystick mode, and is pictured in Figure 10.3.

The electronics on the go-kart are heavily modified from the unit purchased. The braking and steering are controlled mechanically on the stock go-kart, but needed to be modified and controlled electrically. This is accomplished by adding two linear actuators to the go-kart, one for braking and one for steering. The steering system also required the use of a linear position transducer, and several small mechanical parts machined for the braking modifications. Several circuit boards are used to receive signals from the joystick or steering wheel, and then control the go-kart accordingly. These circuit boards included a speed controller for the steering system, a speed controller for the braking system, and a printed circuit board (PCB) designed specifically for the E-Racer, which includes several microcontrollers and other electronic components. The acceleration is controlled by a motor controller connected directly to the motor.

The E-Racer is an electric go-kart, and is therefore battery operated. The stock go-kart had a 36 V battery to control the motor. As a result of the modifications to the go-kart, including the addition of extensive electric components, a supplemental 12 volt battery was added to the go-kart. Each battery has its own charging port and circuit breaker. The batteries are pictured in Figure 10.4.

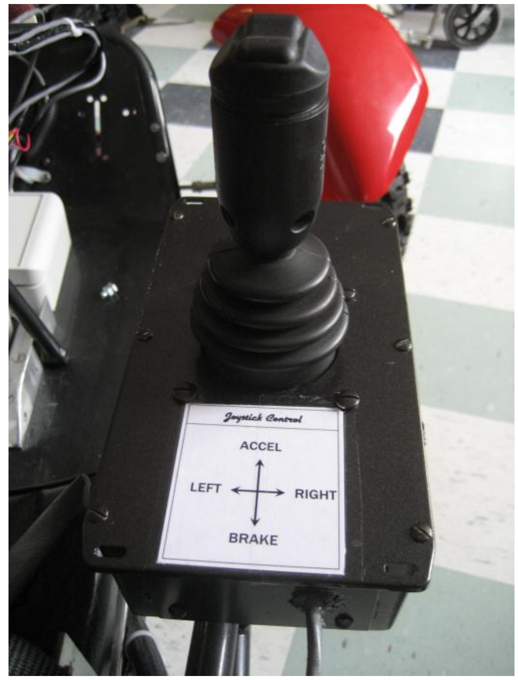

Fig. 10.3. Joystick on the E-Racer.

The total cost parts and material for the E-Racer is approximately $1500.

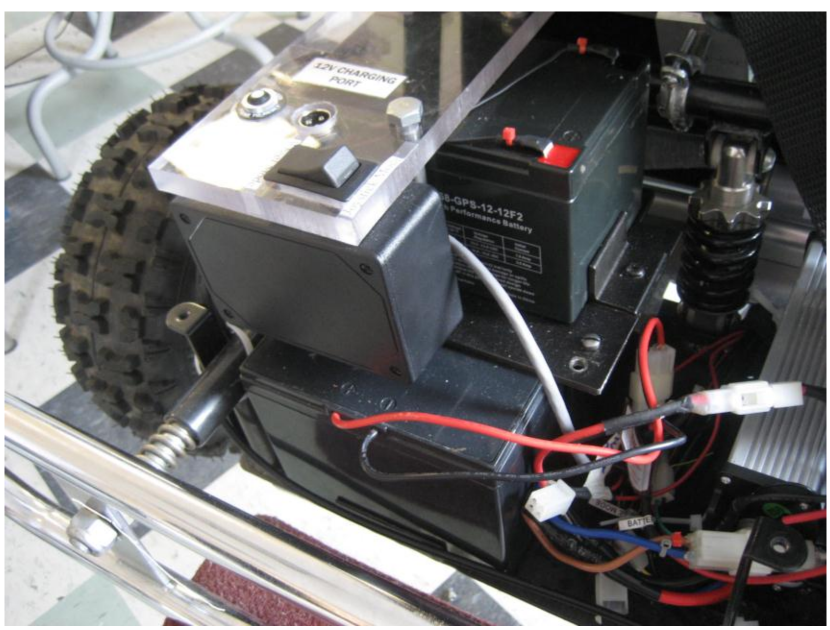

Fig. 10.4. The 36 Volt and 12 Volt batteries.

BACKPACK LEVER ARM SYSTEM

Designers: Lu Ma, Raj Shah and Nahum Kryzman
Client Coordinator: Laura McClement, Canada
Supervising Professor: Dr. John Enderle
Biomedical Engineering Department
University of Connecticut at Storrs,
Storrs, CT 06269

INTRODUCTION

An innovative biomedical device is required to aid Mason, an eight-year old child with cerebral palsy. Mason has a functional right shoulder/arm/ hand, capable of a wide range of motion and fine motor skills. However, his trunk is weak; but he can sit, if properly positioned, upright in a regular chair for some time before tiring. He has trunk supports on his wheelchair to assist him with fatigue. It is very difficult for Mason to obtain his backpack that is usually hung at the back of the wheelchair. The device built here is an electrically operated lever arm, capable of moving the client's belongings to an accessible position. The design makes use of the client's functional right arm. A simple 'ON/OFF' switch will control the movement of the three limbs of the lever arm system, which will sequentially unfold to obtain the position desired. The first Limb is securely fastened to the back of the wheelchair. Limbs 2 and 3 rotate (in that order) in a counterclockwise fashion upon client stimulus to bring the backpack into the position desired. In a position of non-use, the limbs fold into a compact position at the rear of the client's wheelchair.

SUMMARY OF IMPACT

This device brings independence to any client who wants it. Clients who live by themselves will benefit from the ability to transfer object to a position where they can use them. This device is catered to a specific client and is used to move a backpack to a comfortable position for him. However, it is definitely possible to diversify applications using the same basic concepts. A transfer device can be used in the home, office, workplace, or educational facility.

TECHNICAL DESCRIPTION

The backpack lever arm system consists of 3 limbs, where two of them (Limb 2 and Limb 3) are moved by Servo Motors Arms (using Pulse-Width Modulation) for the desired motion. Complete

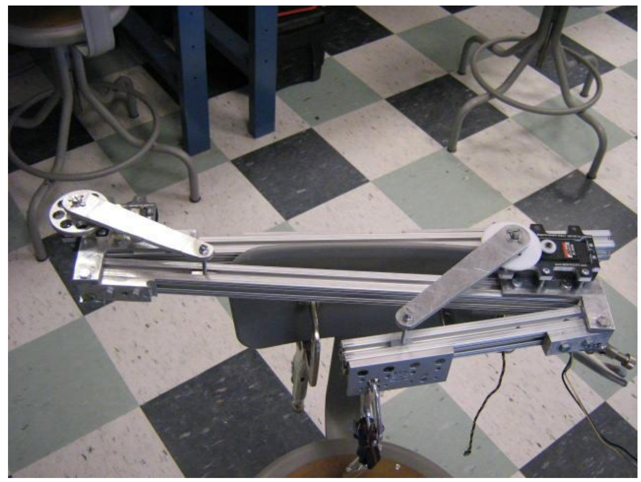

Fig. 10.5. Backpack lever arm system.

motion of the lever arm system is 270 degree rotation of Motor 1 (the HSR-5995TG) and 90 degree rotation of Motor 2 (the HS-785HHB). Limb 1 is fixed to the back of the client's wheelchair using movable cross-over clamps. This feature enables customization, based on the width of different wheelchairs. All three limbs are made out of sturdy 80/20 material. In terms of the Length dimensions, Limb 1 is 22 inches in Length, Limb 2 is 20 inches and Limb 3 is 10 inches. The cross-section of each limb is 1 inch x 1 inch square shaped; the 80/20 material has grooves running along the entire limb. Teflon T-shaped pieces (1 inch x ½ inch) with threaded 8-32 sized holes are placed inside these grooves, and connected to the motors arms to allow for rotation. The limbs are connected via two hinges. Each hinge is made up of two L-shaped aluminum pieces, a solid aluminum block, a bearing, brass sleeve, two Teflon washers, and a single ¼-20 hexagonal head screw.

To describe the functioning of the device in sequence, it starts with a user stimulus. When the switch located on controller (which is attached by a Velcro strap to his right arm chair) is turned, the servo motors to rotate the lever arm. First, Limb 2 rotates about hinge one 180 degrees in a counter-clockwise direction from the folding position. Then Limb 3 rotates 270 degrees counterclockwise about hinge two to the right of Limb 2 to form an L-shape. After that, Limb 2 rotates once again about hinge one 90 degrees clockwise to bring the backpack that is attached to limb three as possible to the client's mid-line as possible. The final positions of three limbs after the rotations are Limb 1 remains attached to the back of the wheelchair, Limb 2 is 6 inches directly above the right arm rest, and Limb 3 is in front of the user with the backpack attached to it. After Mason finishes obtaining his belongings from the backpack, he will simply turn the switch to the "OFF" position to reverse the rotational motions of Limb 2 and Limb 3 to bring the lever arm to a collapsible position at the back of the wheelchair.

Controlling the systematic movements of the device involves a PIC microcontroller and an optimal electrical circuit to run two servo motors. In terms of the circuitry and the manner in which the PIC is connected to various important components, pins 32 and 11 are VDD pins, which connect to the 5 V power supply. This is controlled by a voltage regulator. Pins 31 and 12 are VSS, and connected to ground. Pin 33 connects the forward/reverse switch and the LED to make sure that the PIC is powered and has a program on it. The MCLR pin (Pin 1) connects to a switch, which is used to turn the entire device on or off. Pins 13 and 14 are the oscillators; externally, these are connected by a 4 MHz crystal. Finally, Pins 16 and 17 (RC0 and RC1) are connected to the signal input parts of the motors. In addition, the motors individually must have connections to the power supply and ground. The following is a schematic of the circuit.

The costs of the parts/materials for this project were approximately $750.

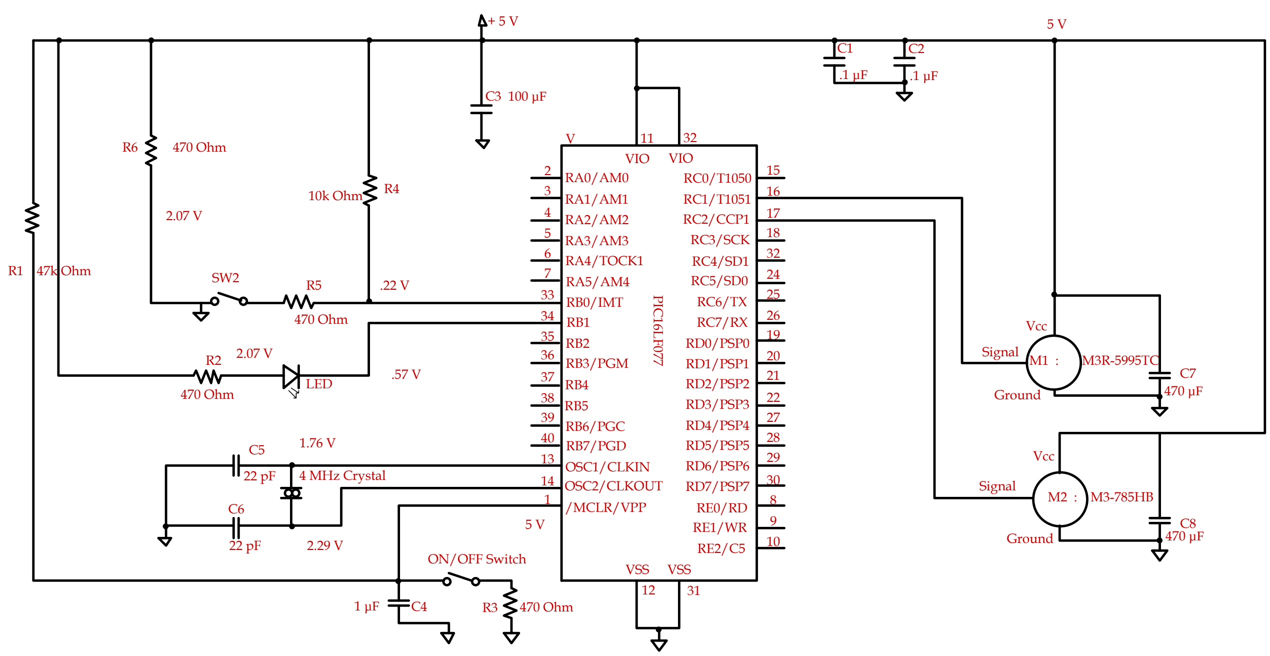

Fig. 10.6. Schematic of the servo motors control circuit.

SHAMPOO & CONDITIONER IDENTIFICATION DEVICE

Designers: Lu Ma, Raj Shah and Nahum Kryzman
Client Coordinator: Dr. Brooke Hallowell, Ohio University, Athens, OH 45701
Supervising Professor: Dr. John Enderle
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Storrs, CT 06269

INTRODUCTION

The Shampoo & Conditioner Identification Device is designed to aid an elderly client, Mrs. Smith, who faces reduced visual perception, and substantial memory loss. The client is unable to differentiate between products within the household, and wishes to maintain her independence by using a device that helps make this distinction. Specifically, this assistive device is used to help in identifying shampoo and conditioner bottles in the shower. Fundamentally, the device is a waterproof 'talking' belt, customizable to different size bottles via a water proof iPod strap/holder. It outputs 'Shampoo!' or 'Conditioner!' upon a push of a button.

SUMMARY OF IMPACT

This product can be used for patients with low visual acuity, which may be caused by a disorder, or during healing time after ophthalmic surgical procedures. Patients (especially those that are single) may need temporary assistance in recognition of items within their household. Thus, a device such as the shampoo/conditioner identifier provides assistance in doing so. The current project is catered to the identification of specific bottles of hair products for use in the shower. However, it is possible to diversify applications using the same concept. A recognition device can be used in the kitchen for beverage bottles or food containers.

TECHNICAL DESCRIPTION

The Shampoo & Conditioner Identification Device consists of a voice-recorder player, which plays a pre-recorded message (outputted through a small attached speaker) when activated. The audio output is amplified by a circuit to ensure that the client is able to hear the message clearly. A large button located on the circuit serves as the activation point. The amplification system used is based around a

Fig. 10.7. Shampoo & conditioner identification device.

Speaker Peripheral Module made by Digilent INC. This system is based around an LM4876 audio amplifier. The LM4876 is a single audio power amplifier capable of delivering 1.1W of continuous average power to an 8Ω load. This amplifier runs on a voltage range between 3.3 and 5 V. Like other audio amplifiers in the Boomer series, the LM4876 is designed specifically to provide high quality output power with a minimal number of external components. The following is a schematic of the amplification system provided by Digilent INC.

The device operates on two AAA batteries included with the device. The two AAA batteries are housed in a battery holder connected by a pair of wires on the circuit board. All the electrical components are sealed air tight in a thin layer of plastic. However, the battery holder was left open for easy access when changing the batteries.

The entire circuit is placed into a water proof iPod Pro Armband. The iPod Pro Armband is made for use in swimming or diving. The armband is made from superior quality neoprene. Neoprene is a type of synthetic rubber that is often used in applications that require water resistance such as wetsuits and hoses.

The cost of the parts/materials for this project is $450.

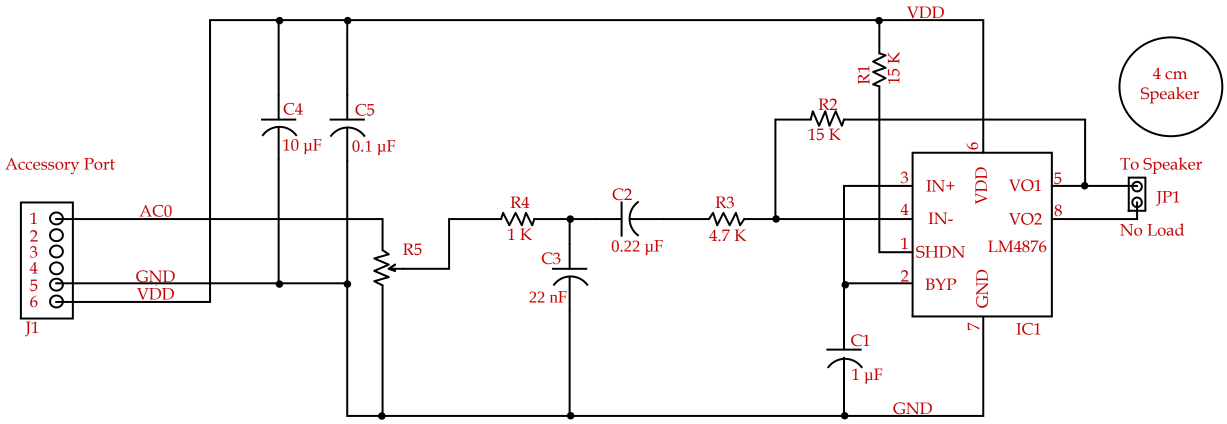

Fig. 10.8. Schematic of the amplification system (Digilent INC.).

Fig. 10.9. Insulated circuit and the battery holder.

THE ASSISTIVE ROBOTIC ARM

Designers: Alon Dagan and Michael Khalil
Client Coordinator: Merriam Kurland, Speech Pathologist, Hampton Elementary School, Hampton, CT 06247
Supervising Professor: Dr. John Enderle
Department of Biomedical Engineering
University of Connecticut
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INTRODUCTION

The assistive robotic arm is a device developed to aid a child with cerebral palsy. Cerebral palsy is a debilitating disease that affects the portions of the brain necessary for fine motor control and stability. As this illness does not affect mental capacity, children can become quite frustrated with the inability to control their own limbs. The discrepancies between the client's mental and physical capacity can cause a great deal of anxiety and stress. Our client has difficulty typing, eating, and interacting with other students. While he has an aide who helps him in class, he feels a lack of independence that affects his self-esteem. The robotic assistive device helps bridge this gap between physical and mental abilities for the client.

SUMMARY OF IMPACT

The assistive robotic device reduces the client's frustration and provides greater independence. The assistive robotic arm acts as a third limb for the client, translating his gross motor movements into fine motions. It is hoped that this device reduces some of the frustration in the client's life and also give him a greater sense of independence.

TECHNICAL DESCRIPTION

The assistive robotic arm is comprised of a three major mechanism that mimic the function of the shoulder, elbow and the wrist. The shoulder movement is emulated using a servo motor base. This motor rotates the entire robot arm 180 degrees and provides the client with a full range of motion to grab objects off his tray or a neighboring desk.

On top of the shoulder mechanism is an elevator mechanism that helps elevate the arm. The arm is capable of increasing 6 inches in its height so that he will be able to elevate various objects that he might be using in his class and aid in his final goal of gaining independence. The main component of the elevator mechanism is a linear actuator (motor) that is be capable of lifting the elbow portion of the arm to the motors maximum stroke length of 6 inches.

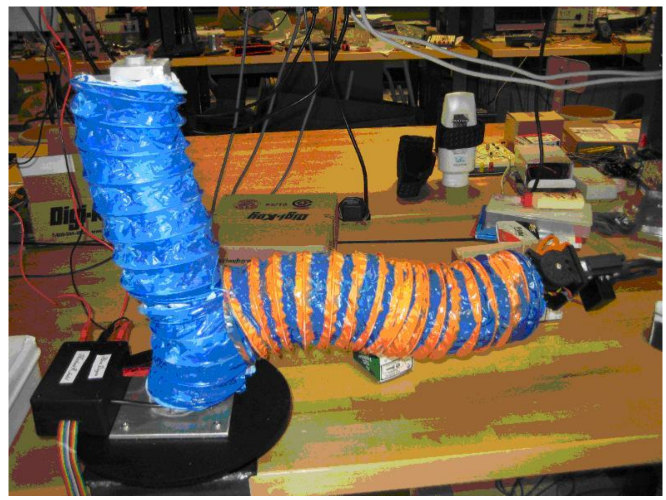

Fig. 10.10. The assistive robotic arm.

To mimic the elbow, the assistive robotic arm has a mechanism controlled by a processing unit that is capable of taking X,Y coordinates and converting it to angular coordinates for the elbow. This way, the movement of the 2 segments of the arm attached to the elbow compensate for each other when they move. The processing unit sends a pulse width modulation signal to a servo motor at the elbow, which determines the duty cycle for the servo motor and allows it to move the segments of the arm to a desired length.

The operation of the wrist rotates the grabber based on an input from the joystick controller by the client. The wrist is capable of panning and tilting to aid the client in picking up objects regardless of height off of the ground. It is capable of mimicking the flexion/extension and the abduction/adduction functions of the human wrist.

The gripper mechanism consists of a vise-like grabbing component connected directly to a motor. Within the vise is a pressure sensor that communicates with the pressure sensor cutoff circuitry. These components work together to allow for a sturdy grip that does not endanger the client or his peers. An end effector, called the "Big Gripper", was purchased as the gripping mechanism for the assistive robotic arm. The gripper's fingers measure at 3 inches long and open wide enough to grasp a 12 oz. tennis ball. The body of the gripper is comprised of a rugged but lightweight PVC plastic.

The cost of parts/material is approximately $70.

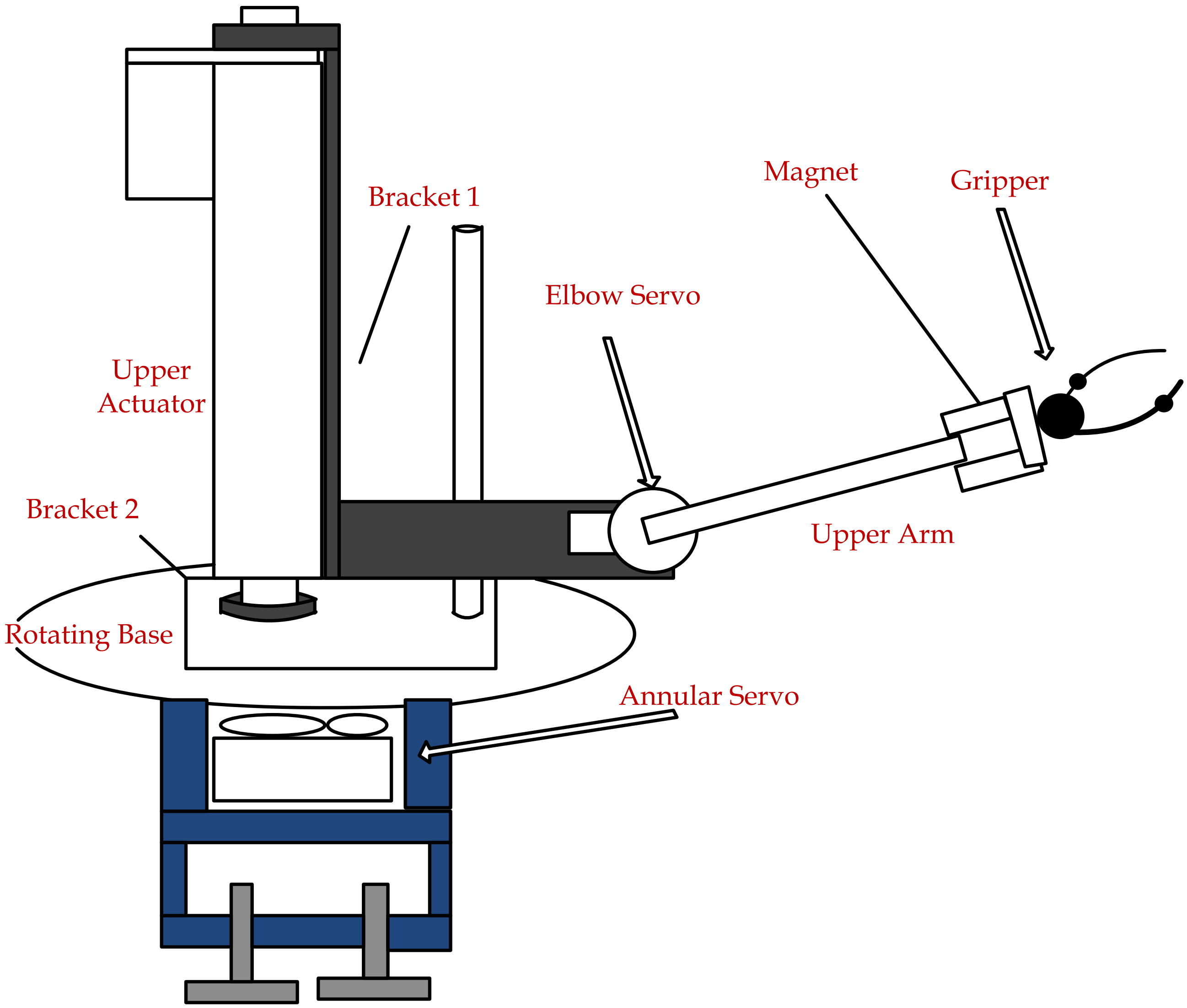

Fig. 10.11. Drawing of the assistive robotic arm.

ALTERNATIVE MOUSE INPUT DEVICE: PROVIDES ALTERNATIVE INPUT DEVICES FOR ADAPTIVE COMPUTER CONTROL

Designers: Derek Kulakowski, Matthew Zywiak, and Andrew McLean
Client Coordinator: Brooke Hallowell, Ohio University, Athens, OH
Supervising Professor: Dr. John D. Enderle
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INTRODUCTION

The alternative input device is designed to improve the speed and accuracy of the multiple users over daily use. There are two devices, an optical track ball mouse and an optical foot mouse. These two devices aim to help those with limited mobility. Along with the two devices are a set of computer games, intending to improve the navigation skills of the user. Current products are offered but are not aimed at improving the skills of persons with disabilities. Our design focuses on the strengths of the user, specifically lower extremity movement for the foot mouse, and small movement of the hands.

SUMMARY OF IMPACT

The design focuses on the needs of two types of clients. For those with limited upper extremity movement, an input device that makes use of the foot is designed. For those with limited lower extremity movement, an input device that makes use of the hands is designed. By having two different input devices, a user can practice on each device, improving skills and coordination on both devices. Two devices also allow two separate users to practice at one time. The games provide the interface for improving the skills before the user is ready for more advanced interface control.

TECHNICAL DESCRIPTION

The optical foot mouse is composed of three main parts, the foot mouse, the pedal switches, and the base. The foot mouse is composed of ¼″ thick Plexiglas. This houses an optical mouse base and the circuitry inside of it. Attached to the foot mouse is a Velcro strap to be used to secure the user's foot onto the foot mouse. The pedal switches are momentary contact switches that operate the right and left clicking functions of the foot mouse. The pedal switches are mounted to the Plexiglas base along with a mouse pad for scanning of the foot mouse. The foot mouse connects to the pedal switches using wires that are secured to the base. The connection to the computer is through a USB port, which extends out of the foot mouse.

Fig. 10.12. Final alternative input devices, foot mouse(top) and track ball mouse(bottom).

The track ball mouse also has three main components, the track ball box, the track ball and its base, and the two contact buttons. The housing of the track ball mouse is a hard polymer plastic of dimensions 9 ½″ x 6 ¼″ x 3 ¾″. Holes have been punched and milled out of the top of the box to allow the fitting of the buttons and track ball mouse. The next component is the track ball and its base. The track ball is a 4 ½" Atari track ball which has been painted blue and yellow for scanning purposes. The base that holds the track ball is a steel cylinder with three washers welded on top. Placed on these washers are three ¼" ball bearings, which allow for a smooth rolling surface for the track ball. Mounted on the steel cylinder is the optical track mechanism. The last components are the two 1 inch contact buttons that provide the right and left clicking functions for the mouse. These buttons are wired to the optical scanning mechanism and the mechanism connects to the computer via USB connection.

The last parts of this project are the two interactive games. These games are designed to focus on the coordination and speed of the user while using the input devices. The first game is a "hedgehog" game in which the user clicks on various objects to make them disappear before time runs out. As the user progresses through the game, the difficulty increases as more objects enter the screen, the background changes, and the speed of the objects increases. The second game is a brick breaker game in which the user uses a paddle to ricochet a ball towards various colored bricks to destroy them. As the user progresses through the game, the speed of the ball increases, the brick arrangement changes, and the amount of the bricks increases. Also, bonuses are included in the game, which include adding another ball into the game.

The cost for the parts/material is approximately $250.

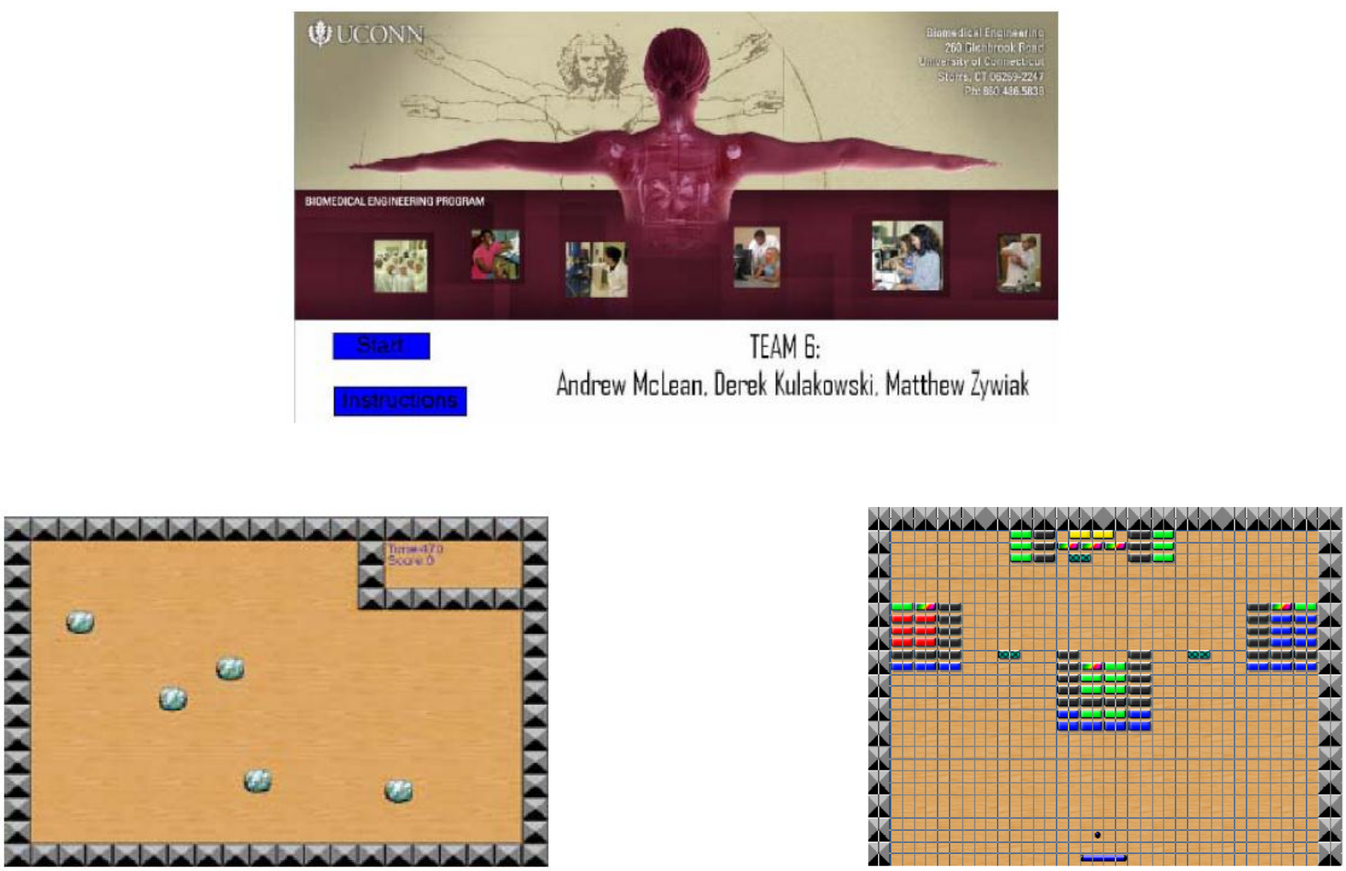

Fig. 10.13. Gaming interfaces, start menu(top), hedgehog game(left), brick breaker game(right).

ACCELEROMETER CONTROLLED ART ASSISTANT

Designers: Andrew McLean, Derek Kulakowski, Matthew Zywiak
Client Coordinator: Brooke Hallowell, Ohio University, Athens, OH
Supervising Professor: Dr. John Enderle
Program Director & Professor for Biomedical Engineering
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INTRODUCTION

The Accelerometer Controlled Art Assistant is designed to allow persons with limited upper body motor control to draw. This device is simply an X-Y track system composed of two worm screws (see Figure 10.14). These worm screws are driven by DC motors that are controlled by the client. The drawing utensil is moved up/down, left/right depending on which motor is activated. Motors are activated based on signal from two accelerometers, which detect changes in pitch and tilt. Ultimately this device will give the user a sense of interaction and control when drawing.

SUMMARY OF IMPACT

A client with limited upper body motor control wishes to draw and paint. The device described here gives this capability to the client suing writs accelerometers. Drawing and painting is a good way to stimulate the senses and this device allows the client to take an active part in their art creations that stimulates cognitive senses as well as stimulating the visual and auditory senses. While this device needs assistance in setting it up, after this, the client can completely control the device to draw and paint.

TECHNICAL DESCRIPTION

The structure of the X-Y track system is made of several components. The self-manufactured worm screw, motor mounds and drawing cart are all made of aluminum. Aluminum is characterized by a high strength to weight ratio, providing the necessary strength for the mechanism, while minimizing weight. The frame of the track, as well as the purchased worm screw, is made from steel. The high strength properties of steel provide the necessary strength to resist torsion and tension that is present in this mechanism. The final part of the structure is the hardwood backboard. This is mounted onto the steel frame; the hardwood is relatively light and does not add much weight relative to the rest of the mechanism. While the mechanical properties of the hardwood are not as good as the various metals in the system, it still has more than enough strength to support the art paper and the force from the drawing utensil.

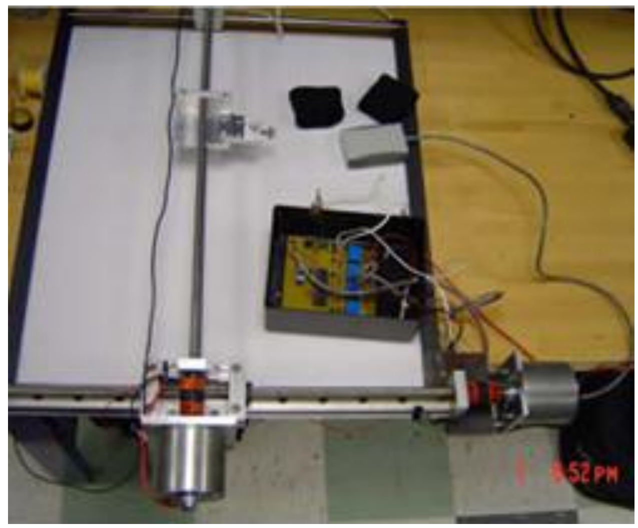

Fig. 10.14. Complete art assistant.

Attached to each wrist of the user is a Mesmic duel axis accelerometer. These accelerometers operate on a 50% duty cycle when horizontal and a 0-100% duty cycle when tilted vertically. This signal goes through a RC circuit to reduce the duty cycle into a single output voltage, which varies +.5 volts when tilted. This signal is processed by the PIC16877A microchip. There is a set voltage thresholds programmed into the PIC, that, if they are surpassed, the PIC sends a signal to designated pins. Voltage thresholds are surpassed when the accelerometer is tilted greater than 45 degrees. If the voltage is within the horizontal range, then no output is given.

The PIC alone cannot provide sufficient current to the motors and makes use of voltage relays. This allows the PIC to control the forward and reverse directions of the motors. The circuit diagram for this device shown in Figure 10.15.

The relays wired to the motors are attached to the worm screws on the X-Y track system. Each worm screw is powered by a 12V reversible DC motor. These motors, on average, draw a current of 3A. The reason 12V DC motors are used is because of cost and fine movement is not required. At the end of each track are micro switches that turn the motor off. These switches are used to ensure the motor does not continue to run when it reaches the end of the track system.

The total cost for all the components is approximately $750.

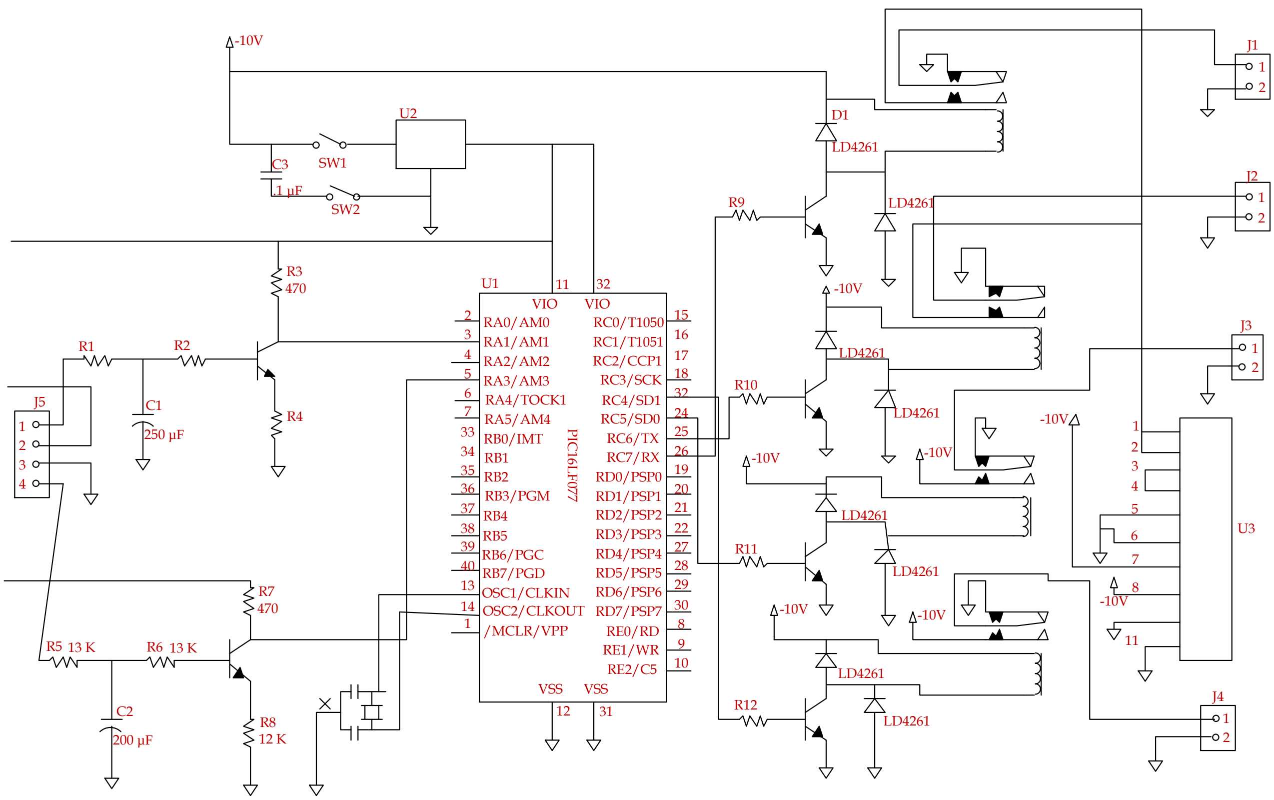

Fig. 10.15. Circuit diagram for art assistant.

GAME FOR IMPROVING SPEED AND ACCURACY OF NAME RECALL

Designers: Matthew Zywiak, Derek Kulakowski, Andrew McLean
Client Coordinator: Brooke Hallowell, Ohio University
Supervising Professor: Dr. John Enderle
Biomedical Engineering Department
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Storrs, CT 06268

INTRODUCTION

The Game for Improving Speed and Accuracy of Name Recall is designed to help individuals with cognitive disorders, such as Dementia and Alzheimer's. Often, these individuals have trouble remembering the names and faces of family and friends. The purpose of this project is to allow these individuals to practice naming friends and family so that when they interact with these people, they are able to recall the names and faces. The game

Fig. 10.16. The multiple choice game screenshot.

consists of three main screens, the Main Screen, Game Screen (see Figure 10.16), and Load Pictures Screen. The computer game includes voice recognition for elderly users who are not familiar with a computer.

SUMMARY OF IMPACT

The design criteria for The Game for Improving Speed and Accuracy of Name Recall are that is it be easy to use and stimulating. To accomplish this, the game is made to be simple to use for individuals who are not computer users, thus eliminating the use of large navigation menus. Further, voice recognition is used while playing the game for ease in use. The game is also stimulating and challenging.

TECHNICAL DESCRIPTION

The computer game is written in Visual Basic, a part of Microsoft Visual Studio developer suite. To allow for integration of the voice recognition software, another Microsoft Software Development Kit is used. This kit contained a Speech Recognition Engine along with documentation. Visual Basic used the Speech Engine so that the code is used in the program to recognize spoken words as input and convert them into text that the program used.

Three main functions are used to create the game environment. The SpeechInitialized function initializes all of the variables needed within the game and sets up the speech engine to begin receiving information from the headset. A headset is used to improve sound quality with a digital signal. Analog signals are often subject to distortion which digital signals are not.

The second function is the RebuildGrammar function, where words entered into the game are placed inside the grammar unit of the Speech Engine and used to create recognizable words.

The third function is the SpeechRecognized function, which recognizes words that are turned into text that is then used to drive the game with the appropriate response.

The actual coding of the game is done with standard Visual Basic language using event driven programming. This means that events happen on the screen only when certain buttons are pressed by or by events taking place not visible to the user.

A game feature allows individuals to save long lists of names and pictures without having to enter them every time they began a game.

The cost for this computer game was negligible. All programs and devices were provided by the University of Connecticut.

MONITOR LIFT FOR ADJUSTMENT OF COMPUTER DISPLAY

Designers: Patrick Keating, Thuy Pham, Daniel Zachs, and Katie Zilm
Client Coordinator: Brooke Hallowell, Ph.D., CCC-SLP, F-ASHA
Supervising Professor: Dr. John Enderle
Biomedical Engineering Program
260 Glenbrook Rd.
Storrs, CT 06279

INTRODUCTION

Often, neurological disorders result in impaired auditory and visual sensory function. Communication with a person with a neurological disorder is sometimes difficult because of their inability to express the extent of their disabilities through traditional means. Neurological disorders that some patients experience spans all areas that affects mental comprehension, physical mobility, and all means of communication. Level of comprehension is difficult to known because of their inability to respond after receiving an input, say, a visual stimuli from a computer. This project improves a system designed for communication with persons with neurological disorders by changing the height of a computer monitor for ease in use.

SUMMARY OF IMPACT

The device created is simple to use and does not distract the client. The environmentally friendly nature of this device makes it appealing in the day to day use. The speed is fast enough that is does not take an excessively long time to lift the monitor 12 or more inches.

TECHNICAL DESCRIPTION

The Monitor lift raises a 27 inch flat panel monitor 12 inches off of the table surface and then back down. The monitor lift is extremely easy to use. It has a footprint of 18″ wide and a depth of 24″. The platform sits flush on top of a desk. The monitor lift itself weighs only 32.4 lbs., so it is very easy for it to be relocated if necessary. The monitor lift's design, especially the shape and size of the platform, provides excellent stability, so no clamps, straps or other securing devices are necessary. It simply rests on top of the desk's surface. Rubber grips on the bottom of the aluminum platform keep it in place and prevent any possibility of the monitor lift sliding around on the desktop.

Once the monitor is attached to the mount, the monitor rests approximately 0.7″ above the surface of the platform at the lowest height and is level with the desktop. To operate the device, the practitioner uses a DPDT switch to raise the monitor up or down. It defaults to the 'off' setting, which is the middle position. Labels clearly indicate which way to hold the switch to move the monitor up or down. For safety reasons, the lift operates only while the switch is being held one way or another.

An internal limit switch keeps the shaft from rotating outside of its 18″ movement range. If the momentary switch is held in the downwards position when the lift is already completely lowered, the limit switch prevents the actuator from being damaged or getting locked up. The same is true for the upper limit of the shaft range. If the switch is held in the up position when the actuator has already extended the full 18″, the internal limit switch prevents it from moving any further.

The adapter supplies the monitor lift with a 9V power source.

The cost of parts/material was about $450.

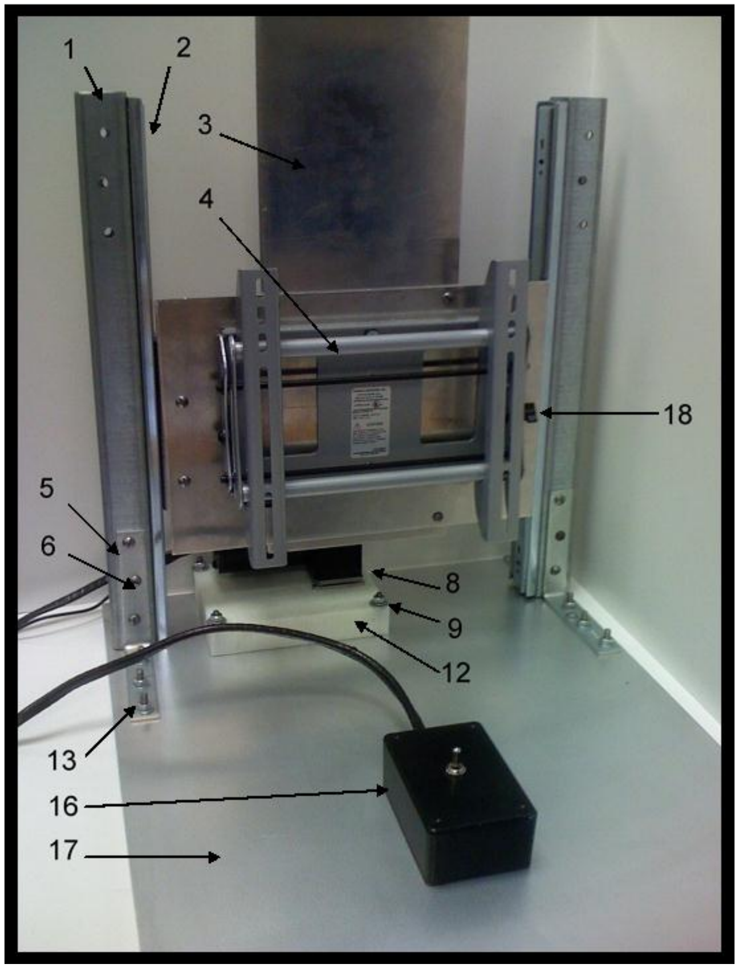

Fig. 10.17. The monitor lift.

PAINT CAP REMOVER

Designers: Patrick Keating, Thuy Pham, Daniel Zachs, and Katie Zilm
Client Coordinator: Brooke Hallowell, Ph.D., CCC-SLP, F-ASHA
Supervising Professor: Dr. John Enderle
Biomedical Engineering Program
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Storrs, CT 06279

INTRODUCTION

Multiple Sclerosis (MS) is a chronic inflammatory disease that affects the central nervous system by damaging the myelin sheath of neurons. Our client is an artist with MS who would like to continue to paint but is unable to because of his difficulty opening paint tubes. He has loss of function in one hand, and an overall strength loss in the other hand.

SUMMARY OF IMPACT

Approximately 250,000 to 350,000 people in the United States have MS, which typically occurs between the ages of 20 and 40. The paint cap removal aid designed for our client has had a great impact in his ability to paint independently, without the need for someone to open his paint tubes. The ultimate goal of the paint cap removal device is to provide our client the maximal convenience and

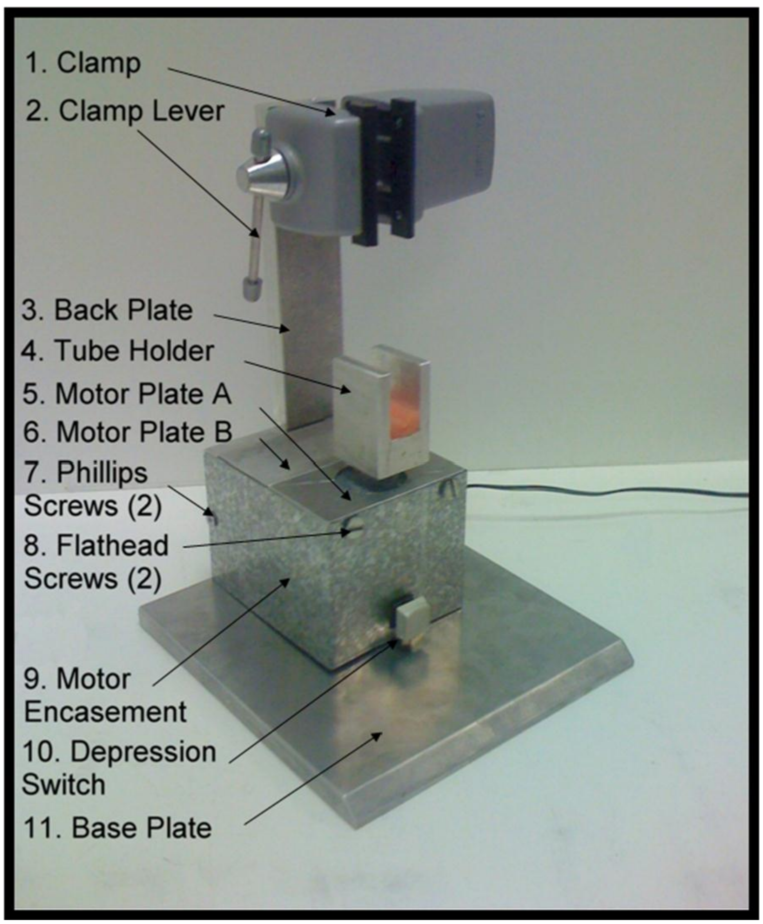

Fig. 10.18. The oil paint cap remover.

comfort in his working environment that requires minimal strength, is easy to operate, and is compact.

TECHNICAL DESCRIPTION

This paint cap removal aid is designed specifically for Grumbacher 1.25 oz. oil paint tubes. However, any tube of the same general geometry and size will fit this device. In addition, caps with different designs, such as round with teeth versus round with no teeth, are easily removed with this device.

Grumbacher recently began to make smooth cap heads for their paint tubes without the distinctive teeth as previously produced. The paint cap removal aid is designed to accommodate both of these cap styles.

Figure 10.18 shows the paint cap removal aid. It operates using a motor and requires a typical wall electric outlet.

The paint cap remover features a momentary switch located just above the base. The switch allows the motors to spin when it is manually depressed and held there. The location of the switch is key- it promotes safety and easy use of the device. It is located far enough away from any moving parts so that fingers will not contact them and it is located close to the base surface so that the user can rest their hand on the surface while holding the button.

Our client can remove the cap from a paint tube in three easy steps. First, the tube is placed in the tube holder. Second, the vise is closed, which can be done by simply hitting the lever; it does not need to be tightened with any significant amount of force. Third, push the button to remove the cap.

The cost of parts/material was about $110.

CHAPTER 11
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KNEE REHABILITATION PROJECT

Designers: Caitlin Barnes, Dzuy Nguyen, Matthew Tse
Client Coordinator: Michael Blei, Denver Health Medical Center, Denver, CO
Supervising Professor: Dr. Kimberly E. Newman
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INTRODUCTION

Knee connective tissue rehabilitation involves splinting the knee and providing static stretching in a controlled manner to maintain and extend range of motion after corrective surgery. The patient leaves the operation with the ability to bend the knee to 90 degrees. The objective of the post-operative therapy is to maintain this deflection and extend it to 110 degrees.

There are commercial products that perform this function; however, they do not have automated sensing and monitoring capabilities. The goal of this design project is to create a prototype system that prevents the user from executing motion that damages the repair while providing the force necessary to obtain the desired deflection, up to 110 degrees. The force is to be provided over specified time intervals. The device senses the applied force and provides monitoring capability. The force is limited to a maximum allowable value.

SUMMARY OF IMPACT

Every year, nearly 300,000 patients in the United States undergo knee replacement surgery. Following this surgery, a patient's range of motion (ROM) in the affected joint is significantly reduced. One of the most important factors in regaining ROM after such a surgery is an aggressive rehabilitation program. In daily living, a person requires roughly 67 degrees of knee flexion to walk, 93 degrees to rise from a chair, and 125 to kneel in prayer. Through controlled stretching of the joint, gradually increasing the tension of the connective tissue in the knee, a patient can regain near pre-operative range of motion.

TECHNICAL DESCRIPTION

The knee rehabilitation system includes a mechanical device to assist in static-progressive stretch therapy, and sensors to record the time and duration of use, as well as the applied force and the flexion angle achieved by the user.

Fig. 11.1. Knee rehab device.

Operation of the system is accomplished through the use of a lead screw to translate the patient's foot along a track. The motion of the lead screw is entirely controlled by the patient using a hand crank. This high level of patient control lowers the incidence of muscle guarding, which in turn leads to a more successful rehabilitation program. Data collection is completely autonomous, which allows the system to function as a compliance device, and also makes the device useable and accessible to the target user, a geriatric total knee replacement patient.

The patient is expected to use the device for 30 minutes three times per day during the course of the rehabilitation program. When the hand crank is rotated clockwise, the lead screw causes the pedal mechanism to move towards the patient's body, thus putting the knee in flexion. Extension is accomplished by reversing the direction of the crank. As the patient is expected to be exercising at the extremes of their range of motion, the pedal mechanism can be disconnected from the lead screw to quickly move from one extreme to the other, while allowing finely incremented motion when engaged. Load cells mounted on the pedal mechanism record excessive forces, which are indicative of muscle guarding. Tilt sensors mounted on the patient's leg record the angle of the knee, and a timer on the tilt sensor records the duration of use. When the foot is removed from the pedal at the conclusion of the therapy session, the collected data is transmitted to the patient's physician through a Tele-Health Home Monitoring system.

The cost of parts/material is approx. $1500.

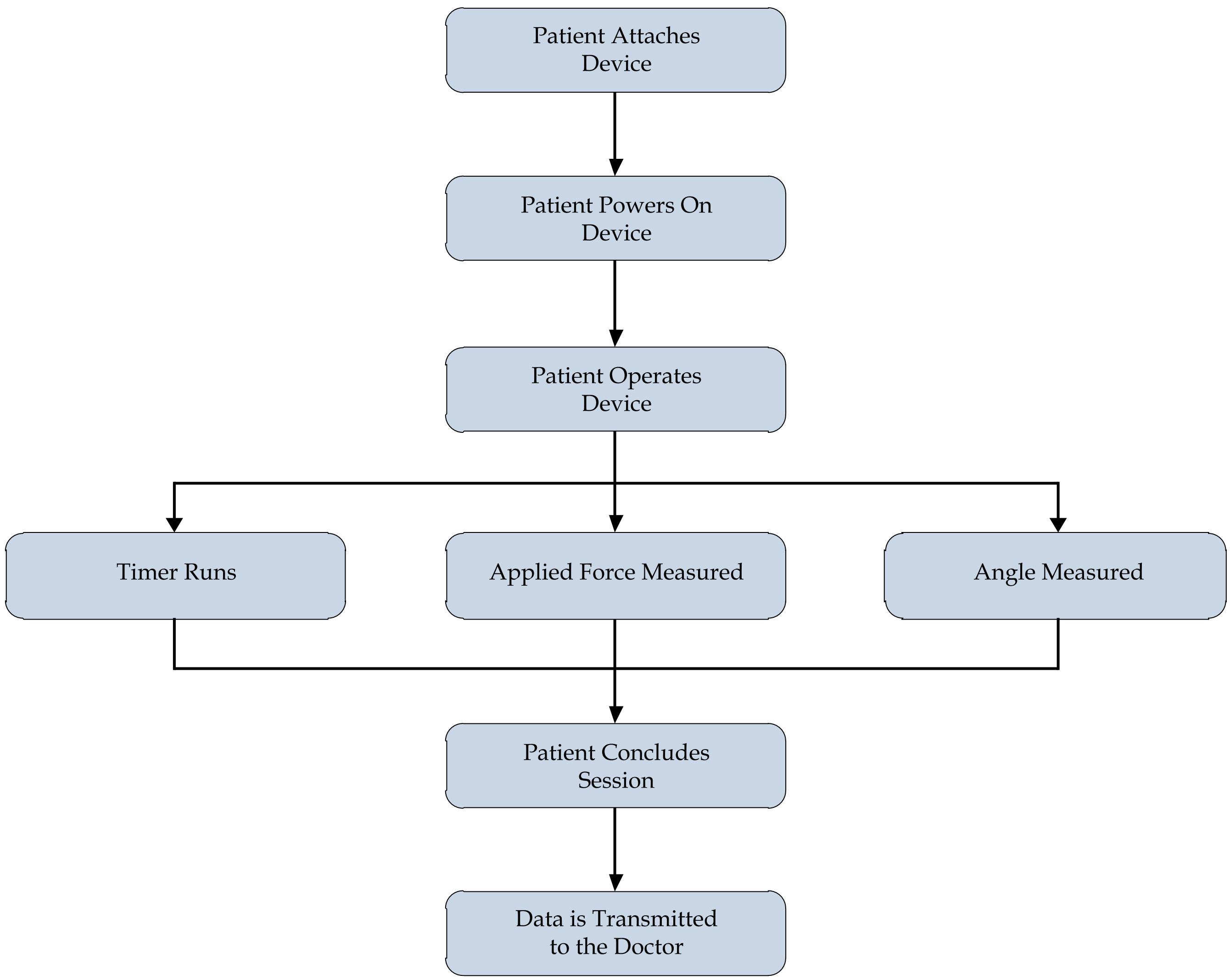

Fig. 11.2. System overview diagram.

WEARABLE MOUSE

Designers: Nasser Alhamlan, Onyekachukwu Igabari, David Lumpkin
Client Coordinator: Assistive Technology Partners, University of Colorado at Denver and Health Sciences Center
Supervising Professor: Dr. Irvin R. Jones
Electrical and Computer Engineering Department
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INTRODUCTION

The purpose of the project is to provide access to a computer and assistance to operate a computer for an injured individual with limited motor abilities in some part of their body. A human-computer interface is designed to enable such an individual to operate a computer. The interface simulates the cursor movements and functions of a standard computer mouse by interpreting gestures by the individual. Through a combination of hardware and software interfaces, all basic functionality (e.g. internet and email) of the computer is accessible.

In September 2007 the University of Denver received a project request to develop a computer interface for a patient with systematic nerve damage due to a spinal cord injury. The paralysis was total except for the patient's left arm and from the neck up. In addition the patient had no use of his hands, preventing the use of standard computing interfaces.

SUMMARY OF IMPACT

From the University of Alabama National Spinal Cord Injury (SCI) Statistical Center – (March 2002): 250,000 Americans are spinal cord injured. 52% of spinal cord injured individuals are considered paraplegic and 47% quadriplegic. Approximately 11,000 new injuries occur each year. SCI injuries are most commonly caused by vehicular accidents (37%), violence (28%), falls (21%), sports-related (6%), and other (8%). The most rapidly increasing cause of injuries is due to violence; vehicular accident injuries are decreasing in number. We can only assume that the number of spinal cord injuries will increase due to the wars in Afghanistan and Iraq.

TECHNICAL DESCRIPTION

The system includes a sensing device and a microprocessor integrated into a wearable human computer interface (Figure 11.4). The sensing device

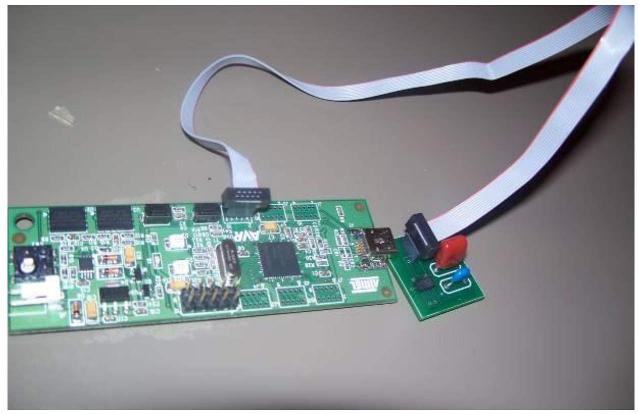

Fig. 11.3. Wearable Mouse Prototype.

is used to monitor the position and/or motion of the user's body part (e.g. arm). The microprocessor provides the interface to the computer system and implements the calculations necessary to interpret sensor data into mouse positioning and click data. The device is implemented on a wearable platform in the style of a wrist-guard. It is attached to the computer with a USB cable and is designed to be used while sitting in front of a computer system. The device is insulated to prevent electrical interference or damage to the components while the device is being used.

The sensor subsystem is an accelerometer. When the user moves, the motion is detected by the accelerometer and converted into cursor/mouse positioning data by the microcontroller (Figure 11.5). This data is sent to the computer over the USB cable. Additionally, the user is able to move in a predefined pattern, or gesture, to initiate a mouse click. The microcontroller interprets this motion as a click and sends the appropriate signal to the computer. The system is calibrated to work for a variety of users, but has methods for re-calibrating to a specific user's needs.

The cost of parts/materials was $128. The weight of the parts/materials was 15 grams.

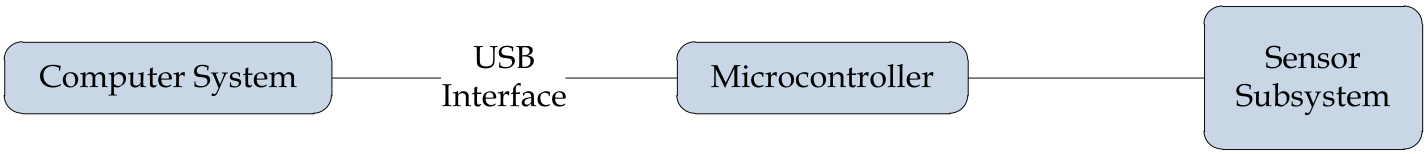

Fig. 12.4. System block diagram.

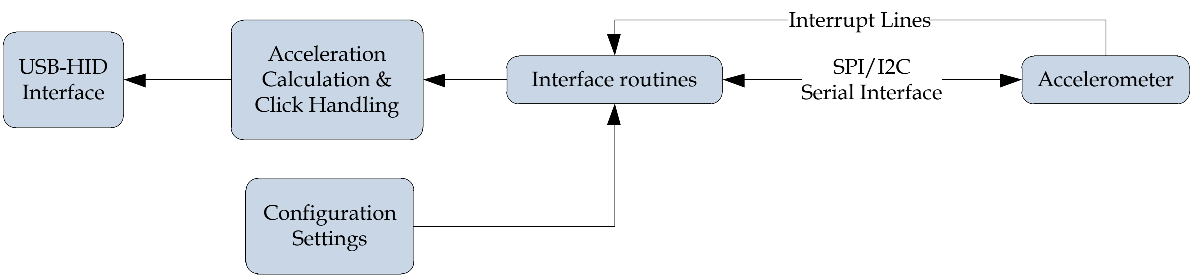

Fig. 11.5. Microcontroller interface diagram.

RECIPROCATING GAIT ORTHOSIS

Designers: Andrew Abarca, Scott Allen, Elizabeth Nottingham, Stephen Shirley
Client Coordinator: Dr. Harry "JR" Brandt, Sunrise Shoes and Pedorthis Service, Denver, CO
Supervising Professor: Dr. Corinne Lengsfeld
Mechanical and Materials Engineering Department
University of Denver,
Denver, CO 80208

INTRODUCTION

The inability for paraplegics to stand and walk cause several physiological complications such as pressure sores, urinary and intestinal stasis, accelerated osteoporosis, edema, spasticity and an increase in cardiovascular risk. To alleviate these problems numerous orthotic devices have been created to provide upright stance, as well as some level of mobility. This project is focused on the reciprocating gait orthosis (RGO).

SUMMARY OF IMPACT

In spite of the rapid evolution in orthotic design, these devices require high energy expenditure with low efficiency of energy to movement. Additionally, many patients complain of the bulk of the design that is difficult to put on and take off without assistance. On average it takes users 8 to 9 minutes to put on the device and 4 to 5 minutes to remove. Though 50 years has passed since the origin of the design, and numerous attempts at improvement, as many as 71% of all patients prescribed the device become non-users within one year.

Additional problems arise due to the costs involved with these devices. Some of these devices can cost as much $10,000 which is largely due to the manufacturing constraints as every device is completely customized to a single patient, eliminating the potential for mass production and economies of scale. Complete customization is also problematic, particularly for children, as height and weight changes of the patient require a completely new system.

TECHNICAL DESCRIPTION

The re-design elevates the position of the rocker bar and reduces the energy requirements for the RGO by 49%. Raising the rocker bar increases the ability to apply greater forces and torque to the mechanism. It utilizes the upper body muscles (shoulders) for rotation, instead of relying on hip abduction. This allows for greater rotation in the sagittal plane.

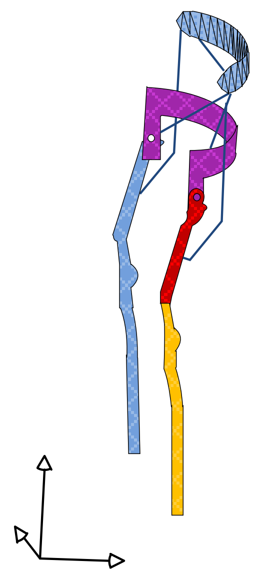

Fig. 11.6. Reciprocating gait orthosis frame.

The undesirable effects produced by raising the rocker bar are counter acted by the advancements of the new design. The same magnitude of rocker bar rotation produces a smaller displacement of the foot. More force needs to be applied to produce the same amount of displacement. This increases the amount of force that the moment arm experiences during gait. However, the increase in ability to generate rocker bar rotation counter-acts this decrease in displacement.

The cost of parts/material was about $500.

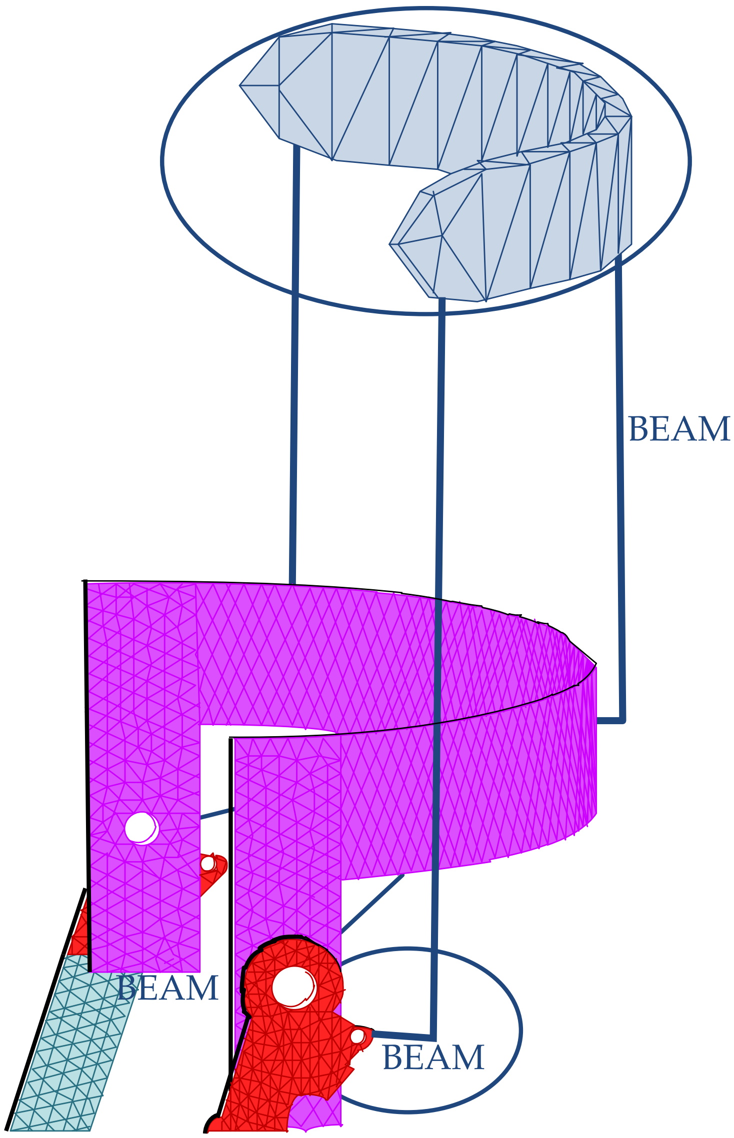

Fig. 11.7. Rocker bar redesign.

CHAPTER 12
UNIVERSITY OF MASSACHUSETTS AT LOWELL

Department of Electrical and Computer Engineering
University of Massachusetts Lowell,
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MATCHING CARD GAME: A GAME THAT INVOLVES EASILY MODIFIED MATCHING CARDS AND PROVIDES VISUAL ANSWERS

Designer: Christine Brunelle
Client Coordinator: Karen, Brookside Elementary School, Dracut MA
Supervising Professor: Alan Rux
Electrical and Computer Engineering Department
University of Massachusetts, Lowell,
Lowell, MA 01854

INTRODUCTION

The Matching Card Game was conceived as an upgrade to the current equipment that the kindergarten classroom of the Brookside Elementary School in Dracut, MA. The device has ten slots with pictures behind them. These slots accept cards with the same pictures. When a card is inserted into a slot, the box determines whether the right card is 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, then a green light turns on and a musical tune will play, whereas if a wrong card is put into the wrong slot, a red light turns on and a buzzing sound is heard. The Matching Card Game is meant to be a learning tool for mentally and physically disabled children. The pictures on the cards are easily modified at the discretion of the teacher. The game idea came from the system already in place (See Figure 11.1), which requires the teacher's attention at all times to provide the necessary correction to the child's action. The Matching Card Game is an independent learning tool, so the teacher can set up what he/she wants the student to study, and leave the child alone to learn. The ultimate goal of this project is to create a universal independent learning device that can be modified according to the teacher's discretion.

SUMMARY OF IMPACT

This device allows a teacher to place in front of a student the desired learning lesson, such as matching colors, to work on the project independently. In this fashion, the teacher can focus their attention on other children in the classroom. The game helps the student as well, by allowing them a sense of independent accomplishment. The game is easily modified to do something more complicated than matching colors, for example, it could be used in higher level classes to learn the multiplication tables.

TECHNICAL DESCRIPTION

The game has four main parts: optical switches, multiplexers, a microcontroller, and light emitting diodes (LEDS). Four optical switches are put in each slot to allow for a binary number up to ten. Each card has notches or holes in a particular order that is inherent to the correct slot for that card. When a card is inserted, the outputs from the optical switches go to the multiplexers to be fed into the microcontroller. The microcontroller then determines whether the input is correct for that slot and outputs accordingly, and then switches to the next slot and so on. In this scrolling manner, the microcontroller operates the multiplexers to read slots one through ten sequentially, and constantly check the status of the slot.

The components are placed in a box made of ABS plastic due to the nature of the classroom that it is used in. The optical switches (H21A1, 40 total) are chosen because they were slotted. The multiplexers (74150, 4 total) are 16-1 bit converters so that the microcontroller (Basic Stamp BS2p40, 1 total) scrolls between slots and have a parallel input. At the request of the teacher, large green LED's are used in comparison to the red LED's.

The cost of parts/material was about $300.

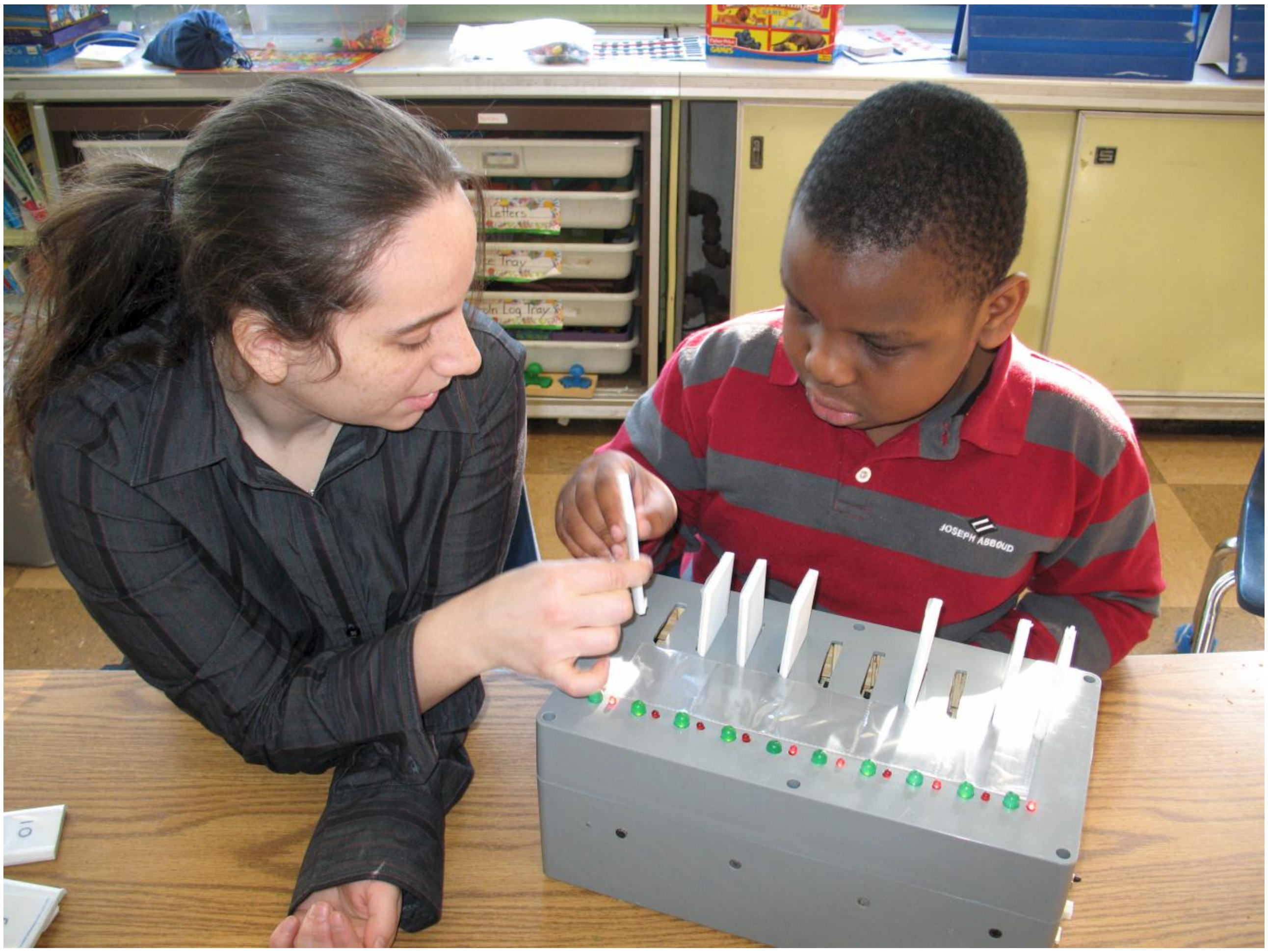

Fig. 12.1. A student showing the device to the client.

TOUCH SCREEN GAMES: SOFTWARE PROVIDING LEARNING ACTIVITIES, CURRICULUM REINFORCEMENT, AND CAUSE AND EFFECT STIMULATION

Designer: Dan Emerson
Client Coordinator: Marie Haggerty, Shore Educational Collaborative, Chelsea MA
Advisor: Jay Fu
Electrical and Computer Engineering Department
University of Massachusetts, Lowell,
Lowell, MA 01854

INTRODUCTION

Touch Screen Games is designed to provide learning activities and curriculum reinforcement, along with cause and effect stimulation, for students of the Shore Educational Collaborative in Chelsea MA. These students benefit from multiple types of learning activities, such as vocabulary, counting, tracing, ordering and simple puzzle games that using a touch screen monitor. All of the activities have some level of curriculum reinforcement and motor skill development. The Touch Screen Games presented here replaces an already existing software/hardware device that uses a custom designed infrared sensor that senses a touch on either side of the screen. By using open source licensing, Touch Screen Games provides improved functionality and is available to any individual or group who can benefit from its use.

SUMMARY OF IMPACT

Touch Screen Games improves the available benefits of the previous device by using a fully active touch screen monitor. These new games are made available by using an actual touch screen monitor

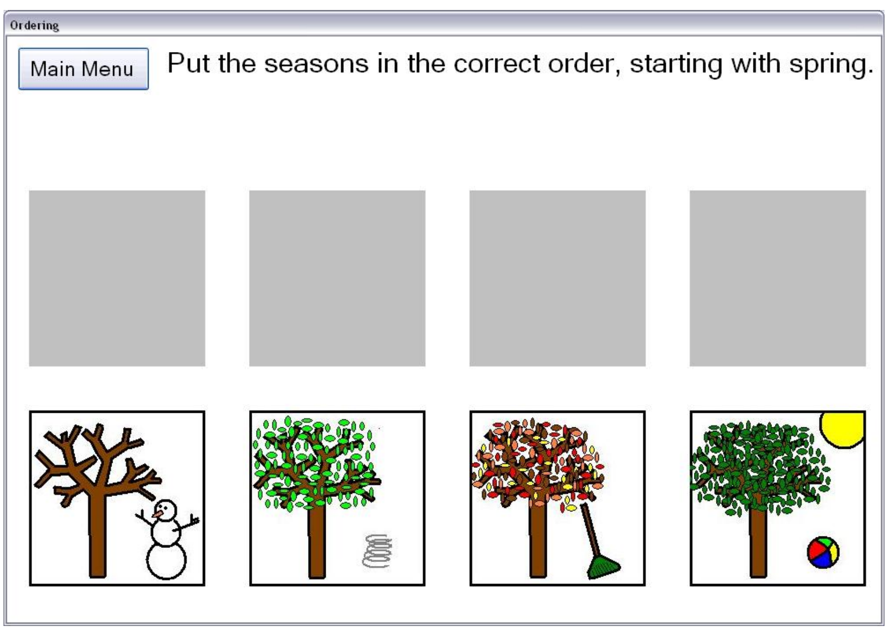

Fig. 12.2. Touch screen games in action – ordering seasons.

that adds more fine motor skill and cause and effect stimulation than those that were available with the custom designed hardware. Touch Screen Games provides educators with an extra and more powerful tool that combines classroom learning with motor skill development, and cause and effect experimentation.

TECHNICAL DESCRIPTION

Touch Screen Games is built in Microsoft Visual Basic Express Edition 2005. The Visual Studio family provides tools for efficient and effective user interface design linked to a wide range of programming languages. Visual Basic, as a programming language, is well suited to user driven programs and less intensive coding. Writing Touch Screen Games in Visual Basic allowed for more time for focusing on designing the content of the activities rather than on building user interface and dealing with more complex programming schemes that come with other programming languages.

The user inputs to Touch Screen Games are understood as mouse actions. By using Visual Basic's generic MouseDown, MouseUp, MouseMove, and Click functions, Touch Screen Games receives input from any device functioning as a computer mouse. Touch Screen Games can use "off the shelf" touch screen hardware rather than rely on custom designed interfacing hardware. A G-Vision L15AX-JA-452G 15" serial touch screen LCD monitor is to be used with Touch Screen Games.

In Touch Screen Games, counting and vocabulary activities function very similarly. Counting activities present a number of objects to the user and display two possible answers. Vocabulary activities either display an object to the user and present two possible answers, or display multiple objects and ask the user to find a specific one. To do this, the software generates a random number defining the correct answer. This number is checked against the previously used correct answer to ensure that the program doesn't repeatedly ask the same question. The program then generates another random number to define the wrong answer. If the wrong answer is the same as the correct answer, the value is regenerated. Based on the type of game, the picture boxes are filled in with the correct images. When the user clicks or touches an answer, a check is done to decide whether or not it is the correct answer. If so, the form is reloaded, and then a counter is incremented. If the counter reaches a certain value, a congratulatory message is displayed to the user. If the counter has not been reached, the form is reloaded and the next question is asked. If the user clicks the wrong answer, they are told that it is wrong and the form is reloaded.

Ordering and Puzzle games use similar image dragging code to make available different activities to the user. In the ordering activities, a set of images is displayed to the user in a random predetermined order. The user is then asked to move the images into the correct order. For the puzzle game activities, certain images must be moved to certain locations while avoiding other locations. In each type of activity, when the dragging code senses a 'MouseDown' on an image, it records that mouse down coordinate and enables dragging. If the mouse moves over that image while dragging is enabled, the mouse down and mouse move coordinates are translated to the form coordinate system and the image is moved. For both activity types, timers are set to constantly check the location of the movable objects and act accordingly. If they are in the final location, the congratulatory message is displayed. If they are somewhere they are not allowed to be, the image is moved back to the original location.

Tracing activities allow the user to follow directions and trace a pattern. The different lines involved in tracing a shape are defined as different stages. An image is displayed with a starting and ending point for that stage of the drawing. If the user mouses down on the starting point, a graphic is drawn following their line. If they trace too far outside a determined bound, the image is reset and the stage is set back to the first. If the user mouses up inside the proper end point for that stage, the next stage is loaded. If all the stages of the drawing have been completed, the congratulatory message is displayed.

The only cost of Touch Screen Games is the touch screen monitor, costing approximately $330.

INTERACTIVE TACTILE BALL: A DEVICE FOR ENFORCING CAUSE AND EFFECT RELATIONSHIPS

Designer: David Smith
Client: Susan - LifeLinks Inc.
Supervising Professor: Alan Rux
Electrical and Computer Engineering Department
University of Massachusetts, Lowell,
Lowell, MA 01854

INTRODUCTION

The interactive tactile ball was designed to reinforce cause and effect relationship. By rewarding interaction with the ball by lights blinking and children's music playing, a student is engaged and causal events are reinforced. The goal is to use a soft ball to focus on three areas of learning for the students with two modes of operation. The first was cause and effect—with a simple feedback mode, touching the brightly colored circles gave a positive feedback, reinforcing cause and effect. Colored circles on the surface the ball act as switches and are textured, providing tactile feedback to the students. The game mode provides the third learning mode, memory. The student must remember which light turned on and touch the appropriate light for a positive feedback. Touching the wrong switch cued a negative feedback.

SUMMARY OF IMPACT

LifeLinks needed a device to reinforce cause and effect. The interactive tactile ball described here is a tool to engage their clients. As such, LifeLinks required a device versatile enough for use by students of varying degree of disability, and plush enough to not worry about injury. The self-contained toy stimulated the student for long periods of time, as well as provided positive and negative feedback in their lives. Operation of the interactive ball does not require actions to be performed by the teacher except to change it from simple feedback to the game mode.

TECHNICAL DESCRIPTION

The main structure of the interactive tactile ball is a foam soccer ball eight inches in diameter. It is cut in half, hollow in the center for batteries and electronics and has holes drilled out to fit the input switches, output lights and speaker. The ball is held together by Velcro and an outdoor-grade rip-stop nylon shell that covers the ball to ensure a waterproof and rugged exterior. The lights on the outside are high-efficiency light emitting diodes (LEDs) to provide the maximum brightness at the lowest power consumption. The switches are momentary pushbutton switches that are normally off and turn on when pressure is applied.

Fig. 12.3. The interactive tactile ball.

The electronics that control the output of the device are divided into three groups. The first is I/O formatting. This takes inputs from six switches and encodes it into a binary coded decimal input to the microprocessor. It also takes three coded outputs from the microprocessor and selects one output to turn on one set of LEDs. The second section of electronics is the sound playback chip. This chip was recorded previously, and when used it receives an address from the microprocessor and plays a sound message. The music is played through a speaker that is mounted near the surface of the ball but is under a small amount of protective foam. The last section of electronics is the microprocessor, which controls the operation of the device. The inputs to the system are a switch governing simple feedback or game mode, and six switches that tell the microprocessor which button has been activated. The outputs of the microprocessor are the LED, a signal to tell the chip when to play, and a signal to turn the system off when it has been inactive for a period of time.

When the device is activated, it determines if it is in game mode or simple feedback mode. If in simple mode, it outputs addresses for the correct sound message and plays the sound and then blinks the corresponding LEDs. If the game switch is activated, a random switch is selected and blinks. The user must activate the corresponding switch for music to play. If the wrong switch is activated, a negative feedback message is played, telling the user to "try again." Once the correct switch is activated and music is played, a new random switch is selected and lights up. If no switch is activated, the system powers itself off.

The whole system is battery powered, and parts are selected based on their power consumption to maximize battery life. This, coupled with the self-power off and on configuration switch allows minimal set-up and carefree operation.

The cost of this device is about $120.

Fig. 12.4. Student with interactive tactile ball and clients.

THE REMOTE CONTROLLED TRICYCLE: A WIRELESSLY CONTROLLED TRICYCLE THAT HANDICAPPED AND MENTALLY CHALLENGED PATIENTS CAN USE

Designer: Emile Dagher
Client/Organization: Bob Zalis & Brooke, Hogan Center, Danvers MA
Supervising Professor: John Fairchild
Electrical and Computer Engineering Department
University of Massachusetts, Lowell,
Lowell, MA 01854

INTRODUCTION

The purpose of this project is to provide caregivers a way to control a motorized tricycle. Control is accomplished wirelessly, which eliminates any physical contact between the caregiver and the person riding the tricycle. The device is helpful especially for those who do not have the power to ride the tricycle themselves.

Using the remote control, the caregiver controls the forward and backward movement of the tricycle. Because there is no physical contact between the patient and the person controlling the tricycle, safety measures and controls are implemented in the design to keep the tricycle and its rider as safe as possible. The tricycle can be stopped by a click of a button from the remote control.

Compatibility, simplicity and ease of use have made this project a great success.

SUMMARY OF IMPACT

The idea for this project came from a nurse working at the Hogan Center in Danvers, MA. The patient using this device has physical and mental disabilities. She loves riding her tricycle around the Hogan Center. Because she does not have the power to pedal a tricycle herself, the nurse pushes her around on the tricycle.

The nurse suffers back pain after pushing the tricycle for long period of times. She has suggested having the tricycle motorized and controlled using a remote control. When the tricycle moves, the patient pedals along. By pedaling, the patient trains her muscles and develops more power in her legs. The goal for the patient is to ride the tricycle herself in the near future.

Fig. 12.5. The remote controlled tricycle.

TECHNICAL DESCRIPTION

Both parts of the project, the transmitting side (remote control) and the receiving side are designed using very simple and basic techniques. Easy to use ICs along with the use of Parallax Inc.'s Basic Stamp microcontroller and Crydom Co's power relays helped make this design simple and easy to operate.

The remote control uses switches and push buttons to send data. Data is encoded and converted into a serial data, which then gets amplified and modulated at 434MHz. The data signal is then transmitted to the receiver.

At the receiver, the RF signal is demodulated and decoded into 4 parallel data lines. Data is then processed by the basic stamp microcontroller, which controls relays, brakes and the movement of the tricycle. This flow of data is illustrated in Figure 12.7.

Fig. 12.6. Remote Control.

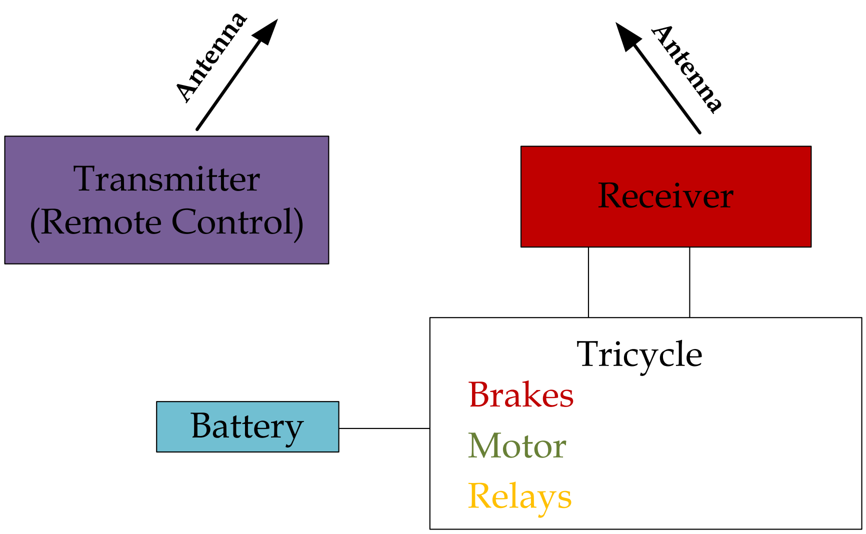

Fig. 12.7. Flow of data between components.

PROVIDING A TOUCH OF INDEPENDENCE: A SWITCH ACTIVATED ENVIRONMENTAL CONTROL SYSTEM

Designer: Frank M. Lentine
Supervising Professor: Jay Fu
Department of Electrical and Computer Engineering
University of Massachusetts - Lowell
Lowell, MA 01854-5104

INTRODUCTION

The Touch of Independence (TI) is designed to enable a client with limited motor control to control electrical devices within his immediate surroundings. This device consists of a transmitter and several receivers that provide remote ON / OFF functionality for any AC-powered devices within the client's room. The TI is activated by depressing a pair of large buttons mounted to the client's bed. The ability to simply turn on and off devices in his immediate surroundings provides the client with a

Fig. 12.8. The touch of independence.

level of independence he has never previously experienced. Prior to receiving the TI, the client was completely at the mercy of the aides he relies upon. Simple desires, such as turning on a light or the television, required the client to get the attention of an aide to provide assistance.

SUMMARY OF IMPACT

The design criteria for the TI are defined by the extremely limited capabilities of the client. With concentration, he has partial control over his left hand and head, with a large amount of concentration. But the left hand lacks any fine motor skills. Aside from his left hand and head, he has no muscle control and cannot leave his bed without assistance from an aide. The client is also essentially non-verbal. Thus the TI had to be simple to use, touch activated, and provide control over essential devices in the client's environment. Control of both a bedside lamp and a television were deemed essential to meet the goal of providing the client with some level of independence. The TI provides an essential need (turning on a lamp without assistance) in addition to an enjoyable desire (the ability to turn on a television without assistance). The TI thus gives the client some control over decisions regarding his environment, in addition to reducing the level of dependence the client has on his aides while relaxing in his room.

TECHNICAL DESCRIPTION

The TI consists of two major functional units. A single transmitter module controls two wireless receiver modules. The ability to control a third device is built into the transmitter, allowing expandability should the client desire it.

The transmitter module is based on a PIC 12F509 microcontroller running on a 4 MHz clock provided by an Epson SG31P oscillator. This microcontroller sleeps, to conserve battery power, until the client presses a button. By pressing a button, the corresponding input to the microcontroller is pulled low. Upon this change of state to the input, the microcontroller encodes the current state of the inputs using the Manchester Encoding Scheme. This encoded data is then sent serially from the PIC 12F509 microcontroller to a Rentron TWS-434 RF transmitter. The transmitter then transmits this serial data stream as a 434 MHz wireless RF signal. The transmitter module consists of a small box that is easily slipped under the client's bed. Two 1/8" jacks are provided as inputs to the device. A pair of Able net Jellybean switches are mounted to the client's bed and plugged into the transmitter module to provide the client-to-device interface. A benefit of this design is the ability to easily change the actual client-to-device interface should the client's abilities change. The PIC 12F509, RF transmitter, and oscillator are powered by a single 9V battery, which is then down-converted to 5VDC internal to the device.

The receiver module is also based on a PIC 12F509 microcontroller running on a 4MHz clock provided by an SG31P oscillator. When the RWS-434 RF receiver receives a wireless signal from the transmitter module, it outputs the serial data received to the PIC 12F509. The microcontroller then decodes this serial data and compares it to the current output states of the two outputs. If the input data does not match the current state for one of the outputs, that output is toggled. Each receiver unit has a single output circuit connected to a different output of the microcontroller. This allows each of the two buttons on the transmitter module to control a different receiver module. This output circuit consists of a transistor and a pair of resistors intended to increase the output current of the microcontroller. This output is then applied to a Crydom CDS-2410 solid state relay to switch AC power to the target device on or off using a DC input. The 120 VAC provided to the relay comes into the receiver unit from a standard AC wall plug. The relay output is then applied to an AC jack, similar to those on the walls of most homes, on the receiver unit. This jack provides power to the device under control.

The cost of parts/material is approximately $250.

REMOTE CONTROL OPERATED FOOD DISPENSER

Designer: Hitesh Amin
Client Coordinator: Jill Siebeking, Helping Hands Monkey Helper.
Supervising Professor: Jay Fu
Department of Electrical and Computer Engineering
University of Massachusetts, Lowell
Lowell, MA, 01854

INTRODUCTION

The objective of this project is to design a wireless remote control to operate a food dispenser. The project was delivered to Helping Hands Monkey Helper, located in Cambridge MA. They train monkeys to help people with a spinal cord injury. These monkeys act as a care taker by doing routine work such as pick up a remote control, pills, phone from the floor, to turn on the lights and more. One of the monkeys that they have trained does not go inside a cage after helping the client, so they decided to put a food dispenser with wired switch inside the cage, which provides food as an incentive to go inside a cage. However, few times a monkey broke the wire by mistake, so based on the need a prototype of the Remote Control Operated Food Dispenser was designed.

SUMMARY OF IMPACT

With this new design, the client does not have to be concerned about wires anymore. Finally, the client does not need any assistance to turn on the device, as she does presently. She can turn on the device by herself just by pushing a button. Moreover, very small amount of food will be provided to a monkey every time. The Helping Hands can also use this device while they train other monkeys.

TECHNICAL DESCRIPTION

The device consists of two units: a transmitter and a receiver. A TWS-434A, Holtek HT-12E, encodes the IC and jelly bean switches used by the transmitter. The oscillator resistor (Rosc) for HT–12E is determined by using the oscillator frequency vs. supply voltage graph provided in the data sheet of HT–12E. The receiver is designed using RWS–434 and Holtek HT-12D decoder IC. The oscillator resistor (Rosc) for HT-12D is determined by using an equation "fosc(decoder)=50fosc(encoder)" and the graph provided in HT-12D data sheet. To regulate

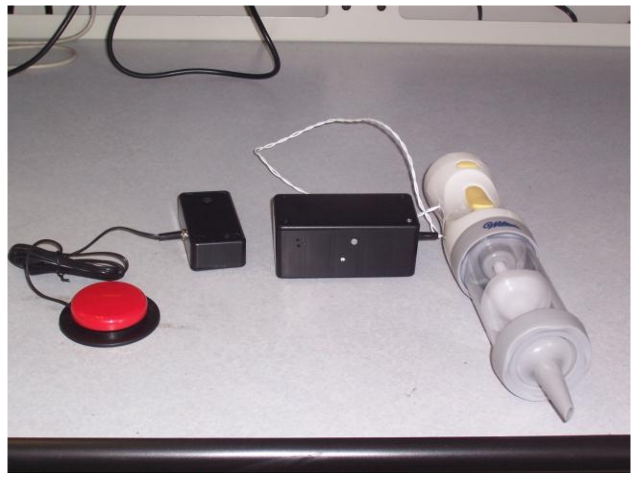

Fig. 12.9. Final project.

Fig. 12.10. Coordinator of helping hands.

the amount of peanut butter or cream cheese dispensed, the food dispenser needs to be ON for one second or less. So, using LM555 timer IC, the monostable timer circuit is designed, and instead of connecting data output of HT–12D directly to the solid state relay, it is connected to the timer circuit. It also solves another problem such as when the switch is pressed for longer time by mistake, the relay will not operate for more than a second. The output pin of LM555 is connected to the base of 2N3904 transistor through 10KΩ resistor. The 10 kΩ resistor is connected to the base of a transistor to convert the changing current to a changing voltage, and to amplify the voltage. The collector of a transistor is connected to the solid state relay. The 1N4001 diode is connected across the relay to protect the transistor from damage when the load is switched off. The relay is used as a switch to turn on the food dispenser. A cordless cookie press is used as a food dispenser, which is operated with 4 AA batteries.

When the jelly bean switch is pressed, it sends the data in a binary code to an encoder. The binary signals are encoded based on HT – 12E's preprogrammed address setting A0- A9. Data from encoder IC is sent to the data input of TWS -434A by a square wave. Then, the input data is transmitted through the TWS – 434A and is received by a receiver. The RWS – 434 converts a radio wave into a square wave and sends the digital data output waveforms to the HT – 12D decoder, the decoder converts the data into binary impulses. The voltage change at the Data output of HT-12D triggers the flip-flop in LM555 timer, and releases the short circuit across the capacitor and drives the output high. The voltage across the capacitor then increases exponentially for a period of t = 1.1 RC. For this time t, relay connected to the timer through a transistor receives high voltage and stays ON. That completes the circuit between pin 4 and 3 of the relay and turns ON the food dispenser.

The transmitter is powered using two AAA batteries, since The TWS – 434 operates from 1.5V to 12V DC. HT – 12E operates between 2.4V – 5V DC. The lifetime for these batteries is 36 days. The RWS-434 operates between 4.5V to 5.5V DC, HT-12D, LM555 and solid-state relay operates at 3.2V DC. The receiver is powered using 4.8V, AC to DC power adapter.

The total cost for this project is $97.00.

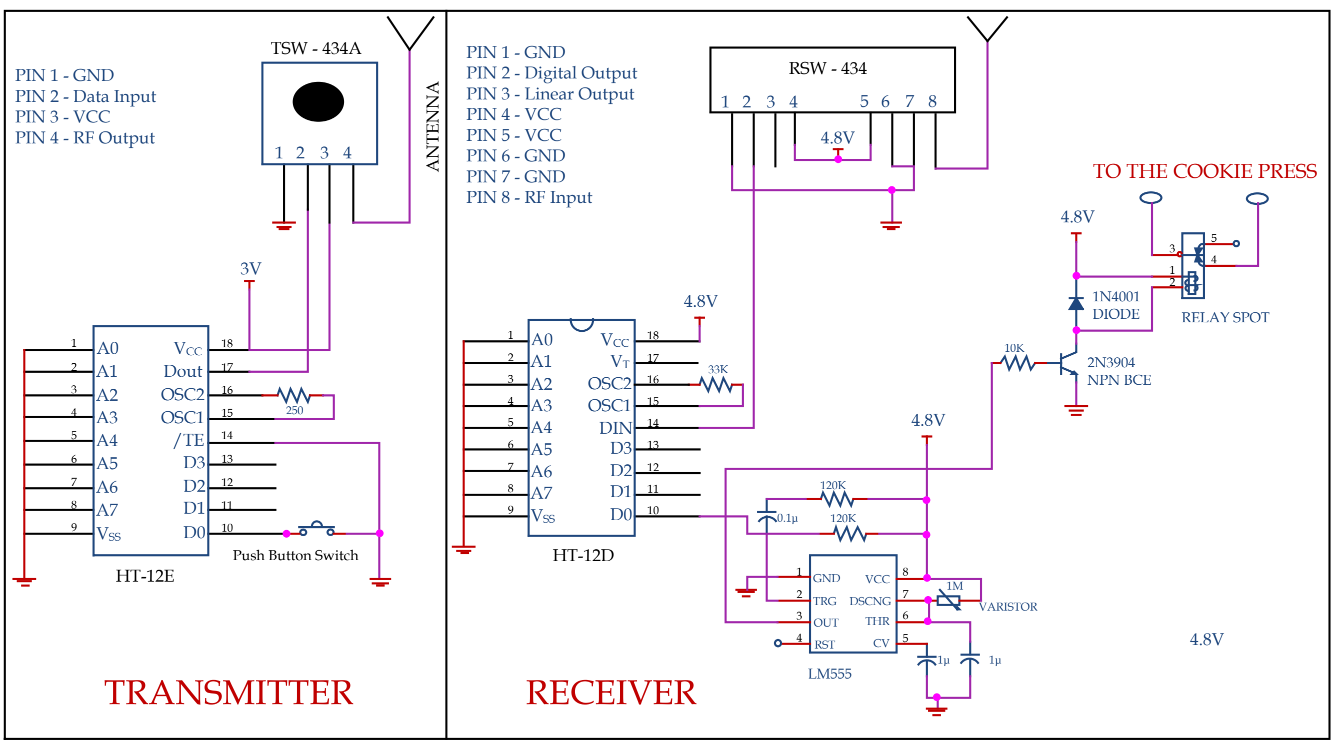

Fig. 12.11. Schematic of transmitter and receiver.

SPEECH TRAINER

Designer: Iliana Voynichka
Client Coordinators: Marie Haggerty, Jeff Baehrend
Supervising Professor: Alan Rux
Department of Electrical and Computer Engineering
University of Massachusetts Lowell,
Lowell, MA 01854

INTRODUCTION

The Speech Trainer is designed to help people with speech disabilities improve their communication skills. The device was not tailored for a specific client, but for classroom use by all students. With this in consideration, it had to be 1) safe, 2) portable, 3) easy to use, and 4) adaptable to different users. The device has four buttons, a record/playback switch, a difficulty selection switch, light emitting diodes (LEDs), a microphone and a speaker; it is powered by four AA batteries. The Speech Trainer operates by having four words recorded to it by a speech therapist, and then listening to a student pronounce those words and determining if they were said correctly.

There are not many tools on the market to help people with speech disorders improve their verbal skills. Most available devices act as a talking box

Fig. 12.12. A Client using the speech trainer.

and generate phrases and words instead of the person using them. The speech trainer could be used as a speech-generating device, but its main goal is to help the user improve his or her communication skills.

SUMMARY OF IMPACT

The Speech Trainer lets people with speech disabilities practice their verbal skills in a fun and easy manner. The client can use this device even when their speech therapist is not there to help them. The device listens to the way the word is pronounced and determines if it is correct. It lets the user try three times before concluding that the word is wrong.

TECHNICAL DESCRIPTION

The main components of the Speech Trainer are record and playback chip (ISD2560), microcontroller (Basic Stamp) and voice recognition chip (VR Stamp).

The ISD chip is used to record and play the words or phrases to be practiced. The VR stamp saves a template of the acoustic characteristics of the recorded word, and later compares it to the spoken word to determine if it is correct or not. The programming capabilities of the VR Stamp allows the user to be able to select between three levels of difficulty: 1 – less strict, 2 – medium, 3 – very strict. This provides people with severe speech impairment with more flexibility. The Basic Stamp controls the operation of the ISD chip, the VR Stamp and the push buttons and switches.

To record a word, the switch is put in record position, one of the four buttons is pressed and the desired word is spoken into the microphone. The user has to say the word twice in order to train the voice recognition chip. To indicate that recording is in progress, a red light emitting diode (LED) lights up when the user is prompted to say the word again. The voice recognition stores the characteristics of the spoken word in memory during the record cycle. To practice a word, the switch is put in playback position, a level of difficulty is selected for the voice recognition, and the button associated with that word is pressed. The recorded word is played back and the user is prompted to repeat it. The VR Stamp then compares the spoken word to the original one. If they are the same, a message is played and the LED associated with the word lights up. If they aren't the same, the user is given two more tries to say the word, if he or she doesn't succeed, the device beeps and the practice cycle is over. The Block Diagram in Figure 12.13 depicts the connections between the different components.

The approximate cost of the project is $250.

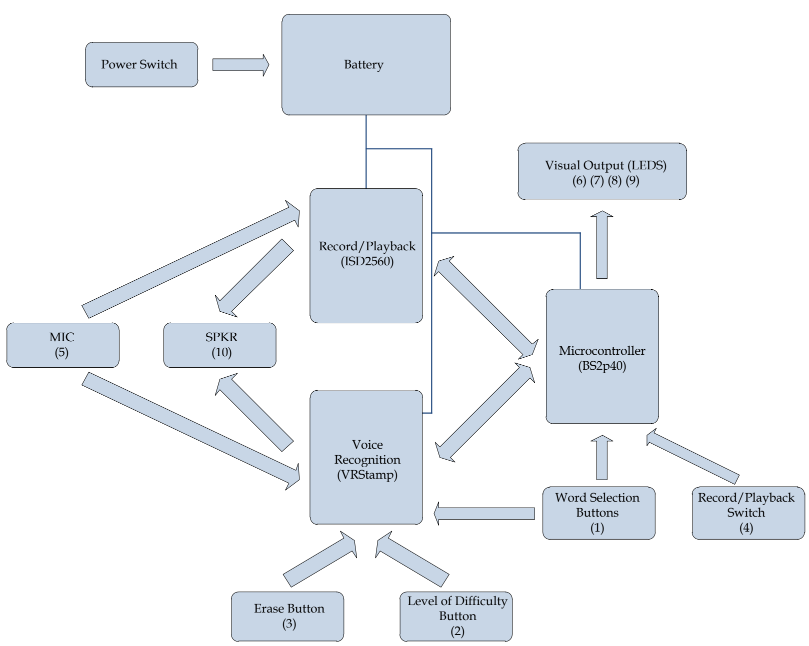

Fig. 12.13. Speech trainer block diagram.

AUTOMATED LASER POINTING DEVICE FOR CAPUCHIN MONKEY HELPERS

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 Lowell
Lowell, MA, 01854

INTRODUCTION

The automated laser pointing device enables people with limited mobility to point to object(s) in their environment. Capuchin monkey helpers are trained to respond to the laser 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. Upon completion, the automated laser pointer was presented to Helping Hands Monkey Helpers in Boston, MA. Their clients have very limited mobility and have trouble manipulating a laser pointer to identify objects in their environment. This device allows them to have more control over their environment and decreases their dependence on their caretakers.

SUMMARY OF IMPACT

Helping Hands of Boston is a nonprofit organization that breeds, raises and trains capuchin monkeys to assist people with limited mobility. Many of their clients have spinal cord injuries. One method of training involves the use of the laser pointer to point to an object(s) in the room. The monkeys are trained to retrieve the selected object(s) for the client. They can also be trained to perform a task in response to the laser. The client may experience trouble physically manipulating a laser pointer to point out an object. To alleviate this problem, they will instead maneuver a small joystick to position the laser on the desired object. This device allows their clients to take control of the laser pointing device and become more independent.

TECHNICAL DESCRIPTION

The automated laser pointer was realized with two separate modules; a transmitter and a receiver (see Figure 12.15). The transmitter module is a wireless handheld unit. It has an on/off switch, a button and 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 also contains a microcontroller running another small program to control its operation. The laser is mounted on two servos, and all of them are directly connected to the receiver via

Fig. 12.14. Student with a trained capuchin monkey.

a cable. It has an on/off 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 a slow movement of the laser. For coarse adjustments, large deviation from the central axis results in a fast movement of the laser. Once the laser is positioned correctly, the client activates the button to excite the laser. Exciting the laser simply 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 this state and positions the laser accordingly by sending pulse-width-modulated (PWM) signals to the servos.

The device is intended to operate indoors, specifically in a room 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 a wheelchair, table or 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 providing 5 V and 10 W. The transmitter module consumes less than 8 mA during normal operation and is powered by four AA batteries, providing 4.8 volts and 2500mAh.

The cost of parts/material for one unit is less than $300.

Fig. 12.15. Automated laser pointing device.

THE SOAP DISPENSER: A CUSTOMIZED AUTOMATED SOAP DISPENSER FOR A CHILD WITH CEREBRAL PALSY

Designer: Mark Houseman
Client Coordinator: Bethany Campbell, Forestdale Memorial School, Malden, MA
Supervising Professor: Chuck Maffeo
Electrical and Computer Engineering Department
University of Massachusetts, Lowell,
Lowell, MA 01854

INTRODUCTION

The Soap Dispenser (SD) is an automated soap distributor that provides an independently operable method of hand hygiene for persons with disabilities. Commercially available dispensers dispense soap downward, but not every disabled person wants soap dispensed downward. Additionally, most high end automated soap dispensers are mountable rather than mobile countertop devices. The SD is an alternative to commercially available dispensers that meets the needs of persons with disabilities by dispensing soap sideways into a shallow dish, while retaining the ability to be easily relocated.

SUMMARY OF IMPACT

The SD is designed to dispense soap frequently, efficiently, and without adult assistance to a child with Cerebral Palsy. Most soap dispensers require some form of muscle contraction on the part of the operator for soap to be dispensed. My client lacks the ability to grip tightly with his hands, and the ability to rotate his palm to face upwards. As a result, he requires assistance any time he wants to wash his hands. The SD uses an infrared sensor to detect motion, which triggers soap dispensation into a shallow dish. Additionally, the SD is easily used without rotating the hand palm upward. The SD is shown in Figure 12.16.

The design of the SD is defined to meet the needs of a student with Cerebral Palsy who is currently attending the Forestdale Memorial School. The class of children with disabilities at Forestdale Memorial School ranges from ten to fifteen students. The ratio of teacher to students varies depending on the number of helpers a teacher has on a given day, but can be averaged as one to five. Any time spent washing hands with one student is time taken away from the rest of the students. With the SD, my client is able to wash his hands without taking up large amounts of the teachers' time.

TECHNICAL DESCRIPTION

The housing for the SD is made from 3/4 inch wide aluminum tubing, 26 gauge steel plating, 16 gauge steel plating and 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 the strength need for the SD to survive an impact and the painted fiberglass provides water resistance, as well as giving the dispenser a more finished look.

The dispenser has a 3300mAh battery which allows for operation in locations without a nearby AC outlet, but the battery must be recharged once a week by plugging an AC wall adapter into a power jack on the SD. The battery offers the advantage of operating the SD near a sink without also having an AC wall adapter near the sink. Furthermore, the battery is a NiMH, which has the advantage over NiCd batteries of being unchanged by the "memory effect". The "memory effect" is where a battery is recharged before it is completely drained, and loses overall potential capacity. The charging circuit is monitored by a BQ2002T IC. The BQ2002T monitors the battery voltage using a voltage divider, and monitors the battery temperature using 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 an ISD1400 sound chip, a solenoid valve, and a linear solenoid. The ISD1400 sound chip plays a sound, and then the solenoid valve opens enabling soap to flow through the nozzle of the dispenser. After that, the linear solenoid 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 plays back seven consecutive noises before playing a noise that was already played. The audio playback can be toggled on or off using a switch located on the back of the dispenser. The switch is easily used by an adult, but cannot be used by a child with Cerebral Palsy.

The cost of parts and materials was about $600.

Fig. 12.16. The soap dispenser.

THE VOICE CONTROL SYSTEM (VCS): A LANGUAGE INDEPENDENT VOICE CONTROL SYSTEM FOR A PC MOUSE, TELEPHONE, AND TOYS

Designer: Michael Darish
Client Coordinator: John Fairchild
Supervising Professor: Alan Rux,
Electrical and Computer Engineering Department
University of Massachusetts, Lowell,
Lowell, MA 01854

INTRODUCTION

The Voice Control System (VCS) is designed and developed for a five year old girl (client) from Italy to provide her with the ability to control the PC mouse functions using only her voice – specifically the click, drag, drop, and double click functions.

The girl has quadriplegia due to a car accident and is limited in what she could do for herself. She needed the ability to accurately control the PC mouse so she can do homework when she entered school. Although the client's father searched all over Italy, Europe, and the much of the USA, he could not find an acceptable PC mouse (mouse) click, drag, and drop control solution and asked if it was possible to design a system that would use his daughter's voice. The father mentioned that he had a solution for moving the mouse cursor around the screen with a device named Tracker Pro, but it did not meet his daughter's "click" control requirements for school assignments. Since the client is on a ventilator and does not read due to her age, commercially available voice recognition products are too difficult for the client to learn due to the amount of talking time required to initially train these products. Also, these products are designed primarily for the English speaker, and the client speaks only Italian. Additionally, using only voice commands, she now has use of a telephone and has the ability to turn on three toys.

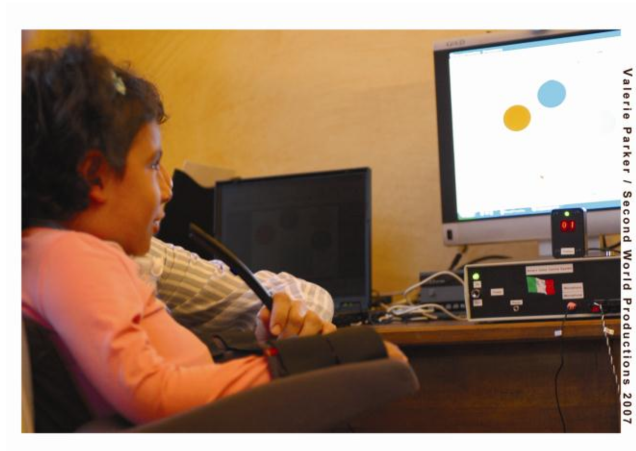

Fig. 12.17. Girl using voice control system.

Fig. 12.18. Voice control system.

SUMMARY OF IMPACT

The design of the VCS is determined by my clients' limited control over her environment and the client's father's request for a device that would provide voice control of PC mouse functions – specifically the click, drag, and drop. Additional functions were added in order to expand the clients' ability to control her world. This device provides her with the ability to self-educate, to entertain, and to explore the world through internet access, make telephone calls, and turn on three toys. The VCS provides her with a sense of freedom and control over her environment.

TECHNICAL DESCRIPTION

The VCS enclosure is an 11″ x 8″ x 4″ plastic chassis as shown in Figure 12.18 and houses the core of the system, which is comprised of two boards. An overall block diagram of the system is shown in Figure 12.19.

The first board is the Voice Recognition Board (VRB) consisting of a filtered power supply and the voice recognition, memory, and display output circuitry. The VRB takes in the analog voice signal via a microphone and sends it for digital signal processing. The resulting digital output is sent to, and stored in, the memory (RAM) as a hexadecimal code.

The second board is the Control board (CIO). The CIO is where recognized output codes stored in the RAM are sent as inputs to the microcontroller. Software within the microcontroller uses the inputs to determine which output control relay(s) to activate.

A keyboard on the top of the enclosure provides the means to enter codes used to either clear a memory location or program a code to correspond to a specific function. A two digit hexadecimal display, also on the enclosure top, provides visual confirmation of trained and recognized function codes. The rear panel has the power input connection, fuse holder, a serial programming port, telephone and toy connectors, the mouse control jack, and a mouse direction switch which allows the left and right mouse click buttons to be reversed.

The ability for the user to reset the device was added through the use of a head activated “pillow switch,” as shown in Figure 12.21.

The cost of parts/material is about $400.

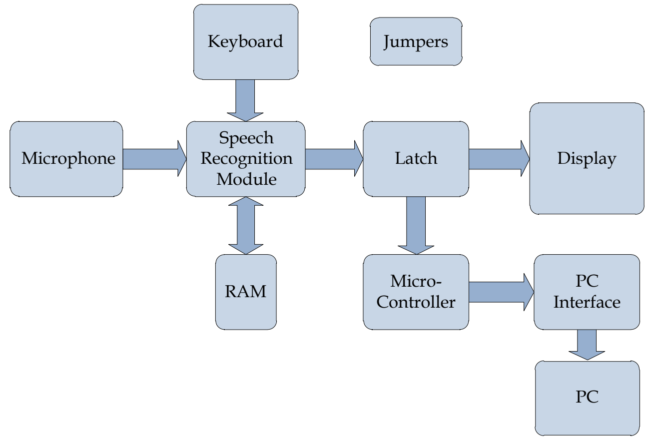

Fig. 12.19. System block diagram.

Fig. 12.20. Voice control system - rear view.

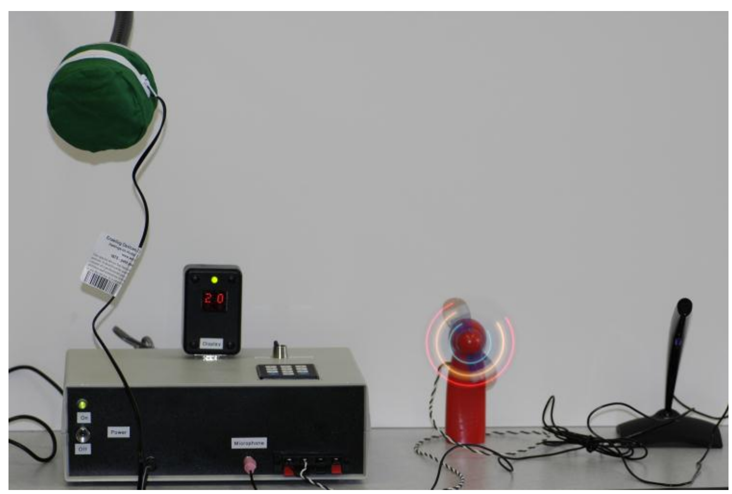

Fig. 12.21. Voice control system with pillow switch and fan.

MEDIA CONTROL CENTER

Designers: Michael L. Bray
Client Coordinator: Deborah, Coastal Educational Collaborative, Salisbury, MA
Supervising Professor: Jay Fu
Electrical and Computer Engineering Department
University of Massachusetts Lowell,
Lowell, MA 01854

INTRODUCTION

At the Coastal Educational Collaborative (CEC), the clients get much joy from viewing the photographs presented to them on a slide projector; however, they cannot interact directly with the projector themselves. Additionally, it is difficult to manage a growing library of photographs on an old slide projector. Some possible solutions are Media Centers, designed for use with a television, and a simple remote for the PC, however these solutions immediately become limiting due to the small sized remote and cost. The Media Control Center (MCC) is designed to provide both solutions, give the CEC a computer-based solution to view photos, providing an easy way to handle a growing photo library, as well as give its clients an opportunity to run the slideshow themselves. The MCC accomplishes this by providing an interface box to a PC running the MCC application software. The application software monitors the interface box over the parallel port, responding to user button presses by opening photos and moving back and forth between photos in the library. These photos are ultimately displayed on the wall through the LCD projector, providing a modern replacement to the old style slide projector. For clients with varying degrees of motor skills, the MCC provides three 1/8" jacks, allowing any button with an 1/8" jack to be connected, such as AbleNet's popular "Big Red Switch" and "Jellybean" style buttons.

When presented with the MCC, the clients at the CEC were overjoyed at being able to view a gallery by themselves, currently consisting of over 100 photographs,. The MCC not only solved the problem of CEC's growing library of photos, but gave their clients a way to interact with one of their most favorite pastimes.

SUMMARY OF IMPACT

The design criteria for the MCC are defined by the functional abilities of the clients and the needs of the facility. The CEC had a LCD projector that could replace their old slide projector, but no means to interact with it. A remote control could be used, but these typically are designed to run PowerPoint slide shows, severely limiting the ability to expand their photo library without time and work. Additionally, these remotes are tiny, allowing only a select number of clients to be able to use them depending on their level of motor control. Because the clients have varying degrees of motor control, it is necessary to design an interface that allows the facility to use the appropriate sized button to fit the needs of the client. To accommodate this, jacks were used rather than building buttons directly into the MCC. The result is a device that allows for individual button customization, allowing all clients

Fig. 12.22. Media control center interface box.

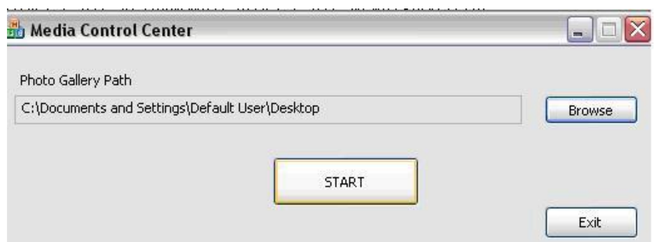

Fig. 12.23. Media control center application software.

to interact with it, and a solution that can handle the CEC's ever-growing library of photographs. The MCC also offers the opportunity for clients of the CEC to view photos unassisted, giving the clients a feeling of independence, as well as freeing up the hands of staff members to assist others in the facility.

TECHNICAL DESCRIPTION

The MCC interface box contains three 1/8" stereo jacks which allow the user to connect a standard "Jellybean" style input device designed for use by persons with disabilities. Button presses are latched and read by the MCC application software via the parallel port. The application software, written in C++, is 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 Figure 12.23) allows the user to select the source location of their photo library and stores this path in the Windows Registry to be used as the default. This path can be updated at any time, giving the user the flexibility to move and sort their library as they feel fit. The application looks for files containing the JPG extension which is the photographic standard for digital media. 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 starting the photo viewer, display the next photo, or display 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 ultimately displayed on the wall via the LCD projector.

The cost of materials is approximately $65.

Fig. 12.24. Student showing the device to the client.

THE TACTILE IMAGER: A DEVICE FOR THE VISUALLY IMPAIRED THAT CREATES A TACTILE REPRESENTATION OF A TWO DIMENSIONAL IMAGE

Designer: Nicholas H. Brunelle
Client: Anicia
Client Coordinator: Thomas David, Malden Elementary School, Malden, Ma
Supervising Professor: Alan Rux
Electrical and Computer Engineering Department
University of Massachusetts, Lowell,
Lowell, MA 01854

INTRODUCTION

The Tactile Imager was designed to provide a textured representation of a digital image. The interface of the device is an array of actuators that responds to an input from a computer and from a binary topographical map of the image. Figure 12.25 is an example of how a silhouette of a cat looks when displayed.

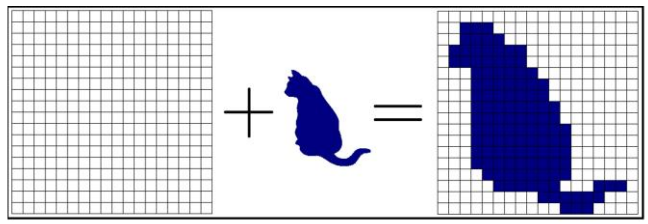

Fig. 12.25. Image output.

The blue squares represent a solenoid that is activated, and forms a raised bump. The white squares represent a solenoid that is off, and this forms a recess in the texture. The user can then feel the image with his or her hands and form a mental picture of the image being displayed. The device is a way of letting the visually impaired experience pictures in ways they previously could not.

SUMMARY OF IMPACT

The device is designed for one particular student in the Malden public school system, but remains the property of the school for use with all visually impaired students. To a person who cannot see, touch and sound are their interface with the world. I have created a way for something that once could only be seen to become something that can be felt.

TECHNICAL DESCRIPTION

The major parts of the device are: the solenoid array (Figure 12.26), the solenoid controller stack, the USB interface card and the power supply. Figure 12.27 shows a block diagram of the interconnection of each part.

Fig. 12.26. Solenoid array.

The solenoid array is constructed of 2 sheets of 3/16” sheet aluminum bolted in parallel with a space in between containing 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. 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 control up to 48 of the 324 solenoids. Each SCC has 6 latches with a common 8 bit data buss and up to 48 switching transistor circuits. The SCCs are controlled by loading 8 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.

Special considerations had to be made for the large power requirements of the system. Each solenoid draws about 240 mA of current. If every solenoid was to be turned on at the same time, the current draw is about 75 A at 12 VDC, and dissipate about 1 kW of power. Cooling fans are 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 to it from a computer and loaded into its memory bubbrt. Data is sent to the USB controller as a string of 42 bytes of binary data. The circuitry on the USB controller card then reads off 1 byte of data at a time, puts the data onto the data buss and enables the corresponding latch which is to hold that data.

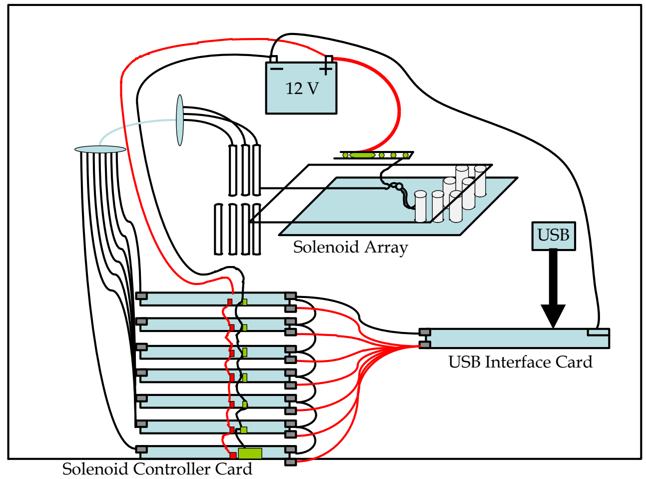

Fig. 12.27. System DIAGRAM.

The device is operated via a computer program. An image is loaded into the program, converted to an 18 by 18 black and white image and outputted to the tactile imager via a USB connection.

The total cost of this device is about $2,000.

Fig. 12.28. Student showing the device to the client.

AUDIO MIXER FOR THE VISUALLY IMPAIRED

Designer: Phong K. Dinh
Client: Bill R.
Client Coordinator: Tony Chavez and Keith Casavoy
Supervising Professor: Prof. Alan Rux
Electrical and Computer Engineering Department
University of Massachusetts, Lowell
Lowell, MA 01854

INTRODUCTION

The Audio Mixer for the Visually Impaired (AMVI) is a device designed for Bill, our client, to control an audio mixer. Bill preferred to control the volumes or faders of each individual channel using sliding potentiometers rather than rotary potentiometers. In addition, the application of large rocker switches and large knobs is used to maximize control and stability of the system. The physical layout for each controlling device is placed directly in front of the operator so that he can fully control every aspect of the audio mixer.

Fig. 12.29. Audio mixers for the visually impaired.

SUMMARY OF IMPACT

The main objective in designing the controls is to ensure Bill has total control of the audio mixer. The large rocker switches and large knobs enable him to locate the controlling devices much quicker than standard mixers. For Bill, controlling the sliding potentiometer was the best part of operating the audio mixer. With a built-in micro-switch inside every sliding potentiometer, Bill is able to simultaneously control mixer functions, something he cannot do easily on conventional mixers.

Fig. 12.30. Bill R. Using AMVI at WGAW radio station located in Gardner, MA.

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 VAC to 12VDC. The console consists of five input channels; within each channel there exist two different sections A & 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 that includes eight phono jacks and two microphone XLR female connectors. The controlling interfaces for the AMVI are the six sliding potentiometers and seven rocker switches.

The audio feedback circuit for the AMVI consists of a Basic Stamp 2E microcontroller from Parallax. This particular microcontroller is used because of its higher memory capacity, operational speed, and higher command capabilities than any other conventional microcontrollers. A voice recorder chip, ISD 2560 is also incorporated to process and store prerecords messages. The messages tell Bill the current status of the mixer. The ISD 2560 is used because of its ability to provide greater sampling frequency (8 kHz/sec) than any other ISD chip, a feature critical in audio feedback systems. The ISD 2560 possesses 60 seconds of record and playback time that is sufficient enough to perform the job.

When in operation of the AMVI, the six rocker switches enables the individual reed relays be energized so that sound or music is output to the program buss. In addition to energizing the reed relays, the basic stamp 2 playbacks the stored messages through the ISD 2560. This message is then heard through the phono jacks located directly in front of Bill. This audio feedback informs the current status of that particular channel. At any time Bill does not know or remember the status of whether what channel is on or off, he enables the status push button, which is isolated from the rest of the switches, to play the entire status of every channel on the audio mixer.

The cost of parts and materials is approximately $1,500.

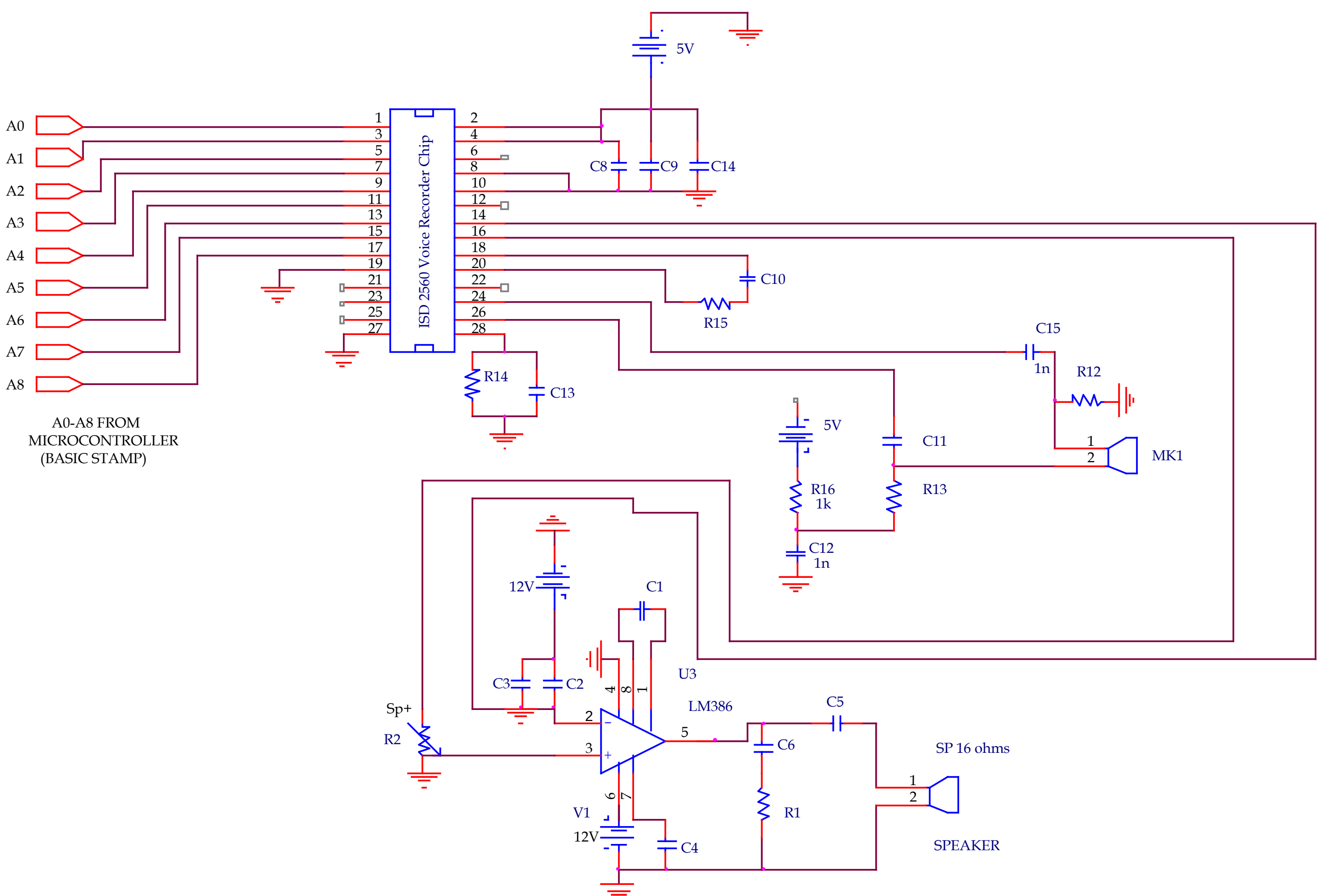

Fig. 12.31. Schematic for audio feedback.

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
University of Massachusetts, Lowell,
Lowell, MA 01854

INTRODUCTION

The Wireless Remote Control Wheelchair Trainer (WRCWT) is a miniature wheelchair frame mounted on the body of a remote control toy car (see Figure 12.32). Clients can practice motorizing the wheelchair control with the WRCWT for a period of time before controlling a full-size motorize wheelchair. This allows them to practice and become familiar with a joystick control that is found on a full-size power wheelchair. The WRCWT can also be a toy for all children to enjoy at the Franciscan Hospital.

SUMMARY OF IMPACT

The design requirement for WRCWT is described by Bonnie Paulino at the Franciscan Hospital for Children. She described the children's disabilities and expressed their needs. Most of their challenges are in the area of communication, mobility, motor control, vision and hearing. The children using the WRCWT have mobility and fine motor control difficulties. Clients rely on their wheelchair to get around. The product is designed to help increase motor control by allowing them to exercise their fingers using the joystick.

TECHNICAL DESCRIPTION

The structure of the WRCWT includes an 18 inch tall toy wheelchair from the American Girl Company. The frame underneath is a toy car frame 6 inches high from New Bright Company. The two frames are mounted together with two 3/8 inch screws. The wheelchair and remote control have an on/off power switch.

The remote control step design is similar to that of a controller on a real power wheelchair. The joystick can move in a 360-degree rotation. The transmitter and antenna are placed inside of the remote control joystick. The schematic used in the device is shown in Figure 12.33. The design used a window comparator to connect the three circuits together. The window comparator has high and low references voltage. The high references voltage is 1.6 volt and low references voltage is 1.4 volt. The LM339 is the chip used for the comparator.

Fig. 12.32. Wireless remote control wheelchair trainers.

The transmitter is an electronic device that sends an electromagnetic signal through the antenna. Two 1.5 V batteries provide the power to turn on the transmitter and receiver. The transmitter is designed using an oscillator, modulator and amplifier. The transmitter module sends a radio frequency (RF) wave through the antenna to the receiver at 45 megahertz (MH). The receiver is mounted on the bottom of the toy wheelchair, where its antenna receives the signal and then decodes it to navigate the position desired by the user.

The WRCWT was powered by six 1.5 V AA Energizer batteries. The batteries are used to power the remote control and the motor connected to the wheelchair. The cost of parts/materials is about $170.00.

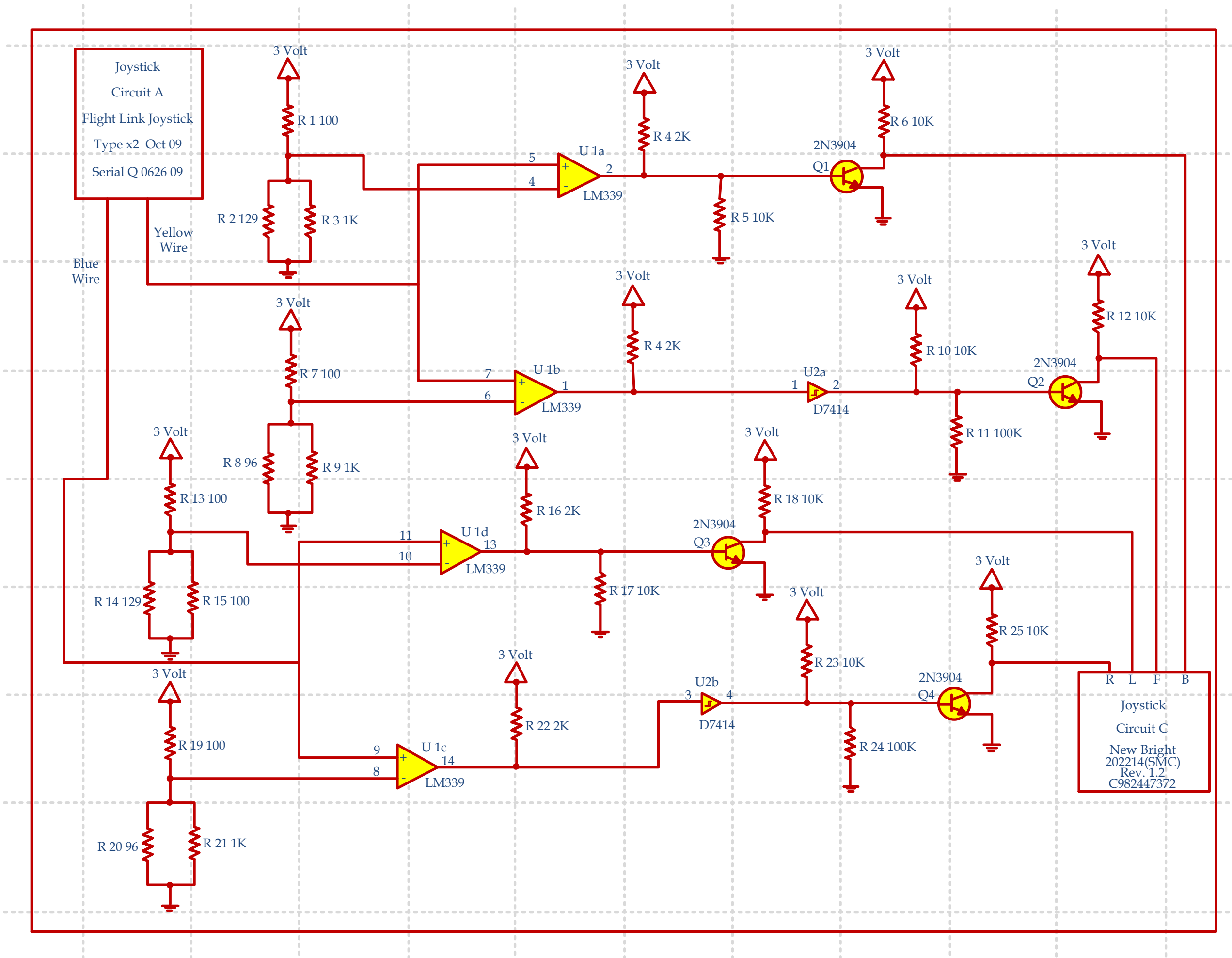

Fig. 12.33. WRCWT joystick schematic.

DUAL TOUCH LEARNING: A MONITOR SCREEN TOUCH LEARNING SYSTEM FOR THE SPECIAL NEEDS CLASSROOM, K THROUGH 12TH GRADE

Designers: Senait Haileselassie
Client Coordinator: Lisa, Shore Educational Collaborative School, Chelsea
Supervising Professor: Prof. Alan Rux
Electrical and Computer Engineering Department
University of Massachusetts, Lowell,
Lowell, MA 01854

INTRODUCTION

Students who have limited or poor hand, finger and arm dexterity find it difficult to interface with the many computer based software learning programs that are available which require student computer interaction. Most of these students are able to activate large switches and have sufficient hand-arm movement to touch the face of the computer monitor that they are using. A low cost touch screen device is described here that is attached to a computer monitor to replace the computer mouse input function. This touch screen allows an alternative input that is easy to use and provides interaction functionality. This device allows interaction with the learning software by touching the monitor screen to indicate their interaction with the learning software program. This input can also be used for other computer interactions that require mouse movement and left or right mouse switch click.

SUMMARY OF IMPACT

The Dual Touch Learning System is developed by a request, or more like a "Wish" from a Special Needs Teacher and the director of Assistive Technology at the Shore Educational Collaborative School, a special needs school with over 90 students with multiple profound disabilities. Students are in grades K to 12 and up to the age of 21 from the Boston area. The school is located in Chelsea, Mass.

The solution to the problem started out as a hardware mouse substitution problem and the ability to interface with available software of one engineering student with a Service Learning Senior Capstone project. But when working with the software, it was determined that the software programs did very little teaching of learning concepts, and in most cases was not age and skill level compatible with the students using the system. Another engineering student joined the team with programming skills and the understanding of the hardware interaction requirements to design new software that would meet the need and wishes of the teachers and students at Shore Educational Collaborative School. The goal is to have a flexible computer interface for students with disabilities and software that meets the needs of the school learning program and the student skill level. It had to be of low cost and allow for modification to the software as needed without professional programming skills.

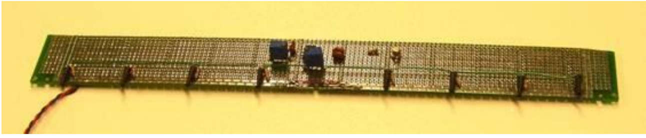

Fig. 12.34. Led array.

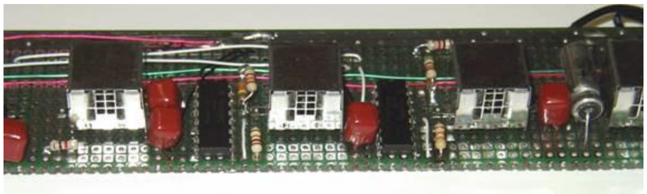

Fig. 12.35. Detector array.

TECHNICAL DESCRIPTION

In the literature review phase of our project and meeting with our Electrical Engineering advisor, he mentioned a machine safety product used to stop machinery like robots or mold injection equipment when a person enters a hazard zone and could be injured by the machinery; a safety light screen, made by Banner and called a "Machine-guard Safety Light

Screen". This is a device sends light from an emitting bar to a receiving detector bar, and provides an alarm signal when the light beam is broken by something that shields the light from the emitter to the detector, and also stops the equipment so personal do not get hurt.

This method of detection is used in this device. A row of light emitting diodes across the top of the Monitor face and a row of detectors across the bottom face form the interface. Circuitry is used to detect when the light beam is interrupted. The interruption data is sent to a modified computer mouse to interface with the computer through the serial mouse port.

Many types of emitters and detectors were tested, both in the visible and infrared ranges.

The best results are with inferred devices. The stray light interference is eliminated by modulating the emitter and filtering the detector output using a system similar to a remote TV control uses.

The final hardware design includes a modulated array of infrared light emitting diodes mounted across the bottom of the computer monitor screen (Figure 12.34).

Across the top of the monitor is a matching set of infrared detectors with band pass filters of 72 kHz, the same frequency used to modulate the emitters. Also on the detector board is the control logic that detects when the infrared light beam is interrupted and it supplies a right or left mouse switch click (Figure 12.35).

A standard two switch computer mouse is modified to receive commands from the control logic on the detector board, which allow the mouse keep its normal function for the teachers use. The two circuits are mounted on a plastic frame that attaches to the monitor face surrounded with Velcro (Figure 12.36).

The cost of parts/material is about $150.

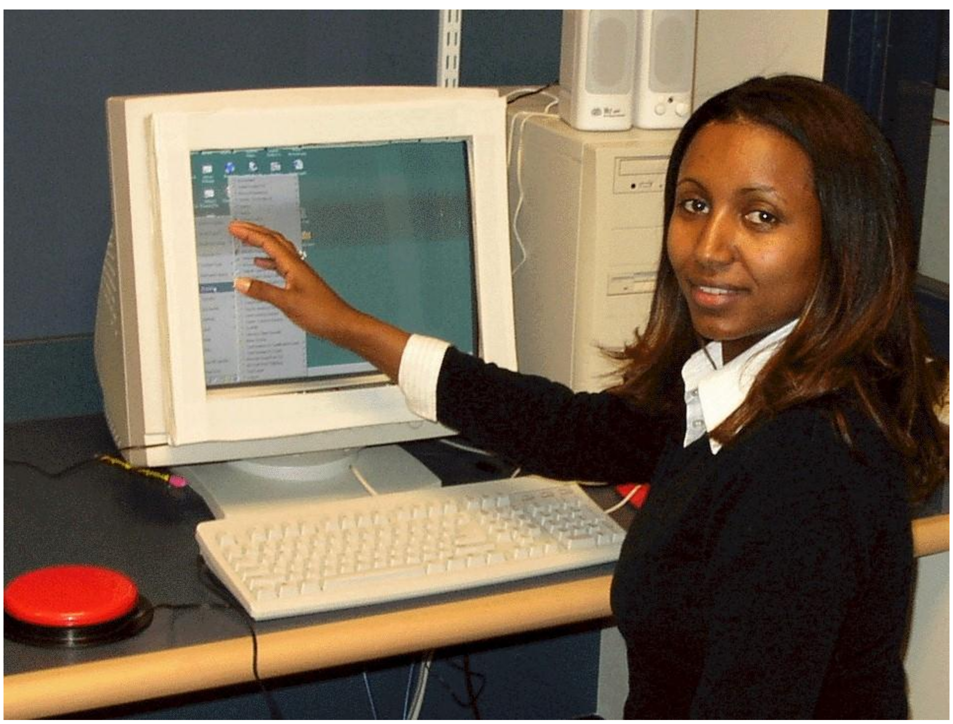

Fig. 12.36. Student demonstrating system.

HANDS DOWN, SIT UP STRAIGHT (HDSS): FEEDBACK/ CORRECTION DEVICE

Designer: Shawn P. Garvey
Client: Leon, Ferryway Middle School, Malden, MA
Supervising Professor: Alan Rux
Electrical and Computer Engineering Department
University of Massachusetts Lowell
Lowell, MA 01854

INTRODUCTION

Hands Down, Sit up Straight (HDSS) is designed as a learning tool for my client. My client has autism. His symptoms include playing with his hair and chewing on his shirt. He also has bad posture. As a result, his teacher has to constantly keep telling him to sit up straight and to keep his hands down. The HDSS detects arm motion and tilt angle and plays a prerecorded message from the teacher. For example, when my client raises his hand past his upper chest to chew on his shirt HDSS detects motion and plays a message - "Please keep your hands down." A tilt sensor detects the angle of his body when he is sitting. If the client leans 'too far' forward it plays a message - "Please sit up straight." HDSS gives my client positive feedback without constant intervention by his teacher.

SUMMARY OF IMPACT

HDSS is designed to be used in a classroom setting. Special education teachers (SET) are very busy working with other students. As a result, the teachers are unable to pay constant attention to all

Fig. 12.37. Client using the device.

students at the same time. Hence, HDSS provides the feedback the client needs when the SET are busy working with other students.

TECHNICAL DESCRIPTION

The HDSS is comprised of a plastic case for the chassis with 4 buttons, 2 LEDs, and battery pack mounted outside the case. HDSS is attached to a strap that is put on the student and wears comfortably. The buttons are for the SET use only and they are: on/off, play/record, start/pause and stop/reset. On/Off turns the power on and powers up the circuit with 6 volts DC. Play/Record is a switch that is always in the play mode unless the SET want to record a new message. To record a new message the SET simply switches to record and pushes the start/pause button to start recording. To stop recording press start/pause again and switch back to play. Start/Pause resets the circuit if a problem arises. The LEDs are green and red. When the on/off switch is on the green LED will turn on to indicate that HDSS is powered up. If the SET want to record a new message then the red LED will turn on indicating recording mode.

HDSS internal circuitry uses two main sensors for tilt and arm motion. A playback/record IC chip is used for message storing and playback (see Figure 12.37). 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 implemented are the Chip Enable (CE) pin 23, Play/Record (P/R) pin 27, Speaker pins 14 and 15, and the addresses (A0-A8) pins 1-9. To record a message, the P/R pin must be low and the CE pin must be pulsed low to start recording, and then pulsed low again to stop recording. To play a message the CE pin needs to pulse to a low voltage and an 8-16 ohm speaker must be attached to pins 14 and 15. When motion and tilt are detected, the CE pin is pulsed to a low voltage, resulting in the message being played back.

For motion, a proximity sensor is used. This proximity sensor has a detection range of 24 cm.

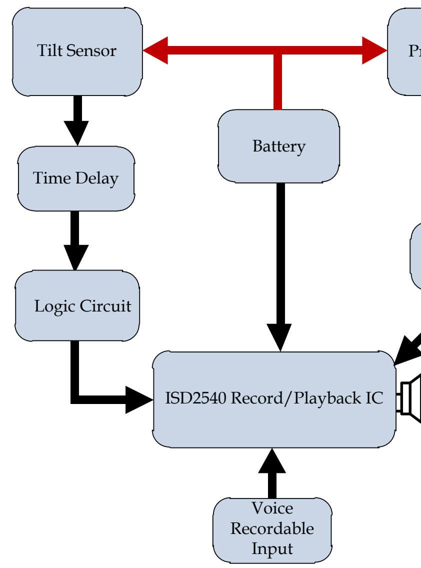

Fig. 12.38. Block diagram.

When this sensor detects movement it sends a high output voltage. That voltage then goes into a logic NAND gate, then to a logic AND gate that 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 tilt sensor produces a high voltage when tilt angle exceed 30 degrees. This high output voltage changes addresses A5 and A7 of the ISD2540 to high; such that when CE pulses low it plays the message at the corresponding address. However, this output voltage of the tilt sensor is only 1.7 V. This is not enough voltage to use the time delay IC and a logic NAND gate. As a result, a simple op-amp increases the voltage to 3.5 volts. From the op-amp, the high voltage goes to a time delay IC allowing enough time to change the address. From the time delay IC, the high voltage goes into a logic NAND gate then 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 parts/ material is about $ 175.

THE SMART HAT: A DEVISE THAT TRACKS THE MOTION OF THE USER'S HEAD

Designers: Thomas M. Donigan
Client Coordinator: name, Malden MA
Supervising Professor: Prof. Alan Rux
Electrical and Computer Engineering Department
University of Massachusetts, Lowell
Lowell, MA 01854

INTRODUCTION

The Smart Hat (SH) is designed as a learning tool to help my client pay more attention in school. This device uses a low-g accelerometer (a microchip that measures gravity) as a two-axis tilt sensor mounted on a baseball cap. When The Smart Hat detects the user's head is no longer in an upright position, 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. When the SH detects the users head is once again in an upright position, the alarm stops and the CD music is turned back on.

SUMMARY OF IMPACT

The purpose of the SH is to help a young girl from Malden named Erica. Erica has Spina Bifida that caused paralysis on her left side, as well as visual and speech impairments. Erica has also been diagnosed with a mild form of Down syndrome. Her disability has caused her to constantly leave her head down or flexed. When her head is flexed, Erica becomes unresponsive, which has made it difficult for her to attend school. Erica has the ability to keep her head up but needs constant reminders from teachers and parents to do so. Because of Erica's love of music, her physical therapist has suggested using a sensor that controls the music in the room to encourage Erica to keep her head in an upright position.

TECHNICAL DESCRIPTION

The SH is composed of two basic components; a tilt-monitoring circuit (Figure 12.40) and an alarm-triggering circuit (Figure 12.41). The tilt monitoring circuit is positioned on the brim of a baseball cap and monitors the orientation of the users head by measuring the net force of gravity along vertical and horizontal axis. This is done by using a low-g accelerometer from Analog Devices - the ADXL213.

Fig. 12.39. Complete project setup.

The outputs of the ADXL213 are digital signals whose 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. In this case, it is used to measure both the pitch and roll of the user's head. Two pulse width modulated signals are fed into a Parallax Basic Stamp microcontroller, BS2 SX, which measures the pulse width of the signals and then calculates the corresponding angle.

If an angle of orientation exceeds 60 degrees for more than three seconds, it means the user's head is no longer upright, and a signal is 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 is composed of a transmitter, a Basic Stamp Microcontroller, two MOSFETS used to switch music on and off, and a 9-

volt battery for power. The circuit itself is encased in a small project box with a power switch, a piezzo buzzer, and terminals used to connect a CD player and speakers. When a signal is picked up by the receiver, the microcontroller turns on the piezzo alarm and cuts off the signal between the CD player and speakers by controlling the gate voltage on the MOSFET.

The cost of parts/material is about $300.

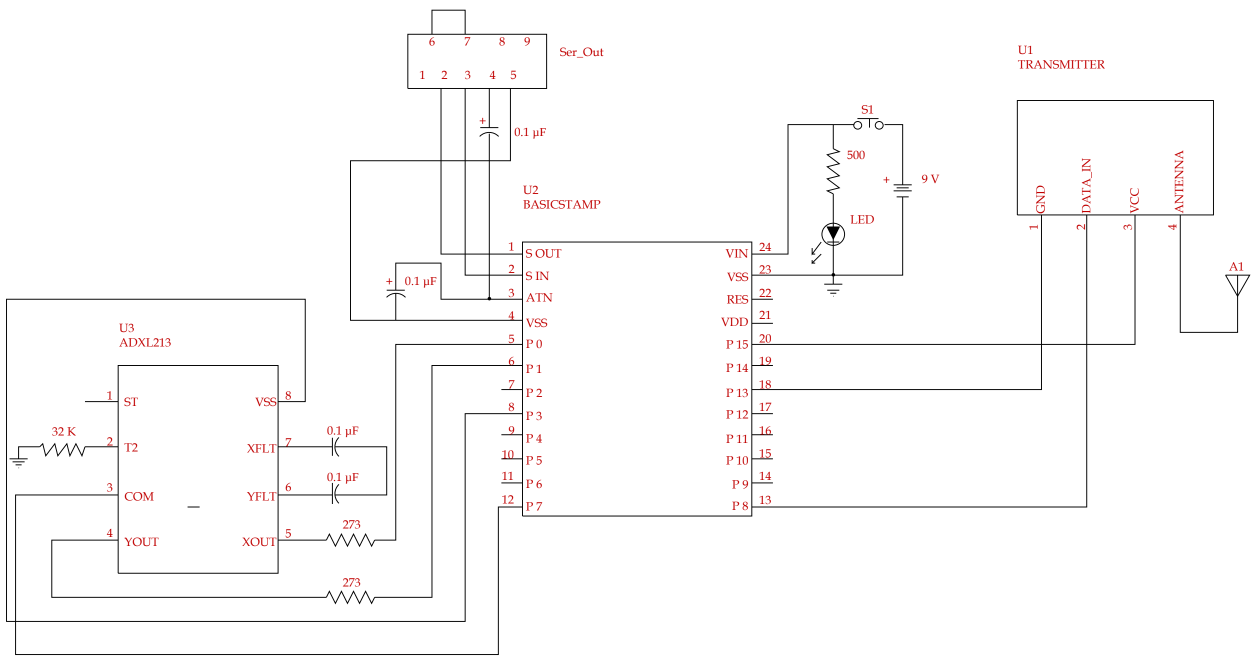

Fig. 12.40. Tilt sensor circuit.

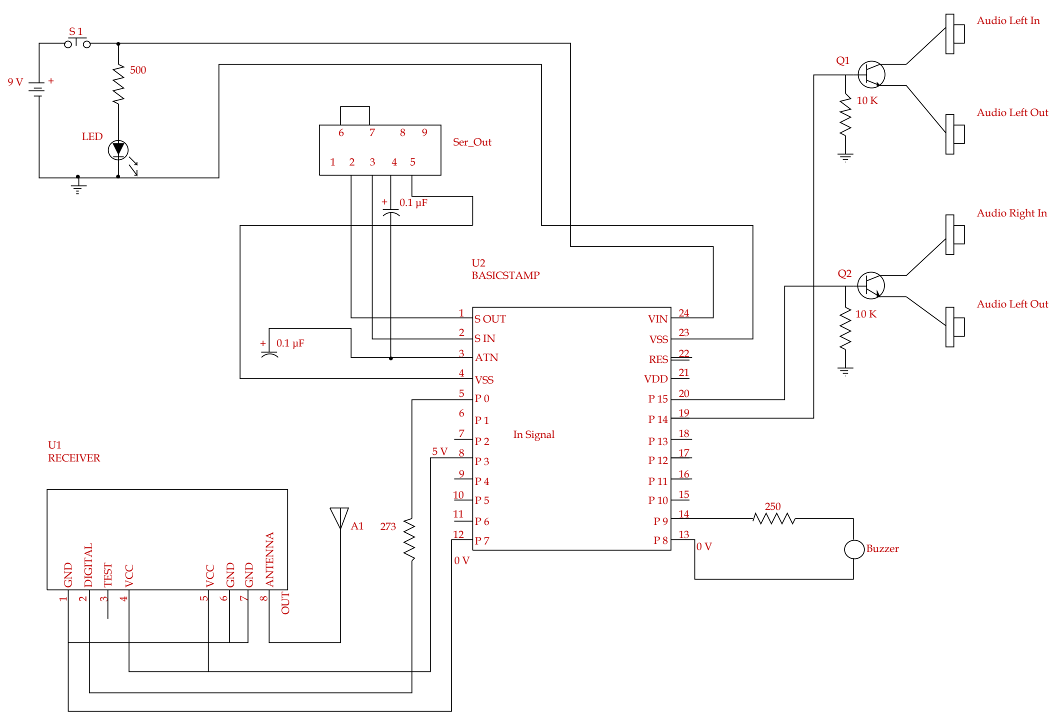

Fig. 12.41. Alarm triggering circuit.

ENHANCED ACCESSIBILITY OF THE COMPUTER INTERFACE: AN INNOVATION PROJECT MERGING A TOUCHSCREEN OVERLAY AND EZITEXT® PREDICTIVE TEXT SOFTWARE

Designer: Victor Piper
Client Coordinator: Susan Azocar, LifeLinks Inc., Lowell, MA
Supervising Professor: Alan Rux
Department of Electrical and Computer Engineering
University of Massachusetts Lowell
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INTRODUCTION

For people with physical disabilities, devices designed for the able-bodied present barriers to complete social functioning. The computer and the Internet, for example, are indispensable tools of productivity, communication, and commerce. Yet the computer keyboard and mouse, portals to the "connected" world, are very challenging for persons without the requisite manual dexterity.

This project seeks to demonstrate that solutions need not be expensive or complex. Instead, barriers can be overcome by simply combining existing technologies in new ways.

Here, a resistive touch screen and a commercial predictive text-entry software package provide improved text entry and mouse functionality for a client whose writing and typing skills are limited because of the physical effects of Cerebral Palsy.

SUMMARY OF IMPACT

The client uses the computer to compose poetry. He has moderate dexterity in his left arm and types in the hunt-and-peck method with his index finger. As such, his text entry speed is limited by his ability to find and to press the correct sequence of keys on the standard keyboard. At present, his typing speed is 5 words per minute.

A solution was developed to compliment his physical abilities. By reducing the number of buttons and increasing their size by 400%, it is expected that the correct button will be easier to find and press. Secondly, a predictive text-entry program is included that reduces the number of keystrokes necessary to type full words.

Fig. 12.42. Student showing the device to the client.

The combined hardware and software package is expected to increase the client's typing speed, thereby allowing him to be more prolific as a poet.

TECHNICAL DESCRIPTION

Deliverables include a 12" resistive touch screen with housing, and a software suite including touch screen driver software and the eZiText® predictive text program.

The decision to redesign the keyboard was based upon two assumptions. First, the hunt-and-peck method has a trade-off between typing speed and typing accuracy. It is assumed that increased key size decreases the need for precision, thereby permitting more rapid keystrokes. It is noted, however, that increased key size results in a larger keyboard, which requires larger arm movements and diminish the gains in typing speed. The problem is overcome by reducing the number of buttons on the interface in proportion to the increase in button size.

Noting the considerable success of the cell phone as a text entry device, the map for the touch screen buttons is modeled on the cell phone layout. Like a cell phone, a set of characters are multi-tap-accessible through a single touch screen button. As shown in Figure 12.43, the left and right mouse buttons and all 84 keys of the standard PC/AT keyboard, with the exception of the function keys and the Num Lock and Scroll Lock keys, are accessible through only 22 buttons.

The second assumption is that combining the mouse and keyboard into a single interface improves productivity by eliminating the need to move the arm between devices.

The touch screen hardware includes a microcontroller circuit that outputs serial data to the PC serial port. A LabVIEW® state-machine program polls the serial port for data, maps X,Y touch coordinates to characters according to the button layout, and then simulates the corresponding keystroke by calling the keyboard event function of the Windows® User Interface API.

Advanced features, such as pointer control, multi-tap text-entry, and keystroke repeat, are implemented as decision trees within the state-machine architecture. Figure 12.44 shows the logical flows implemented in the LabVIEW software.

The eZiText® predictive text-entry software package, produced by Zi Corporation of Alberta, Canada, is selected to reduce the number of keystrokes needed to generate a word. Zi Corporation claims that their product provides a 450% increase in typing speed for multi-tap interfaces by predicting word output based upon a minimal number of input characters.

Zi Corporation donated a development copy of their eZiText predictive text software for the project. A routine written in the C programming language handles calls to the eZiText DLL functions. LabVIEW Code Interface Nodes were used to transfer data between LabVIEW and the C routine.

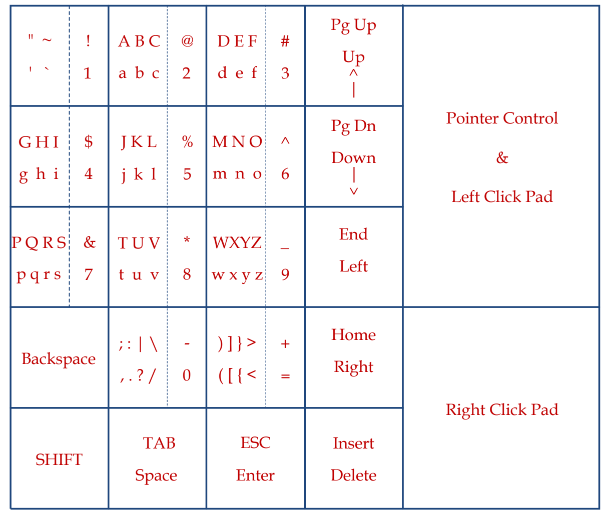

Fig. 12.43. Map of touch screen button layout.

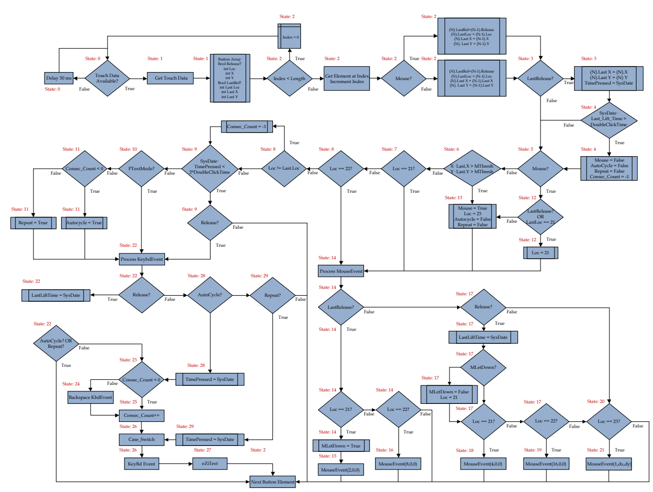

Fig. 12.44. Flow Diagram of state-machine logic.

Once the project is complete and delivered, the client's text-entry rate using a standard keyboard will be compared to the rate achieved using the new interface and predictive text software. Ultimately, however, the success depends on whether the client accepts the delivered project as a suitable replacement for the keyboard and mouse.

The cost of parts/materials is about $200.00.

THE COMMUNICATION DEVICE: A DEVICE THAT PROVIDES SPEECH IMPAIRED PATIENTS A MEAN TO COMMUNICATE

Designer: Younes Elasri
Client Coordinator: Deborah Plumer, Coastal Educational Collaborative, Salisbury, MA
Supervising Professor: Charles J Maffeo, PhD
Electrical and Computer Engineering Department
University of Massachusetts, Lowell
Lowell, MA 01854

INTRODUCTION

The Communication Device (CD) is designed to record and playback voice commands for non-verbal patients at Coastal Educational Collaborative. The therapist stores messages in the CD so the patients can play them back when they need assistance with eating, for example, or any other services. The CD plays a total of six 20-second messages. The device also has six LEDs that scan in a loop, one LED underneath each display picture (See Figure 12.45). The LEDs aid the client in the selection process. When an LED is lit under a desired image, a Jellybean switch is pressed to play the message associated with that image. A similar process is performed to record a message for an associated image.

SUMMARY OF IMPACT

Besides allowing the patient to play a previously recorded message, the CD also helps patients improve their eye-hand coordination. It can be used by an individual or by a group of patients at the Coastal Educational Collaborative.

TECHNICAL DESCRIPTION

The two major components in the design are the ISD25120 (ISD) playback and record chip that provides a high quality of voice reproduction, and the Basic Stamp II microcontroller (See Figure 12.46). The ISD chip is used for direct addressing. The Chip has ten address pins corresponding to ten binary digits. They can be either HIGH (Binary 1) or LOW (binary 0). Each combination of those ten binary numbers refers to the beginning of a memory space, where six 20 second sound recordings are possible. Three I/O pins on the Basic Stamp microcontroller are used as inputs: one for the Jellybean switch, one for the Record switch and one for Play switch. Six

Fig. 12.45. The Communication device.

I/O pins are used as outputs for the six LEDs. Ten I/O pins are used as outputs that are connected directly to the Address pins of the ISD to set the message address, and three I/O pins are used as outputs that are connected to P/R, PD and /CE pins of the ISD. The Basic Stamp is programmed to turn the LEDs ON and OFF in a loop, and map each LED to specific address segmentation.

The CD has two modes: Play and Record.

For the Record Mode, the user turns the Record switch ON, waits until the LED that corresponds to the desirable message is on, and then presses the Jellybean switch and holds it for the duration of the recording. The Basic Stamp then sets the message address on the ISD and sets the Power Down (PD) pin LOW and Chip Enable (/CE) pin LOW for recording. A Microphone is used for this process). To end the recording, the user must take his or her hand off the Jellybean switch, which gives the Stamp the instruction to make PD or /CE go HIGH.

For the Play Mode, the user turns the Record switch OFF, and turns the Play Switch ON, waits until the LED that corresponds to the desirable message is on, then presses the Jellybean Switch. The Basic Stamp then sets the message address on the ISD and Sets PD HIGH and /CE Pulsed LOW for playing. A Speakerphone is used for this process. The end of playback is automatic.

The cost of parts is about $171.64.

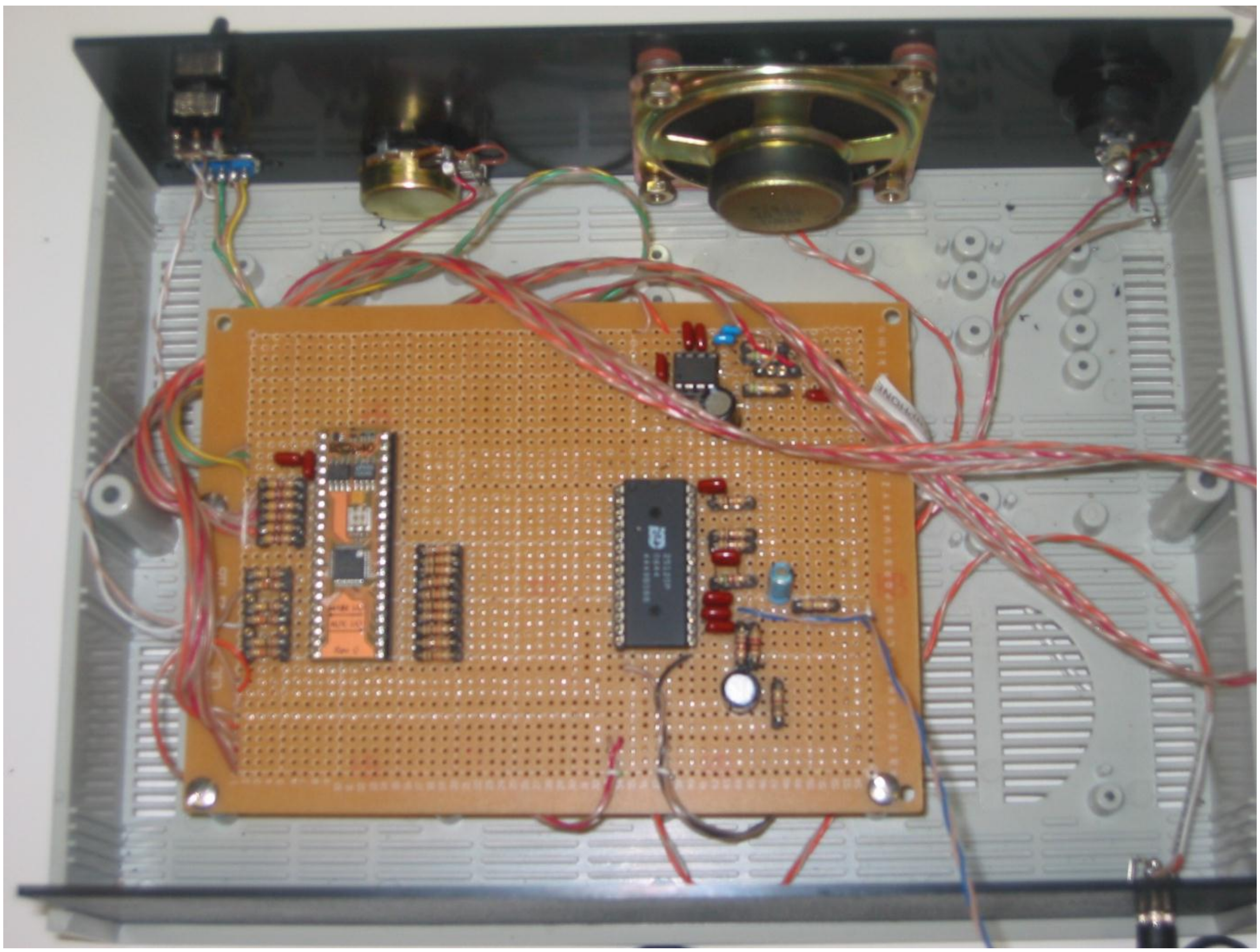

Fig. 12.46. The internal components of the CD.

CHAPTER 13
UNIVERSITY OF NORTH CAROLINA AT CHAPEL HILL

Department of Biomedical Engineering
Room 152 Macnider Hall, CB #7575
Chapel Hill, NC 27599-7575

Principal Investigator:

Richard Goldberg (919) 966-5768

PILLOWCASE FOLDING AID

Designers: Meghan Hegarty and Theresa Forshey
Client Coordinator: Cyeteese Garrett
Supervising Professor: Richard Goldberg
Department of Biomedical Engineering
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INTRODUCTION

Orange Enterprises is a community rehabilitation program that employs people with disabilities to perform a variety of jobs. One of their jobs is to fold and package pillowcases into a plastic sleeve. In general, the individuals selected for this job are not physically impaired, and thus the actual folding action does not present a challenge. Instead, the problem lies in remembering how to orient the pillowcase, the direction in which to fold it, and ensuring that the ends meet and that it is wrinkle-free. The goal of this project is to develop an aid that guides employees throughout the task and enforces proper technique, leading to increased productivity, improved quality, and greater independence.

SUMMARY OF IMPACT

According to the client coordinator, "The pillow case device will be used as a training device for clients as well as a guide for others that may need additional cues to complete all steps of task. At this time we have a limited number of clients who can fold the pillow cases appropriately. With the device, clients will show an increase in productivity. We are also confident that this device will enable more clients to perform the task of folding the different shapes of pillow cases."

TECHNICAL DESCRIPTION

The Pillowcase Folding Aid consists of an acrylic work surface and a center-divide rod (Figure 13.1). The work surface is easily be cleaned, and is hinged at the center for compact storage and simplified transportation. The center-divide rod provides a central axis for folding, and it permits both right- and left-handed operation. The rod is held in place by a magnetic that is mounted into the work surface, and the client can move the rod out of the way when necessary. A vertical side wall is also included to help guide the user in positioning the rod over the magnet in the central location.

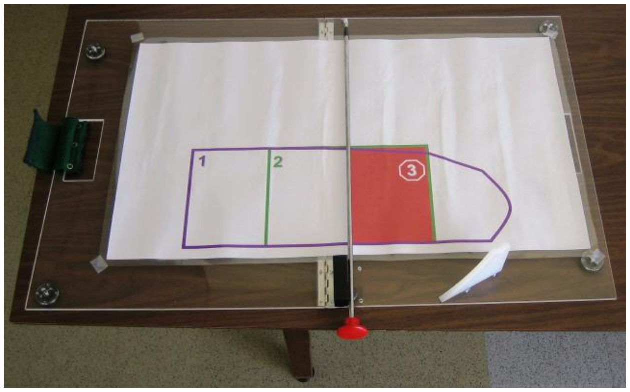

Fig. 13.1. The pillowcase folding aid, which includes the acrylic work surface, a center divide rod that provides a central axis for folding. One of the folding templates is shown on the work surface, which outlines the different steps for folding a particular pillowcase.

We developed instructional templates that guide the user step-by-step through the folding process. They contain numbered outlines of a particular pillowcase at various stages of folding. To keep the process simple for our clients with cognitive limitations, there are no more than 5 numbered steps, and the outlines of the shapes are color-coded to assist with easy matching. Different templates are available for each type of pillowcase. The job coach must tape the appropriate template to the work surface before the client begins using it.

To fold the pillowcase, the client simply needs to match and align it with the appropriate outline on the instructional template. Then, they fold the pillowcase over the center-divide rod axis, which acts as an indicator of the folding direction and ensures that the pillowcase is folded completely in half (Figure 13.2). This matching, aligning, folding sequence is repeated until the pillowcase fits completely within the last shape, which is designed to resemble a 'Stop' sign; the client is easily able to relate to this analogy.

The total cost of the device is approximately $78.

Fig. 13.2 (Top and Bottom). Client folding a pillowcase over the center-divide rod. After completing the fold, the client moves the rod out of the way, realigns the pillowcase on the next pattern on the template, and folds again.

WAFER SEALING AID

Designers: Theresa Forshey and Meghan Hegarty
Client Coordinator: Cyeteese Garrett
Supervising Professor: Richard Goldberg
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INTRODUCTION

Orange Enterprises is a community rehabilitation program that employs people with disabilities to perform a variety of jobs. One of the jobs commonly performed requires employees to place a clear, round sticker, called a wafer seal, along the edge of a folded piece of paper to hold it together for mailing. Currently, employees are handed a roll of wafer seals, the mailings, and a cardboard template. A roll of wafer seal is similar to a roll of tape, but with the stickers mounted to a backing. However it is difficult for anyone, with or without a disability, to remove the stickers from the tape. The client then must slide the mailing into the template, which has semi-circles cut out on the edges to indicate where the wafer seal should go, and attach the wafer seal.

Our client is an employee with poor vision, limited motor control, and use of only one hand to perform this task. It is difficult for him to remove the wafer seal from the roll and to use the template correctly. Furthermore, it is hard for him to see the clear wafer seal sticker. As a result, he cannot effectively do this task independently.

Our goal is to develop a Wafer Sealing Aid so that our client can perform this task at work. This will lead to: (1) greater productivity due to faster sealing times, (2) a decrease in the number of rejected mailings resulting from misplaced wafer seals, and (3) greater independence due to a decrease in the need for supervision and help. Overall, this will serve to increase the number of units completed per hour, resulting in greater income for the client.

SUMMARY OF IMPACT

The client coordinator states that, "The wafer seal device will allow opportunities for clients with vision impairments, limited range of motion, and/or fine motor skills to perform the task of wafer sealing.

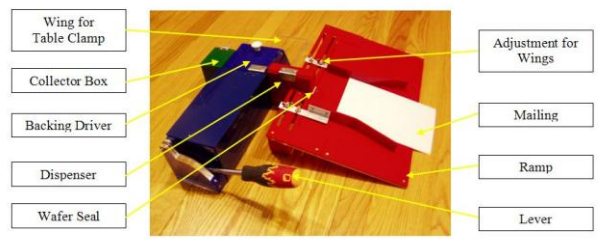

Fig. 13.3. Identifying the parts of the wafer seal device.

The wafer seal device may be used as a training tool as well."

TECHNICAL DESCRIPTION

Our device, shown in Figure 13.3, uses a ratcheted lever system to dispense a single wafer seal for each pull of the lever. The client then slides a mailing into place under the exposed seal, using a ramp and guide arms for alignment, and sticks the wafer seal onto the mailing.

With each pull of the lever, the wafer seal roll is pulled a fixed distance through the dispenser. A ratcheting system pulls the roll in only one direction for each pull/push cycle of the lever. As the backing is pulled through a 180 degree turn just in front of the ramp, the wafer seal becomes partially detached from the backing, making it easy for the client to access it. The empty backing is then collected in the collector box. The client places the mailing on the ramp, right under the partially exposed wafer seal, and the alignment wings allow for correct placement relative to the wafer seal dispenser. At this point, it is easy to stick the wafer seal onto the mailing and complete the operation.

With this device, the client can repeatedly execute the same steps for this task. The steps are: turn the lever, slide the mailing up the ramp, push the wafer seal onto the mailing, slide the mailing back down, and fold the wafer seal over onto the other side of the mailing. While this process consists of many steps, the client is able to perform the task effectively.

The device is safe, adjustable and easy for the job coaches to setup. There is a hinge door with a handle that makes loading the tape into the backing driver easy. The box for this mechanism is long in order to increase stability and allow the lever to be easily reached. The device is stable without a table clamp, but the wing can be clamped to the table as extra precaution. The job coach can adjust the wings, depending on the mailing size and orientation.

The device is made from colored acrylic to provide a professional look as well as making it easy to remove misplaced wafers. The total cost of the project is $183.

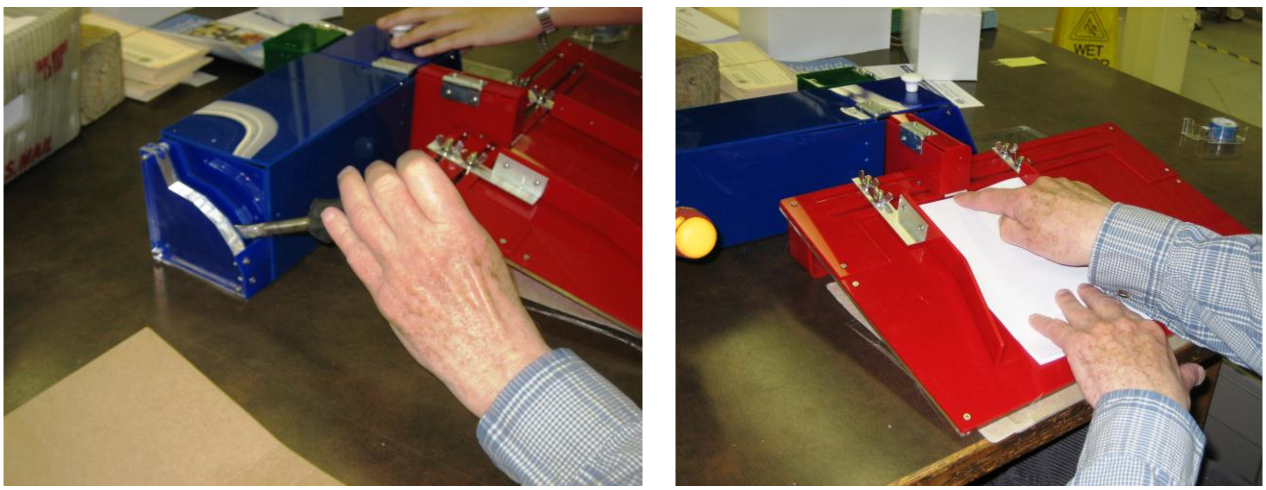

Fig. 13.4. The client is pulling the lever to dispense the next wafer seal, and then sticking the wafer seal onto the folded mailing.

KARAOKE TRAINER

Designers: Swarna Solanki and Omar Aman
Supervising Professor: Richard Goldberg
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INTRODUCTION

Our client is a 19 year old male who has severe mental retardation. He has limited dexterity, visual impairment, and limited verbal capabilities. The client has become motivated to practice vocalizing through music therapy, whereas other forms of speech therapy were ineffective. A music therapy session involves the client's therapist singing a familiar song and stopping before the end of a phrase, for example, "Take me out to the ball…" Once the client verbally finishes the phrase, "game", the therapist will continue singing the next line of the song. If he does not respond, the therapist encourages him to do finish the line before moving on.

The goal of our project is to develop a device that simulates these music therapy sessions so that he can practice vocalizing independently. Voice detection is necessary so that the device knows when the client has vocalized. However, his voice is difficult to understand, so speech recognition is not necessary. As long as he is vocalizing, he is meeting the therapist's goals. In addition, a simple interface is required, preferably one comparable to an Apple iPod shuffle, which he is already familiar with, so that he may use it without supervision.

SUMMARY OF IMPACT

The device successfully motivates the client to practice vocalization by singing along with his favorite songs. The client learned very quickly that the device continues playing the song if he vocalized appropriately. Thus, if he mumbled or whispered the word and the device could not register his voice, the client makes another attempt that is louder and clearer. The positive feedback from the device puts a smile on his face as he claps and listens to the music. This result is exactly the type of influence his family and therapist hoped for. After using the device for a short amount of time, there was an obvious increase in the client's ability to respond verbally to those around him, just as he experiences after a session with his music therapist.

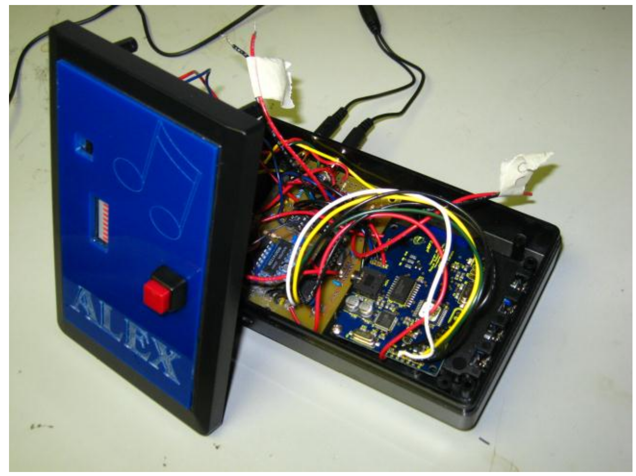

Fig. 13.5. Photo of the device with cover removed to reveal the circuitry inside.

The client's mother stated that the device is simply "Great!" after she saw it in action for the first time. She continued, "there are very few times in Alex's life that somebody can actually make a difference for him. I feel like this device is going to be a huge success!" The client's father stated, "I am so happy, I feel like I am going to cry!"

TECHNICAL DESCRIPTION

The device is based on the PIC 16F876 microcontroller (Microchip, Inc, Chandler AZ). Other major components are the music player, the user interface, and the voice detection circuit. The music player is a Rogue Robotics (Toronto, ON) uMP3 Playback Module. This uses a Secure Digital (SD) card to store MP3 files, and interfaces with the microcontroller to select which song to play. Each song is stored in a folder on the SD card. Each folder contains the song broken into separate tracks according to the client's expected responses.

The user interface consists of a “next” button, similar to the next song button on an iPod Shuffle. This button is active at the beginning of a song, but at the therapist’s request, it becomes inactive once the client starts singing a song. This forces him to complete a song once he starts it.

The voice detection system identifies when the client vocalizes, while ignoring when he claps or grunts, as well as other ambient noises. According to our studies, actual vocalization results in a signal of greater amplitude than background noise or grunts, and of greater duration than hand claps or finger snaps. Thus, the circuit identifies vocalization as signals that are above a minimum threshold duration and amplitude.

In our vocalization detection system, the microphone is connected to an instrumentation amplifier, which is then input to a comparator. This outputs 5 V when the amplified microphone signal exceeds the reference voltage. The comparator output is sent to a retriggerable one shot, which outputs a 5 V pulse for a short time period when the comparator output goes high. Because the one shot is retriggerable, it maintains a constant 5V output as long as the input signal has peaks more often than the output pulse duration of the one shot. This signal is fed to a PIC, which measures the duration of the one shot output, and determines if it is long enough to represent vocalization. The system effectively filters out clapping, finger snapping, grunting, and other short or quiet sounds.

The reference voltage for the comparator is adjusted by the parent or therapist. An LED array shows the relative strength of the reference. Using a potentiometer, the user sets this reference voltage between 0 and 1 V, based on the response of the microphone. The LED array allows a visual comparison between the output signal of the instrumentation amplifier and the reference voltage at input of the comparator.

Our final device employs an external speaker and headphones. The sensitivity control is intentionally difficult to access to avoid accidental adjustment. The next button and LED array, volume control, audio jacks, and on/off switch are all made accessible. The enclosure is custom made of blue acrylic. The total cost of the device is $396.

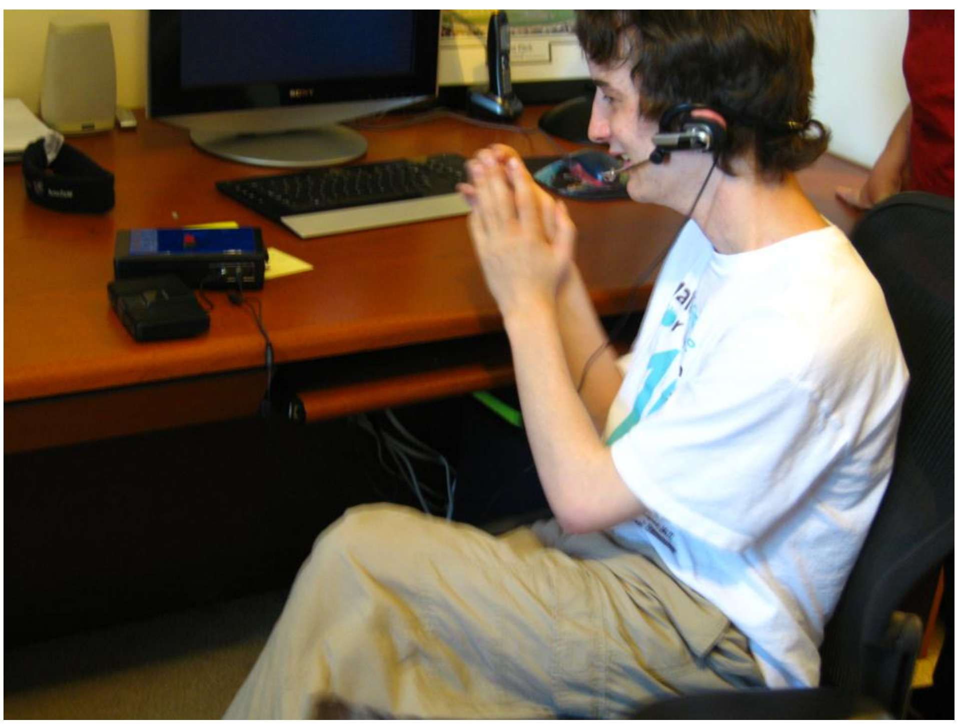

Fig. 13.6. Photo of client using the device.

TRACE AID

Designers: Elliot Greenwald and David Zilber
Client Coordinator: Chris Wensil, Mariposa School for Children with Autism
Supervising Professor: Richard Goldberg
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INTRODUCTION:

The ability to write is a skill essential for natural progression in an academic setting. However, for children with autism, traditional methods for developing this skill are less effective. Typically, the precursor to writing is the development of fine motor control with the dominant hand, which is accomplished via tracing. Even with the one-on-one, personalized instruction and positive reinforcement offered at The Mariposa School, a school for children with autism in Cary, North Carolina, most of their students are not motivated to develop tracing and handwriting skills. The goal of the project is to develop an aid that provides positive feedback when the student is tracing properly over large, printed letters.

SUMMARY OF IMPACT

Our client coordinator at The Mariposa School, Chris Wensil, is excited about the device and its ability to help many children at the school. In particular, he is impressed with the device's immediate impact with several children; they quickly learned that proper tracing keeps the music playing and thus they continue to practice a proper tracing technique.

TECHNICAL DESCRIPTION

The purpose of the device is to provide musical feedback when the child is tracing properly. A photodiode sensor is mounted in the tip of a pen, and the client uses this pen to trace over a piece of paper with a large printed letter (see Figure 13.7). The paper rests on top of a commercial light-bed. Light shines up from the bed, through the paper and the light level is detected by the photodiode sensor. When the sensor is over a dark area on the page, the black ink on the paper blocks a significant amount of light, resulting in a low voltage output from the photodiode. Accordingly, when the sensor is over a

Fig. 13.7. Photo of the device, with a letter A as the tracing area.

blank area on the page, more light reaches the photodiode sensor, its output voltage increases.

If the desired tracing area on the page is solid black, then the device cannot differentiate between a moving pen and a stationary pen positioned over the black areas on the page, because both scenarios results in a low voltage on the photodiode. In addition, low light levels within the ambient environment provide similar signals as the black tracing area. A simple solution is to make the tracing area consist of a checkerboard pattern (note the "A" on Figure 13.7). As a result, when the user is properly tracing over the checkerboard, the photodiode signal is roughly sinusoidal. The microcontroller looks for a sinusoidal signal of a certain minimum frequency, and triggers the musical feedback accordingly.

All calculations are performed with a PIC 16F876 microcontroller (Microchip, Inc., Chandler AZ), which receives input from a simple photodiode embedded within a pen. When the proper signal is received, the microcontroller commands a Rogue Robotics uMP3 board (Toronto ON) to play an MP3 file, which is stored on an easily accessible Secure Digital (SD) card. The device is built into a commercially available children's tracing toy, the Elmer's Paintastics Light Magic. The pen housing is custom built with the use of a rapid-prototyping fusion deposition modeler and other widely available parts. The inking cartridge is from a commercial BIC ballpoint pen, and it fits snugly into the custom pen housing. The teachers easily replace the cartridge when necessary. The pen connects to the circuitry via a cable and 3.5 mm audio stereo plugs. Commercial, external speakers and headphones provide the audio feedback.

Once the Trace-Aid is activated by toggling the main power switch, the user can immediately begin tracing. As long as the pen is moved over the designated tracing area, music is heard from an audio output. However, as soon as the pen leaves the desired tracing area, or the child stops moving the pen, then the music abruptly stops. In the event that the child completes a tracing session with satisfactory results, the instructor may opt to provide an additional reward by playing continuous music. This is accomplished via a "reward" switch, activated by the instructor when appropriate.

The device is battery powered, large enough to accommodate a standard 8 ½" x 11" piece of paper, yet portable enough to fit on a wheelchair lap tray. The total cost of the device is $205.

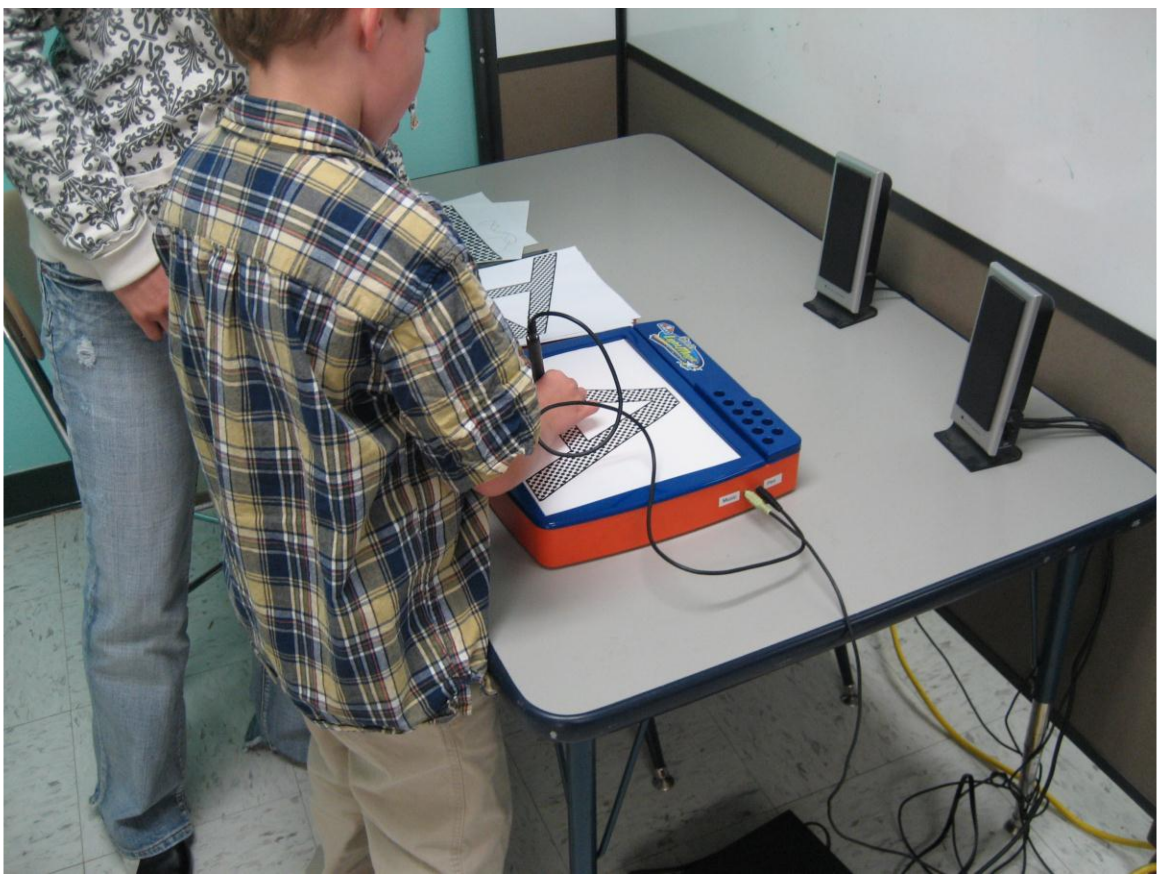

Fig. 13.8. Photo of client using the device.

ROWING MOTION COUNTING DEVICE

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INTRODUCTION

Our client is a 14 year old boy with leukodystrophy. This is a neurological disorder in which the myelin sheath, which covers central nerve fibers, progressively degenerates. This results in a variety of symptoms, including the steady loss of body tone, gait, speech, vision, hearing, and behavior.

His speech therapist requested an activity that would help him understand the concepts of numbers and counting. The goal of this project is to create a counting game that is fun and motivating for the client, and also encourages him to exercise in his wheelchair. The design accounts for his visual and physical impairments so that he can use the device independently.

SUMMARY OF IMPACT

Many individuals with disabilities cannot employ traditional means of learning due to spasticity, visual impairments, and other cognitive and physical disabilities. Our device employs rowing motion to convey the concept of quantity by counting the number of pull/push repetitions. The client's mother commented that, "Jamison is able to use it easily and pulling the handle toward him works better than pushing. He laughs at the end of the counting when you say "Yea! You did it!"

TECHNICAL DESCRIPTION

The Rowing Motion Counter teaches the client how to count by one each time that the client pulls and releases a lever arm. It provides audible feedback of the current count. Figure 13.9 shows a photo of the device. The entire device is mounted on a 0.12 inch thick plate of steel that slides easily into a slot underneath the seat cushion on client's wheelchair for quick installation / removal and portability. The lever arm is adapted from a scooter handlebar. It is connected to a residential door closer, which has an adjustable resistance so that the therapist makes it easier or harder for the client to pull the lever. A potentiometer is also connected at the axis of rotation to read the lever angle.

A Basic Stamp microcontroller (Parallax, Inc., Rocklin CA) controls the system operation. It samples the voltage of the potentiometer (that measures the position of the handlebar); this allows the device to determine when a full rowing motion (pull-release of the lever) is made by the client. By using the Stamp's onboard clock, the device has a precise timing element, which becomes useful for pause operations. Audio feedback is implemented with the Rogue Robotics uMP3 player (Toronto, CA). Audio tracks are recorded into MP3 files and stored on a Secure Digital (SD) card, which provides easy access to audio files.

There are two switch selectable operating modes for the device. In practice mode, there is no desired target. As soon as the client begins to pull, the voice feedback announces the current iteration. When the client counts to 10, the device congratulates the client and the process is reset, allowing the client to start again from 1. If the client pauses for 5 seconds, the device then prompts him to keep going. In game mode, a target is randomly generated and announced upon activation of the device. The client must reach this value through successive strokes of the handlebar. Upon reaching the destination value, the client either pushes the "engage" button or simply pauses for 5 seconds. If this occurs, the device congratulates the client, assigns a new random value, and allows the client to start again. In the case where the client overshoots the target, the device announces the user has passed the target, and requests the user to start from the beginning with the same target value. If the client pauses on a pre-target value, he hears the prompt to keep going.

As the client matures, the resistance involved in pulling the handlebar is easily adjusted by turning a screw, as the residential door closer has adjustability settings. The total cost of parts/materials is about $250.

Fig. 13.9. Photo of the device. It mounts to the client's wheelchair by slipping the horizontal bar on the right side of the photo under the seat cushion. The client grabs the handles with both hands and pulls and releases the handlebar to count. The battery-powered circuitry is mounted in the black box at the bottom of the photo, and audio feedback is provided through the two speakers.

CHAPTER 14
UNIVERSITY OF TOLEDO

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SIT TO STAND WHEELCHAIR – SECOND GENERATION

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INTRODUCTION

The goal of this project is to design and build a wheelchair that allows an individual to transition from a conventional seated position to a supported standing position. The finished product must be safe, reliable, and last for an extended period of time. This wheelchair has many benefits for the client. Providing an individual in a wheelchair with the ability to stand on his/her own provides various health benefits and added independence, comfort, and convenience. The current sit to stand wheelchairs in the market are extremely expensive and very heavy. The proposed solution is to design a sit to stand wheelchair for our client to use that will be lightweight, reliable, and inexpensive. A four bar linkage is employed to generate the wheelchair's motion and two gas spring cylinders are used to provide the necessary force to lift the chair into the standing position, requiring little effort by the user. The wheelchair quickly and easily changes positions. Design considerations included functionality, weight, reliability, and most

Fig. 14.1. Pictures of the final sit-to-stand unit in a standing position.

importantly safety of the wheelchair. While safety and function are absolute necessities with this project, the client requested other requirements for the proposed device. Physical restraints such as arm, leg, and chest supports had to be built into the device to facilitate safe operation. Overall floor size requirements of 26 x 27 inches were established in order to assimilate with the client's main transportation vehicle. Side supports, in addition to adjustable offset footrests, were also incorporated into the final design as illustrated in Figure 14.1.

SUMMARY OF IMPACT

Spina Bifida (SB) is a birth defect caused by improper development of the spinal cord occurring when the spine of the fetus fails to close during the first months of pregnancy. The degree to which one's life is affected by this condition varies. The client, Ms. Jill Caruso, is paralyzed from the waist down and requires the use of a wheelchair for mobility and transportation reasons. Jill requested a wheelchair that is able to go from a conventional seated position to a supported standing posture. She wanted this type of chair for a variety of reasons. For someone in a seated position all day, occasionally standing has dramatic health benefits. It improves circulation, helps prevent sores, takes the pressure off of one's skin, and improves overall comfort. She also wanted to be able to see over the walls at her son's hockey game. Also, the chair assists her in reaching shelves while shopping alone. Several companies currently produce such a chair, but they are quite costly and usually not covered by insurance. Unfortunately, the client's insurance is unable to cover the cost associated with this kind of wheelchair. After completing the chair, Jill has tested it and found it exceeded all her expectations. It has met all her goals and she is now able to do the things she requested. She is delighted to use the chair on a regular basis.

TECHNICAL DESCRIPTION

One of the main preferences of the client is a mechanically operated lifting mechanism rather than an electrically operated one. Due to the size of the van owned by the client and the existing lift mechanism used, the wheelchair design should not be any wider or longer (front to back) than her current manual wheelchair. The existing wheelchair lift mechanism also has weight restrictions that must be considered.

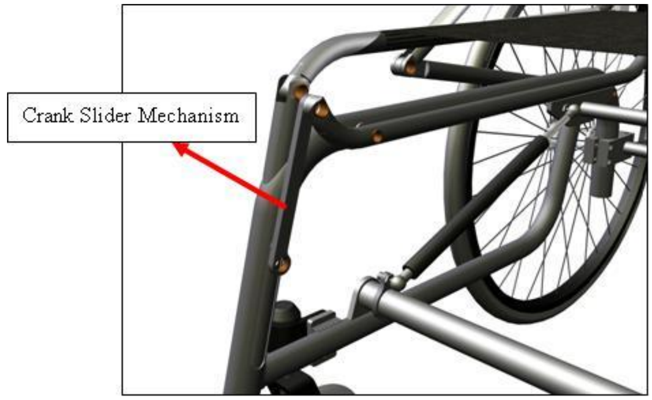

Fig. 14.2. Crank slider mechanism.

Several design options were considered, including using a hydraulic lift assist mechanism, an electric power screw mechanism, a lever assisted mechanism, and gas springs. Hydraulic systems are expensive and have a slow response time. Electric power screw mechanisms are also expensive and bulky. Using a house of quality, it was determined that a gas spring lift assist mechanism is simpler and safer. Through the use of gas springs, all of the client's requirements are met. Gas springs allow for a fully mechanical mechanism. Two gas springs are utilized with one placed on each side of the seat. These springs are attached to the wheelchair frame on one end and the seat bottom on the other. For optimal operating conditions of the gas springs, they are mounted in a nearly vertical position when the chair is in the seated position with the springs compressed. These gas springs are fully adjustable to achieve the required lifting force for the client. They are also relatively small, as well as more cosmetically appealing as compared to other lifting mechanisms. Since the gas springs operate within small spaces and tolerances, size constraints are easily met.

A locking mechanism is used to hold the chair in the seated position during normal operation. When the client desires to transition into the standing position, this latch or locking mechanism is released. The user then applies a force using her arms to initiate motion into the standing position using her arms.

Coupled with the input force of the gas springs and the initial applied force of the user, which is minimal, the chair transitions into the standing position. The standing position is defined as the seat bottom making an angle of 75° with the horizontal. This design requires the seat bottom be hinged at the front of the frame. The use of another hinge also requires a space between the seat bottom and seat back to allow the two parts to become aligned.

While in the standing position, the seat back is supported in one of two ways. A four-bar linkage is used to rotate and raise the chair, supporting the seat back. Another potential design option is the use a telescoping bar. This locks into place when in a standing position, and is easily released by the client. A similar mechanism is used to support the seat bottom if necessary. Using the house of quality, it is determined that using a four bar linkage is the preferred method.

The crank slider mechanism shown in Figure 14.2 is used to lift the chair caster wheels off the ground. This enables the chair to form a wider base for support, while letting the client exert most of her body weight on the front support.

Other considerations include the stability of the wheelchair, as well as leg and upper body supports for the user when in the standing position. There are a variety of ways to stabilize the chair while in the standing position. Prior to elevating in the standing position, the rear wheels are locked into place to prevent any rolling movement of the wheelchair while in the upright position. Any linear motion while in the standing position creates a potential tipping hazard due to momentum generated from the movement. This is accomplished using a standard braking mechanism similar to what is used on most wheelchairs today. To support the legs while in the standing position, padded rests are used that rotate off of the foot rests and lock into place just below the knees. The armrests also rotate prior to transitioning the chair to the standing position. The armrests move from a position at the user's side to a support position just below the user's elbows when in the upright position.

Kinematic Analysis

The modeling for the current design of the wheelchair is done using Autodesk Inventor. By drawing in a fully 3D world, the 4-bar mechanism and the crank slider mechanism that lifts the client out of the seated position are confirmed to function as designed. The basis of the lifting mechanism rests on the design of the 4-bar mechanism that lifts the client into the standing position, while changing the seat angle relative to the ground. It is designed using a graphical solution method as seen in Figure 14.3.

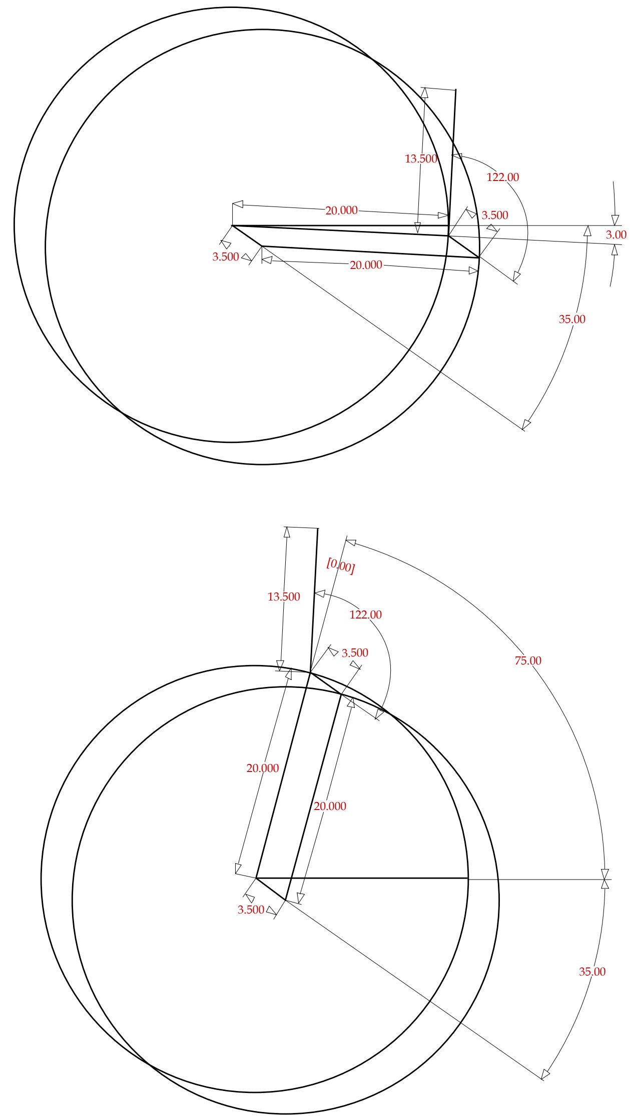

Fig. 14.3. Four bar mechanism moving from the seated position (top) to the standing position (bottom).

The final angle of 75 degrees for the seat relative to the ground is chosen based on existing sit to stand wheelchairs. It provides the safety of keeping the client's center of gravity closer to the center of the supports of the chair. The seat back angle does not change relative to the ground. This makes the seat back perpendicular to the seat in the seated position and at a twelve degree angle when in the standing position as shown in Figure 14.3. The twelve degree angle is necessary to support the client's upper body when standing. Figure 14.4 show images of the design modeled in Autodesk Inventor. Pictured are the seated position, half-way standing, and fully standing positions, respectively.

Design Calculations and Finite Element Analysis

First, a fairly rough stress analysis was completed on the chair in each of its positions. These included the seated, intermediate position just before the foot rests hit the ground, and the full standing position. This is done to identify which position held the critical, or highest, stresses. Thus, a more detailed stress analysis needs to be completed only in that position. The reaction forces for each case are calculated, and the highest stresses are identified for each position. The highest stress is found in the seated position; therefore it was identified as the critical position.

A detailed stress analysis on each member of the frame in the seated position was then conducted. Four members in the frame are analyzed. These are identified as members A, B, C and G. Free body diagrams of these members are shown in Figure 14.5. The estimated weight of the finished sit-to-stand wheelchair is around 40 lbs. The frame is made of Aircraft Grade Chrome-Moly 4130 Steel with a yield strength of 63 MPa. Wall thickness of members A and B are calculated as 0.065", corresponding to a factor of safety of 5.1 and 3.4, respectively. The factor of safety for members G and C are calculated as 11.6 and 14.9, respectively. The welds on member C are also analyzed and found to be very safe with a high factor of safety.

Gas Spring Calculations

The placement of the gas springs is critical in the final design. The moments about the hinge connecting the seat bottom to the frame are taken into consideration in order to determine the optimal placement of the gas springs in the frame. The moment caused by the body weight of the user acts in the opposite direction caused from the gas spring input force. The moment caused by the gas springs must be greater than that caused by the distributed load from the user's body weight on the seat bottom. Also, as the input forces change from the gas springs, the moment about the seat bottom hinge changes accordingly. It is important to note that as gas spring placement changes, the extended and compressed lengths of the cylinders change. This had a large role in determining a supplier for the gas springs.

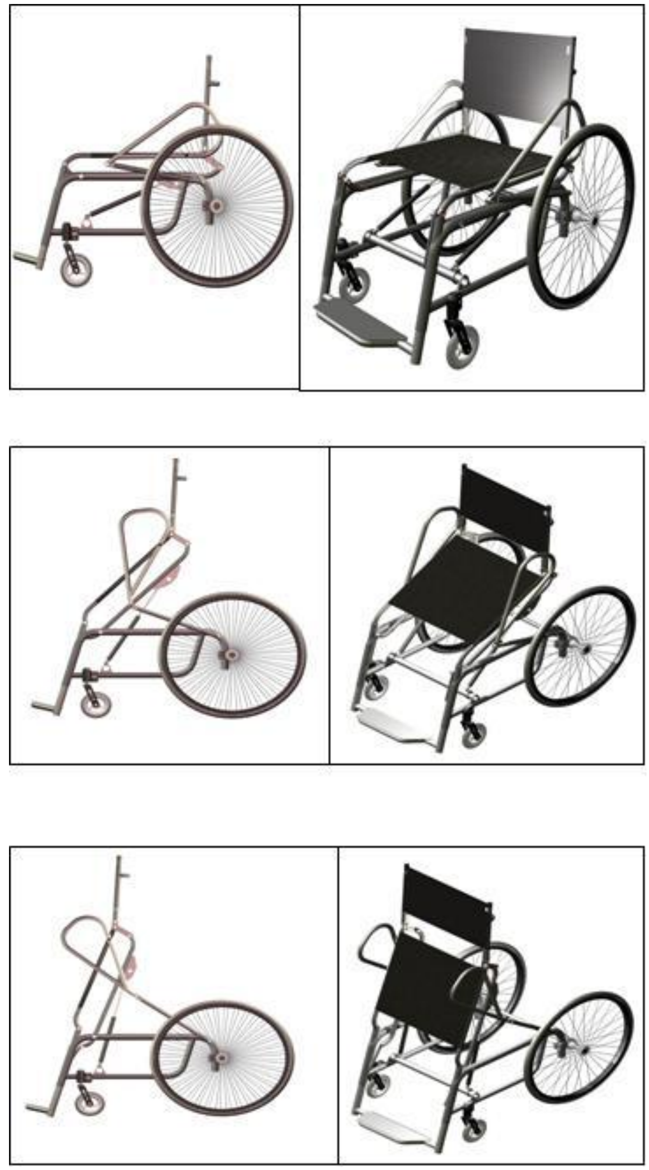

Fig. 14.4. Computer rendering of the final design; the seated position (top), half-way standing (middle), and fully standing positions (bottom).

To have the gas springs custom made is not only very costly, but also require a great deal of lead time due to the processing of the parts. For the given application, accounting for the timeline and budget allotted, a supplier was found that stocks gas springs with the desired input force and extended and compressed lengths as close as possible to those calculated to be the optimal conditions. Once this was determined, the wheelchair design had to be retrofitted in order to accommodate the changed dimensions and placement of the mounting brackets.

The selected gas springs have an adjustable linear force. This was accomplished by bleeding off pressure from them through a release valve until the desired input force was achieved. The gas springs that were thus ordered had initially a much higher than needed input force. Through testing with the client, the supplied force was adjusted to the best working condition.

Machining and Fabrication

Frame material was ordered from Airparts Incorporated. Saxon Products Inc. completed the required tubing bending for the final design. All bent tubing pieces were bent with excess material left at the end to aid in the bending process. After cutting all of these pieces to the required length, the necessary holes were drilled in the tubing in order to make the desired connections.

All flat plate pieces welded onto the frame material that were used to make connections were cut out using a CNC plasma cutter. Sperling Heating & Ventilating Company donated their services and equipment for completion of this task. After getting all the necessary parts machined, the frame was welded together by Bruce Welch and group member Jake Welch. They also handled all other welding, including various parts on the frame. Then all the parts were powder coated, and then assembled. After completion of assembly of the prototype model, extensive testing took place to make adjustments to best fit the client. This included making any necessary alterations that included gas spring adjustment. Testing was conducted to make sure the lifting device worked properly and ensure it met all the clients' expectations. The client was extremely satisfied with how the final product turned out and is looking forward to using it.

Donations were obtained from a titanium wheelchair manufacturer, TiLite, consisting of front wheels with tire and casters, rear wheels with tire and axle bolts, brakes, and a footrest. These donations have been priced out at a value just under $1400. MTS Seating donated their powder coating service on all the steel pieces of the wheelchair. These donations helped the group to stay around the $850 approved budget.

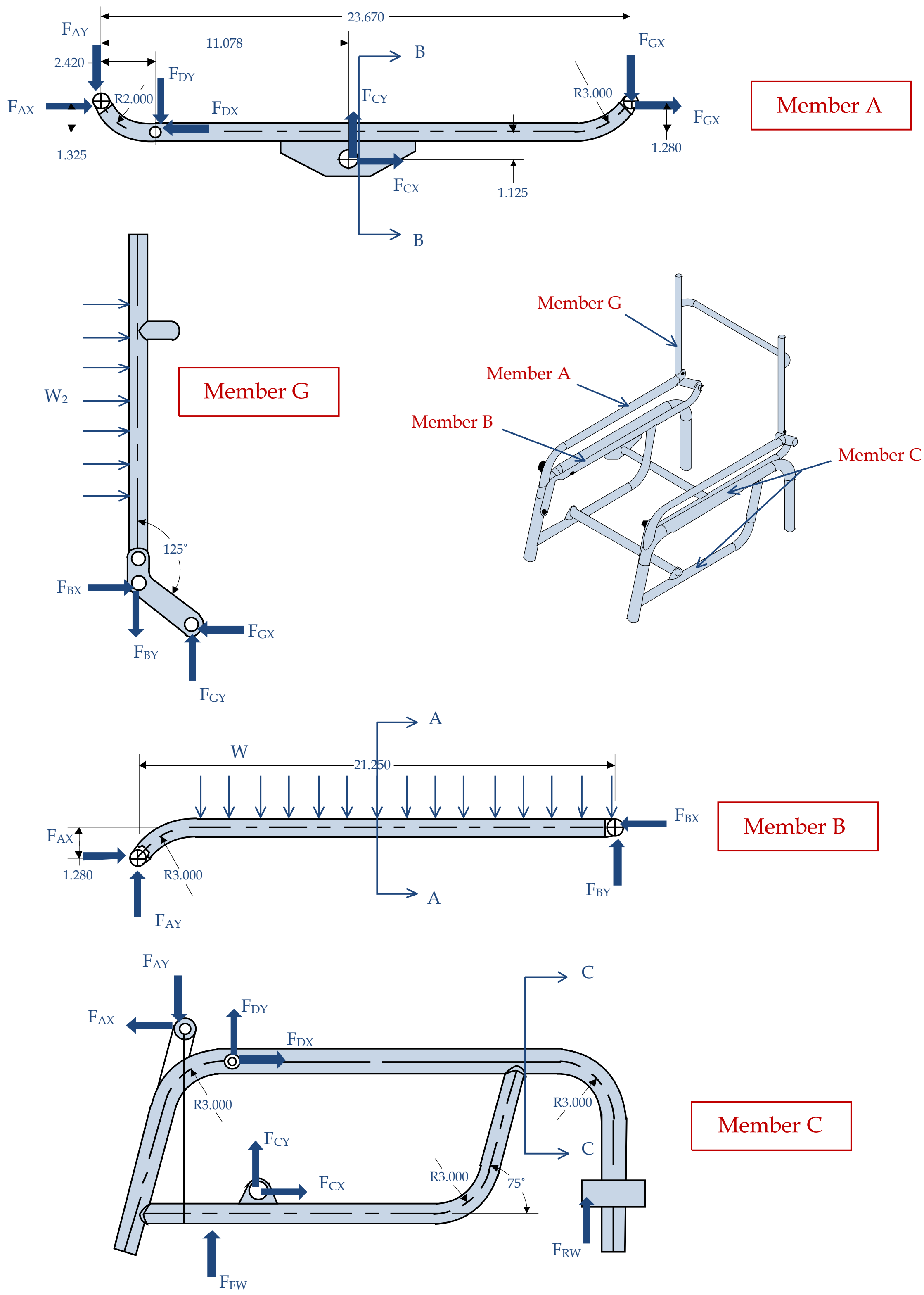

Fig. 14.5. Free body diagrams for members A, B, C and G.

ADAPTATION OF A WHEELCHAIR TO MOUNT A 16MM FILM CAMERA

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INTRODUCTION

The goal of this project is to adapt a wheelchair to allow an individual with a disability to operate the main functions of a Bolex 16mm film camera. This individual is a C5 quadriplegic, with limited use of the shoulders and biceps, but no use of triceps or hands. He is a student at the University of Toledo majoring in film. To complete his major he needs to take FILM 2130. This course requires students to learn about and use the Bolex 16mm film camera. Design objectives focused on allowing the client to tilt and pan the camera, as well as lining up a shot, and running film. A frame that attaches to the client's wheelchair made of aluminum and steel, acts as a platform for the camera. The camera is attached to the frame via a quick release mechanism with a tilting base. A remote viewing system is attached to the eyepiece of the film camera and allows the client to easily see what he is filming. Buttons are placed according to the clients request to operate the camera. Figure 14.6 shows the client using the camera, while seated on his wheelchair, and Figure 14.7 shows a conceptual rendering of the system that was developed.

SUMMARY OF IMPACT

An individual with disability is aspiring to complete a degree in film at the University of Toledo. One of the requirements of the degree is to complete the FILM 2130 course. This course involves the use of a Bolex 16mm camera. The successful completion of this project allowed this individual to operate the film camera independently. After testing the system that was developed, the client found he is easily able to operate the main functions of the Bolex 16mm film camera.

Fig. 14.6. Client using the Bolex 16 mm film camera.

TECHNICAL DESCRIPTION

Adapting the client's wheelchair to allow him to use the Bolex camera involves the design and construction of a stable platform and controls to run the camera. The platform needs to withstand the weight of the camera and also any external loads applied by the client. A steel block clamping system was devised to easily attach the "L" shaped support arm to the wheelchair. The support arm is bolted to the clamping system and is made of extruded aluminum profiles. The profiles are used because of their light weight and rigidity. Also, the aluminum profiles allow for easy attachment of buttons and controls.

Attached to the top of the support arm is a lever locking tilt device. This allows the client to lock in different angles of vision when he is shooting film. Mounted on top of the tilt device is a quick release system. It consists of an aluminum T-slot and locking pin. A T-block is bolted to the bottom of the Bolex camera, and this block then slips into the T-slot on the tilt mount. After the block is inserted, a locking pin is pushed across the front through two holes drilled in the T-slot to hold the camera in place.

To allow the client to see what the camera is actually filming, a digital viewing system is included in the design. The Zigview S2 Digital Eye Piece viewing system is chosen for its remote operation capabilities. Zigview mounts to the eyepiece of the Bolex through a custom Delrin adapter, as shown in Figure 14.8. The adapter presses onto the eyepiece for a secure fit and transfers the image seen through

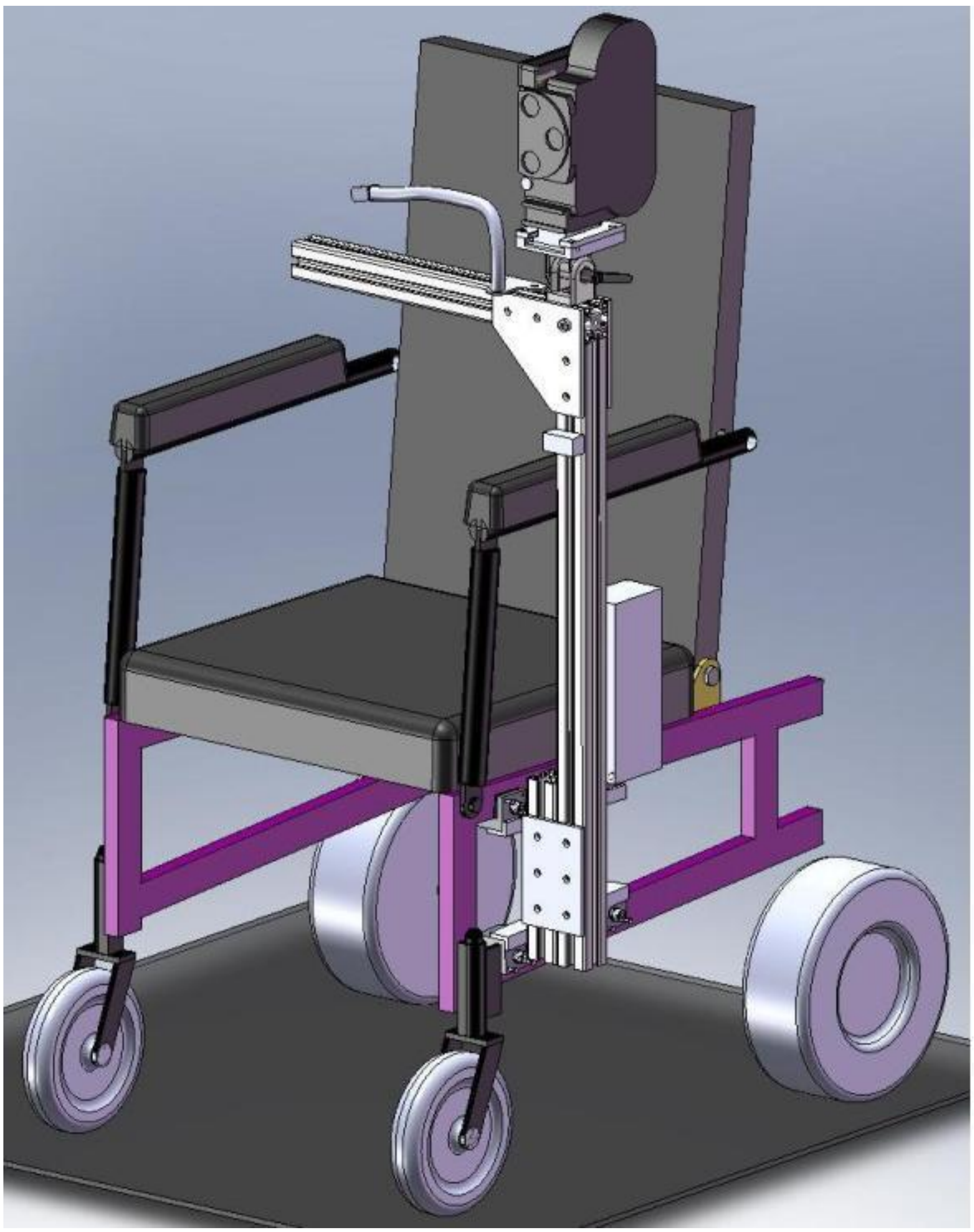

Fig. 14.7. Conceptual rendering of the system.

the eyepiece to a viewing screen. The Zigview's remote 2.5" LCD viewing screen is mounted, via a Velcro strip, on the end of a flexible metal tube that allows adjusting the screen's position. The remote viewing screen allows for the Bolex to be mounted away from the client, and still allows the client to instruct an assistant in accurately tilting the camera. The digital eyepiece captures the image seen in the Bolex eyepiece and displays it on an LCD screen. The LCD screen is attached to the support arm as shown in Figure 14.9 via a flexible tube, which the client can move to position the viewing screen in a convenient location. The power button for the Zigview, which is located on the viewing screen, was modified by making the button larger and also slip-resistant, giving the client the ability to activate the button. A sunshade was also constructed that mounts onto the viewing screen, helping to reduce glare from the sun when filming outdoors.

The Bolex camera runs film in two different modes, continuous run and single shot. To give the client the ability to use the continuous run function, an electric motor made for the Bolex camera is used. It mounts to the side of the Bolex with three screws. A momentary push button switch is wired to control the motor. When the client wants to start filming, he pushes and holds the button down and then releases it when he wants to stop. This switch is mounted on the inside of the support arm upright, which allows for easy access and meets the client's preference.

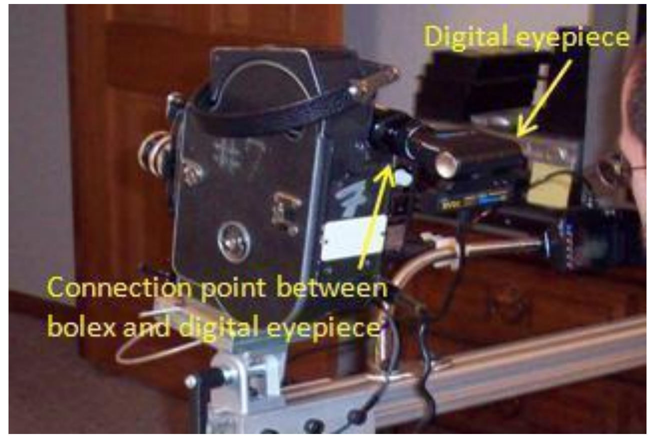

Fig. 14.8. Zigview adaptor.

To take film one frame at a time, the motor is removed and a plunger cable is attached to the single shot button on the Bolex camera. This cable is being borrowed from the UT Film department. The cable is mounted to the side of the support arm in a place denoted by the client. To take a single shot, the client pushes the plunger in until the camera advances the film by one frame. The tips of the buttons have a rubber pad placed on them to help the client push them in and to keep his hand on them.

COSMOL, a finite element package, was used to perform the structural analysis of all the components of the unit. The total cost of the material is about $560.

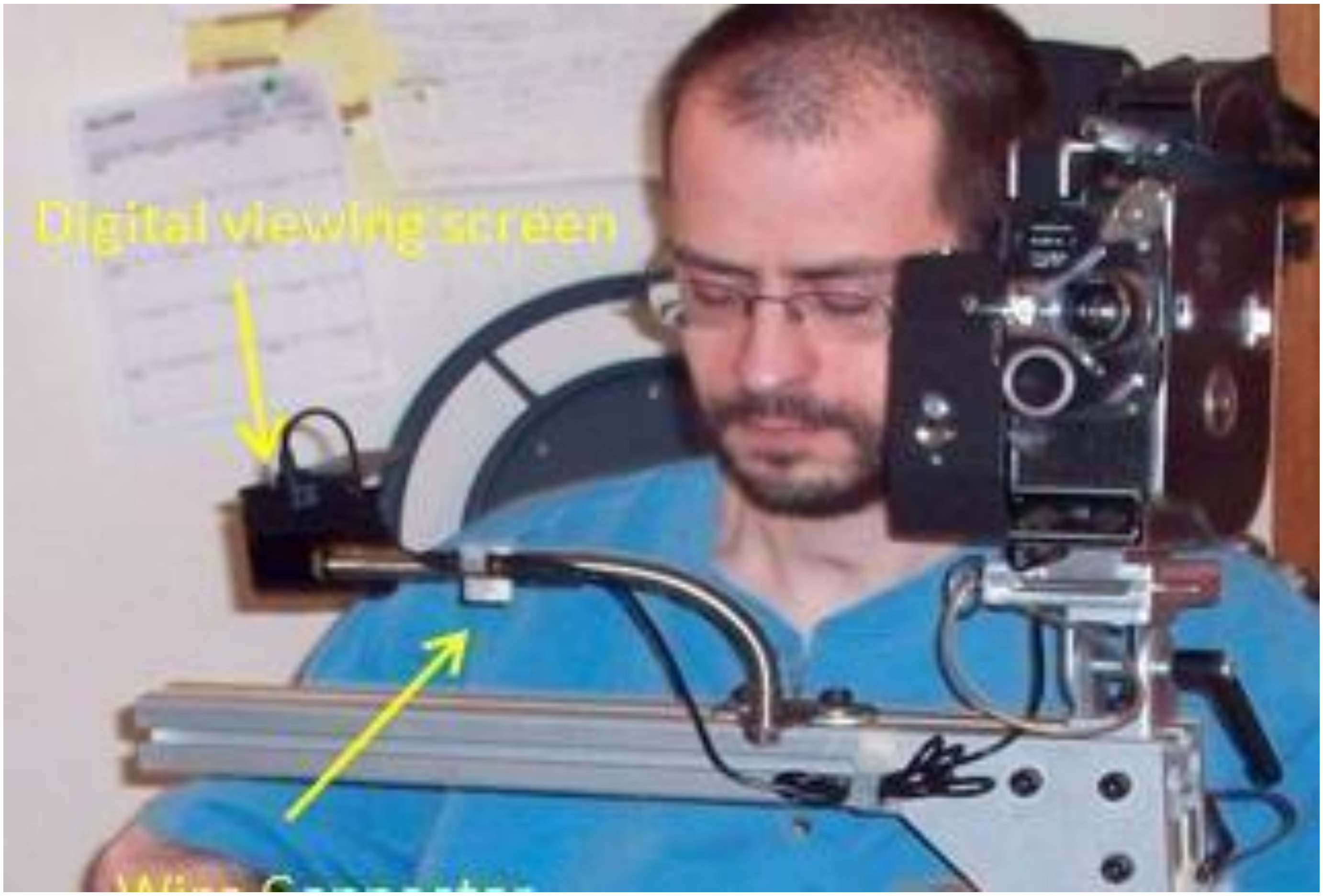

Fig. 14.9. Zigview remote viewing system.

DEVICE TO ASSIST A PATIENT OUT OF A HOSPITAL BED

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INTRODUCTION

The purpose of this project is to design, analyze, build and test a mechanism that assists a patient out of a hospital bed. This device is not focused on a patient with a specific disability but rather any patient that has difficulty getting out of bed independently. After discussing the scope of the project with physical therapists, it was decided that the shoulder would be lifted to help the patient grab the opposite hand rail and swing their legs over the side of the bed. Once the patient achieved sitting position, the rear is be lifted and pushed in a lateral motion to help the patient stand up. This is accomplished by using two air cylinders that would lie under the left shoulder and the right rear of a patient, and inflate to provide lift assistance. The design concept and lift process is depicted in Figure 14.10.

SUMMARY OF IMPACT

Many patients in a hospital have difficulty getting out of bed independently for many reasons. Whatever the case, this device allows the patient to stand independently. This device is also beneficial to hospital personnel because any patient that needs assistance from someone to get out of bed is able use the device instead. The Leadership Team at Flower Hospital, a member of Promedica Health System, assessed the final product and found it novel and useful.

TECHNICAL DESCRIPTION

Two cylinders are used: one for the shoulder with a diameter of 8" and one for the rear with a diameter of 12". A pump designed to inflate air mattresses was found to be adequate. A total of three solenoids and three switches are used to direct the air flow properly. Two of the switches are Double Position Single Throw switches; the third one is a Three Position Single Throw (3PST) switch connected to all three solenoid valves. To operate, a patient flips the shoulder cylinder switch that turns on the pump, and opens the first solenoid allowing air to pass to just the shoulder cylinder. Similarly, the rear cylinder switch is flipped to turn on the pump, and open the second solenoid to allow air to pass just to the rear cylinder. To evacuate the cylinders, the 3PST switch is flipped to open the third solenoid (which is open to the atmosphere) as well as the other two solenoids. An analog timer is added to prevent prolonged use and damage to the pump. The patient flips the switch to turn on the pump, and begins inflating the cylinder; the timer turns the pump off after one minute regardless of whether the patient flipped the switch back off. The switches are housed in a small plastic enclosure and wires are run to a wooden box made of 0.75" treated plywood that contains the three solenoid valves, the safety shut-off timer, the air pump and air tubing. Carpeting is attached to the inside walls of the box to absorb sound. Metal brackets are used to hang the box off the back side of the hospital bed headboard, as shown in Figure 14.11. Stress analysis was conducted to estimate the hoop and longitudinal stresses in both cylinders and a minimum factor of safety of 4 was calculated. Also, the amount of head loss in the system was calculated and the total pressure loss in the system was estimated at .874 psi from the pump outlet to the entry of the cylinders. Despite this head loss, the pump is still capable of achieving sufficient pressure.

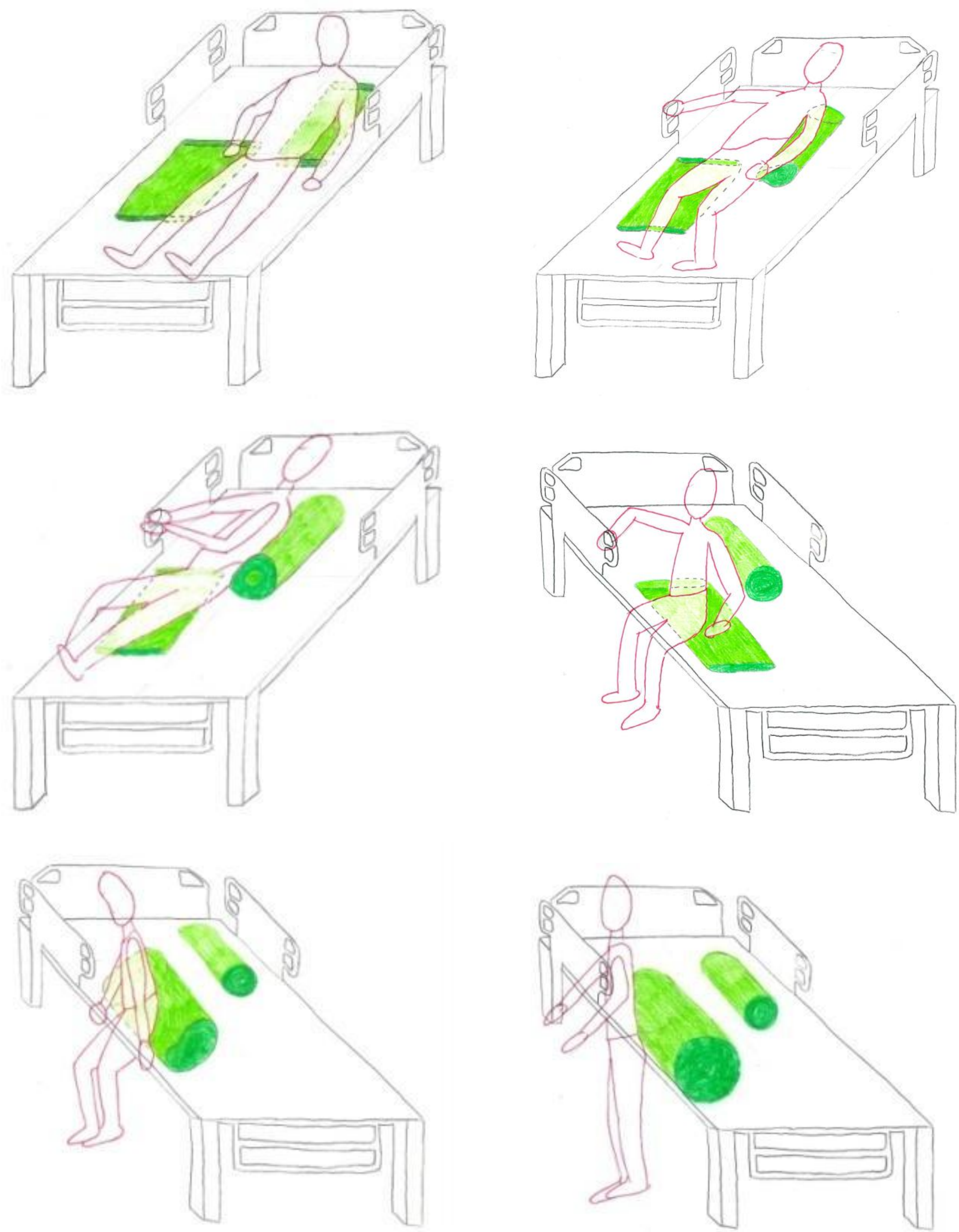

Fig. 14.10. Design Concept (from left to right; begin with both bags deflated, shoulder bag slowly inflates, when shoulder bag inflation is completed, the patient is sitting and the rear bag slowly inflates).

After testing the lifting ability of the rear cylinder, it was decided to place a board on it to provide stability while inflating as shown in Figure 14.12. Without the rigidity, the patient needed to use their abdominal muscles to balance themselves on the flexible cylinder. As the cylinder inflates, one side of the board rises with the cylinder to simulate a wedge. As well as providing stability, the board provides a lateral motion that helps push the patient forward, as opposed to lifting the patient straight up. Each cylinder has its own bolster bag with a pull cord to close the bag. The two bolster bags are sown to a mat, and the board placed on the rear cylinder is attached to the mat made from 100% cotton. The mat is then attached to the longer blue fabric, draw sheet, which is placed crosswise underneath the patient and used to assist in moving a patient from bed to bed or repositioning a bedridden patient.

The total cost of this project is $500.

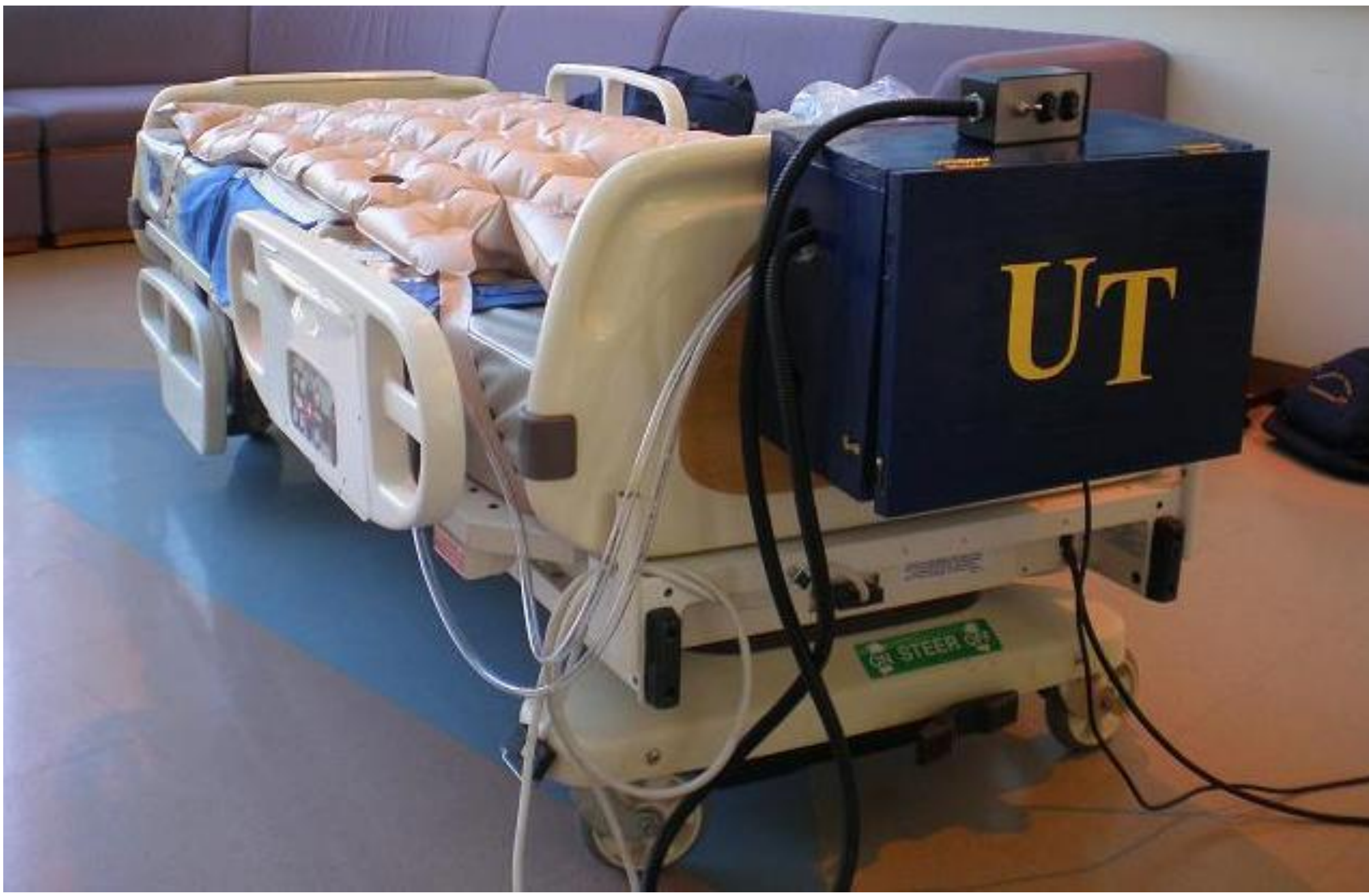

Fig. 14.11. Control box attached to a bed.

Fig. 14.12. Board attached to the rear cylinder

A DEVICE TO ASSIST A CLIENT TO BUCKLE HIS SEAT BELT

Designers: Mike Zimcosky, Mike Cook, Elijah Miller, Jonathan Johnson
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Supervising Professors: Dr. Mohamed Samir Hefzy and Dr. Mehdi Pourazady
Biomechanics and Assistive Technology Laboratory
Department of Mechanical, Industrial, and Manufacturing Engineering
The University of Toledo, Toledo, OH 43606

INTRODUCTION

The goal of this project is to design a system to assist an individual with a physical disability to buckle his seatbelt. The client has a limited range of motion and needs a system that requires minimal exertion to operate. A fully automated system is developed for this purpose that utilizes an auxiliary belt and a motor assembly to buckle and unbuckle the client's seatbelt. The auxiliary belt is attached to both the male end of the client's existing seatbelt, and the motor assembly. To have his seatbelt buckled, the client simply presses a pushbutton switch which activates the motor assembly. The motor assembly rolls up the auxiliary belt and the male end is guided to the female end and locked. When the client is ready to exit the vehicle, another pushbutton switch is pressed that activates an actuator. The actuator depresses a release mechanism that unlatches the seatbelt, and allows the client to exit the vehicle.

SUMMARY OF IMPACT

As a result of having Cerebral Palsy, the client is physically unable to buckle/unbuckle the seatbelt of his car. The client drives to and from work, and either relies on the assistance of others to buckle his seatbelt, or simply forgoes the usage of his seatbelt. This situation presents an obvious problem for the client with regard to safety. This problem is resolved by developing a system that assists the client in buckling his seatbelt independently. The device was successfully tested by the client as shown in Figure 14.13.

TECHNICAL DESCRIPTION

A fully automatic design is created that works by utilizing an auxiliary belt that is permanently attached to the male end of the existing seat belt.

Fig. 14.13. Client successfully using device.

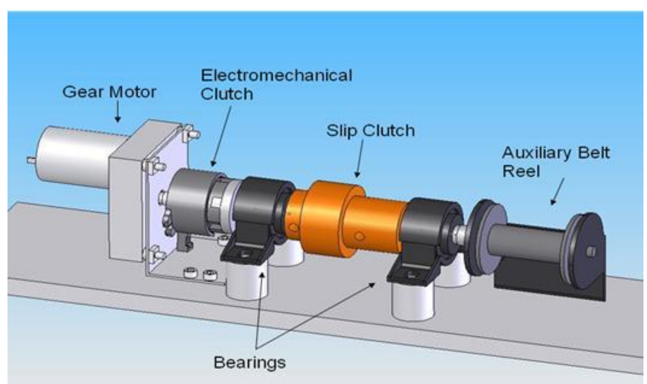

Fig. 14.14. Motor assembly.

The auxiliary belt is kept slack to allow the user to slide underneath it, and into the seat. A 24 volt gear motor with a maximum torque output of 50 in-lb. at 25 rpm is used to provide the force necessary to buckle the seatbelt. The motor assembly, shown in

Figure 14.14, is comprised of the motor, an electromechanical clutch, a slip clutch, two bearings and the auxiliary belt reel. When the seatbelt latch is released and the client wishes to exit the vehicle, the driveshaft of the device must fully disengage so that the existing seatbelt retracts properly. Because the output shaft of a gear motor cannot free-spin when there is no power, an electromechanical clutch is used in line with the output shaft. When the switch is pressed to engage the gear motor, power is also delivered to the clutch allowing the reel to spin and retract the auxiliary belt. When the switch is released, thus disengaging the motor, power is removed from the clutch causing the reel and belt to spin freely. The safety of the client is of prime importance, and the inclusion of the slip clutch helps to ensure it. If for some reason the client are becomes entangled in the belt, the slip clutch slips and allows the motor to free spin without transmitting any more torque to the reel.

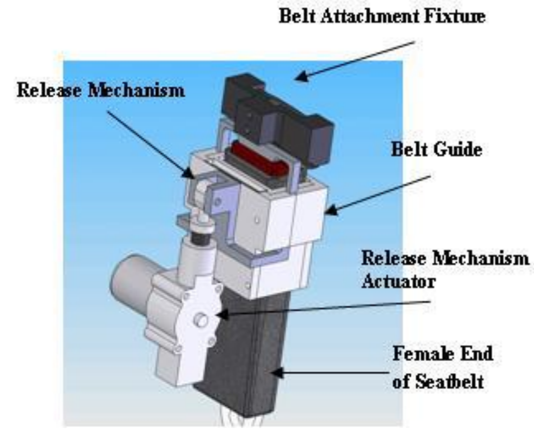

Fig. 14.15. Belt attachment and release fixture.

Figure 14.15 shows the belt attachment and release fixture. It is made of ABS plastic and is used to connect the auxiliary belt to the existing male end of the seatbelt. The release mechanism is made of aluminum and is engaged by the linear actuator. The belt guide is used to align the male and female ends of the seatbelt, and also used to house the release mechanism.

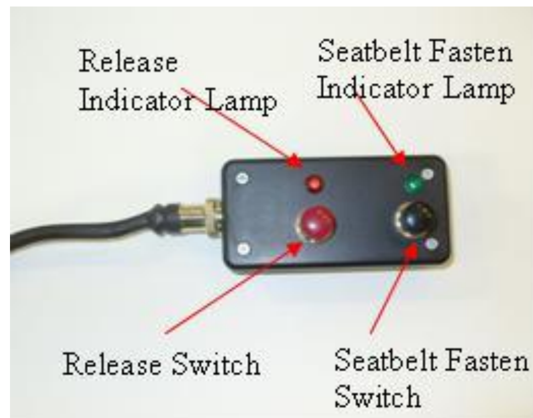

Fig. 14.16. Belt guide control box.

A motor assembly cover is used to prevent any entanglement of foreign objects in the motor assembly. The design requires electronic control of both the seatbelt fastening mechanism and release mechanism. The user operates both of these systems via an electronic control box shown in Figure 14.16. The electronic control box, has two momentary pushbutton switches, one to operate the seatbelt fastening device, the other to operate the release mechanism. Momentary switches are used for safety reasons; they require the user to depress each switch for the entire duration of operation. Should any problems arise, which may compromise the user's safety, the user can let go of the button causing operation to cease. A green indicator lamp illuminates when the seatbelt fasten switch is depressed to alert the user the seatbelt fastening mechanism is in operation. A similar red indicator lamp illuminates when the release switch is depressed. The system is powered by the 12-volt accessory outlet of the client's vehicle. A step up converter is used to transform the 12-volt supply to the necessary 24-volts for the motor. The release mechanism also manually releases to allow for a quick release in the event of an emergency or power failure.

The total cost of the parts of the system is $547.02.

CUSTOMIZED RACING WHEELCHAIR

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INTRODUCTION

The purpose of this project is to design and assemble a fully customized racing wheelchair for an individual using a wheelchair for daily living activities. An I-cage design is used in the construction of the racing wheelchair. An A-frame is employed. Special attention is used in the design of the compensator and steering linkage to allow proper and safe steering during both track racing and road racing. Figure 14.17 depicts the client with the racing wheelchair along with the team of students who worked on this project.

SUMMARY OF IMPACT

The client was born with Spina Bifida. He is a twenty-three year old theatre major at the University of Toledo. He enjoys a wide selection of music and working at the Toledo Zoo, in addition to physical activities, including tennis and biking with a borrowed racing wheelchair. This individual required a customized racing wheelchair with a seating position that allows for maximum performance, with minimal contact points, which may produce pressure sores. He requested a position with the feet and lower legs in front of him, for comfort and circulatory purposes. A racing chair

Fig. 14.17. The client on the racing wheelchair.

is designed and fabricated for use in both competitive and non-competitive environments. The unit was successfully tested by the client. The successful completion of this project allows the client to engage in beneficial overall physical health and weight loss activities, as well as being able to leisurely enjoy the outdoors, away from everyday wheelchair.

TECHNICAL DESCRIPTION

The client requested an open front to the cage, a footrest, and use of the chair on both track and street courses. Two possible cage designs were identified, including I-cage and V-cage designs. Also, three frame designs were identified including T-frame, A-frame and V-frame. To meet the client's needs, an I-cage and an A-frame were selected. Aluminum tubing, ½" (0.125" thick) for the cage and 2" (0.25" thick) for the frame, was used to construct a three wheel racing wheelchair. Standard bicycle components are used that include: front fork and tire, hand brake and rear wheels.

The front steering system consists of several parts unique to a racing wheelchair. One of these ancillary components is a compensator. To keep the front wheel under control while the client powers the rear wheels, a compensator system is needed. A compensator is part of the front steering system and consists of a spring loaded damper to keep the front wheel turned at a specific angle. Without this, the wheel turns freely and prevents the chair from functioning properly.

Given a 3-wheel, I-cage, A-frame, the main calculations determine the center of gravity (CG), the impact load, the critical roll velocity and the force and moment for the compensator. The client's anthropometric data are used in these calculations. The impact load is calculated as 2500 lbf. This is calculated using a mass of 225 lb., which includes the estimated weight of the chair and the rider, and a velocity of 30 mph and an impact time of 91 ms. A critical roll velocity of 23.5 mph was calculated as the highest velocity that can be achieved before the chair overturns as it negotiates a 60 ft. turning radius.

Two sets of handle bars are used: one for steering and the other for track use. The two handle bars are connected with the compensator, as shown in Figure 14.18. The front fork caster angle is 45 degrees.

Fig. 14.18. The two handle bars connected with the compensator.

Design considerations for the steering included allowing the wheelchair to be able to turn on a track, as well as on a road course. The effective steering angle to turn a radius of 60 ft. is calculated as 3.7 degrees. The corresponding angle that the steering handlebar turns is calculated as 5.25 degrees. This angle is used to calculate the force that the user needs to apply on the rear handle bar to maneuver the wheelchair.

I-DEAS, a finite element analysis software package, is used to perform the structural analysis of the cage. A maximum acceptable stress of 12.7 kpsi and a maximum acceptable deflection of 0.06" are found in the cage.

The students working on this project were able to secure a donation for the labor and materials for the aluminum A-frame and I-cage, as well as other support materials. The costs of the other parts of the wheelchair including the rear wheels, compensator cylinder, front wheel and fork and push rims and rubber were $750. The team members posted a detailed description of their design and analysis on the World Wide Web at the following URL address:

http://www.eng.utoledo.edu/mime/design_clinic/design_expo/Fall07Pages/2007-04-07/Home.html

BEACH WHEELCHAIR

Designers: Steffen Brown, Jon Lucas, Jason McDonald, Stephanie Minnich
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Client Advisor: Ms. Jill Caruso
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INTRODUCTION

The purpose of this project is to develop a manually propelled beach wheelchair that a user propels by themselves without assistance on a beach or any sand terrain. The unit is designed and assembled consists of a frame made of furniture grade, ultra violet light resistant Polyvinyl Chloride (PVC) pipe with mountain bike tires mounted on standard rims because of their thick tread. This increases surface area and grip in the sand. The PVC frame is light enough so that the user can easily load and unload the wheelchair into a vehicle, which greatly facilitates transportation. The rear wheels are doubled, two on each side, for a total of four rear wheels. The outer wheels on each side are removable to reduce the overall width to a manageable transportation width. The front two caster wheels are pre-manufactured beach ready balloon wheels. Figure 14.19 depicts the final product.

SUMMARY OF IMPACT

The Ability Center of Greater Toledo (ACGT) is a non-profit organization in northwestern Ohio assisting people with disabilities in living, working, and socializing within a fully accessible community. The ACGT has a beach wheelchair they allow their patrons to rent out, but the wheelchair is very heavy, must be pushed by another individual, and cannot be transported without the use of a trailer. Due to the need of trailer, this wheelchair is rarely used. The successful completion of this project has allowed any client to use it independently. The design of the new chair allows for a variety in customer size, yet still is user-propelled.

TECHNICAL DESCRIPTION

Safety, lightweight components, and transportability are the three main design considerations. The beach wheelchair had to be less than 26” wide, 42” long, 48” high and less than 40 pounds. These criteria are specified to allow the chair to fit in a standard minivan and be lifted by existing wheelchair lifts into the van.

Fig. 14.19. Picture of the actual prototype.

The final design implemented two standard wheelchair rims retrofitted to connect to one another, for a total of two tires on each side. These rims are fitted with large treaded mountain bike tires to increase surface area and traction in the sand. The four rear wheels have axles placed just below the seat. The rear axles are ½ inch steel axles held in place by PVC bushings inserted into the PVC fittings. The front caster wheels are pre-manufactured beach ready caster wheels. Caster housings are fabricated by Unique Fabrications, Inc., using thrust bearings, steel plating, a few bolts and some spacers. The wheelchair frame is constructed with lightweight furniture grade PVC pipe. Furniture grade pipe has an UV inhibitor to disallow the molecular breakdown of the PVC that UV light causes.

The inner wheels rear wheels are secured to the PVC frame easily. The existing hand rims attached to the procured wheels were removed and angle irons attached to the outer wheels are used to bolt the rims together. The angle iron is cut into small pieces that are bolted onto the frame through holes drilled into the tube race of the rim. Holes were then drilled perpendicular to the wheel through the angle iron, and bolts are inserted through these holes and bolted to the hand rim holes on the inner wheels. Figure 14.20 depicts a picture of this assembly. Brakes, footrests and backrest are hard mounted to the frame. Plywood square is hard mounted to the frame, on which the seat pad was secured.

The location of the seat with respect to the rear axle is determined taking into account rear stability and ergonomic considerations. Weight distribution in the sand is a major design consideration as the wheelchair must be maneuverable in the sand. The wheel surface area contacting the sand is calculated at 300 pound load in the seat and equal weight distribution among the four tires. With those values, the wheelchair sinks in the sand less than one inch. Further calculations demonstrate the chair can be propelled by the client. Structural analysis determined the maximum stresses in the PVC frame, and a factor of safety of over 6 was calculated.

The four rear wheels were donated by Gilligan's Health Aid of Ohio, Inc. The cost of all other parts is about $450.00. The students working on this project posted a detailed description of their design and analysis on the World Wide Web at the following URL address:

http://www.eng.utoledo.edu/mime/design_clinic/design_expo/Fall07Pages/2007-04-08/home.html

Fig. 14.20. Picture of the rear wheel connection assembly.

ADAPTATION OF PIANO PEDALS FOR AN ADULT – THIRD GENERATION

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INTRODUCTION

A pianist usually needs two functional feet to play the piano correctly. A music instructor at The University of Toledo and pianist has Multiple Sclerosis (MS) and has been fitted with a motorized wheelchair that allows her to position herself in many different ways so that she can perform many of the essential everyday functions. With the aid of her wheelchair, she can situate herself in the desired position to play the piano with her left foot. The objective of this project is to develop a pedal adaptation device that gives our client the ability to use her left foot to play two piano pedals at one time. The design allows the client to use her left foot to control her piano's right damper pedal. The product developed incorporates a mechanical component that allows the playing of the original damper pedal, with a transposed pedal to the left of the current pedals and an electric solenoid to depress the Una Corda (left most) pedal whenever desired. The device developed is portable and adaptable to different pianos. Figure 14.21 shows the adapted piano and Figure 14.22 depicts the client using the unit.

SUMMARY OF IMPACT

Having to use piano pedals with limited mobility is a considerable challenge. For more difficult music pieces, the use of the damper (right) pedal is essential. The client has MS that has taken her ability to use her right leg and right foot away. Attempting to operate the pedal with the left foot is uncomfortable at best, and considering the client's needs, unacceptable. As demonstrated, she can turn her motorized wheelchair enough to allow her left foot to play the damper pedal. However by moving her body to the right caused an undesirable change in her posture and playing technique. Moving the chair and the client in such a way is neither practical nor safe. The successful completion of this project allows this music instructor to play the damper and the Una Corda pedals at the same time using her left foot. She successfully tested the units on different pianos which positively impacted her profession, and hence her life.

Fig. 14.21. Adapted upright piano.

TECHNICAL DESCRIPTION

This project was attempted twice in the past by two previous teams, and both devices have resulted in unsatisfactory results. It has been emphasized by the client that gaining the ability to use the damper pedal is vital. A hybrid design that uses both mechanical and electric components to perform the desired actions was selected. The final design of the system is comprised of a hollow steel rod 95/8" outer diameter and ½" inner diameter) that has two new pedals semi-rigidly affixed to it. One pedal sits to the left of and at the same height as the three existing piano pedals, while the other pedal is positioned directly above the piano damper (right most) pedal. Levers are used so when the client presses the new left pedal downward, the motion is transferred to the pedal above the damper pedal. While playing this portion of the device, the Una Corda (left most) pedal can be played at the same time using a solenoid. A switch has been fitted to the side of the new manufactured left pedal for the client to push on and off by rotating her feet, thus activating and deactivating the Una Corda as she wants.

A continuous duty 120 VAC solenoid, 18P-C-120A solenoid from Guardian Electric Manufacturing, is used in the design. The solenoid can be plugged into any grounded wall outlet without any additional sources needed. It has a maximum stroke length of one inch, while producing 60 ounces of push force. Overall, it is small enough to fit into the designed system, less than 2 inches wide by 2.093 inches thick by 2.5 inches tall. Sponges and insulation are used to dampen the electrical noise that is produced by the solenoid.

A hollow rod is attached to bearings at both ends, allowing for the rotation in the system. The bearings inside their brackets are press fitted into them, and placed at each end of the rod. This bearing-bracket assembly allowed the rod to be attached to the external frame of the device, while still allowing the rod to rotate as needed. The frame, which serves as the support structure for the apparatus, is constructed from hollow aluminum square tubing. Spring locking mechanisms on the outer frame of the device are used to allow the client to change the height of the new pedals as she deems necessary, so that the device can be used on many different pianos. Overall, the finished product weights less than ten pounds. A carrying case has also been fitted to the final product so that the client will have an easier time taking the device from work to home and back. The unit is also made esthetically pleasing by powder coating most of the device black. This helps the device blend in with the black baby grand piano that she plays on both at school and home.

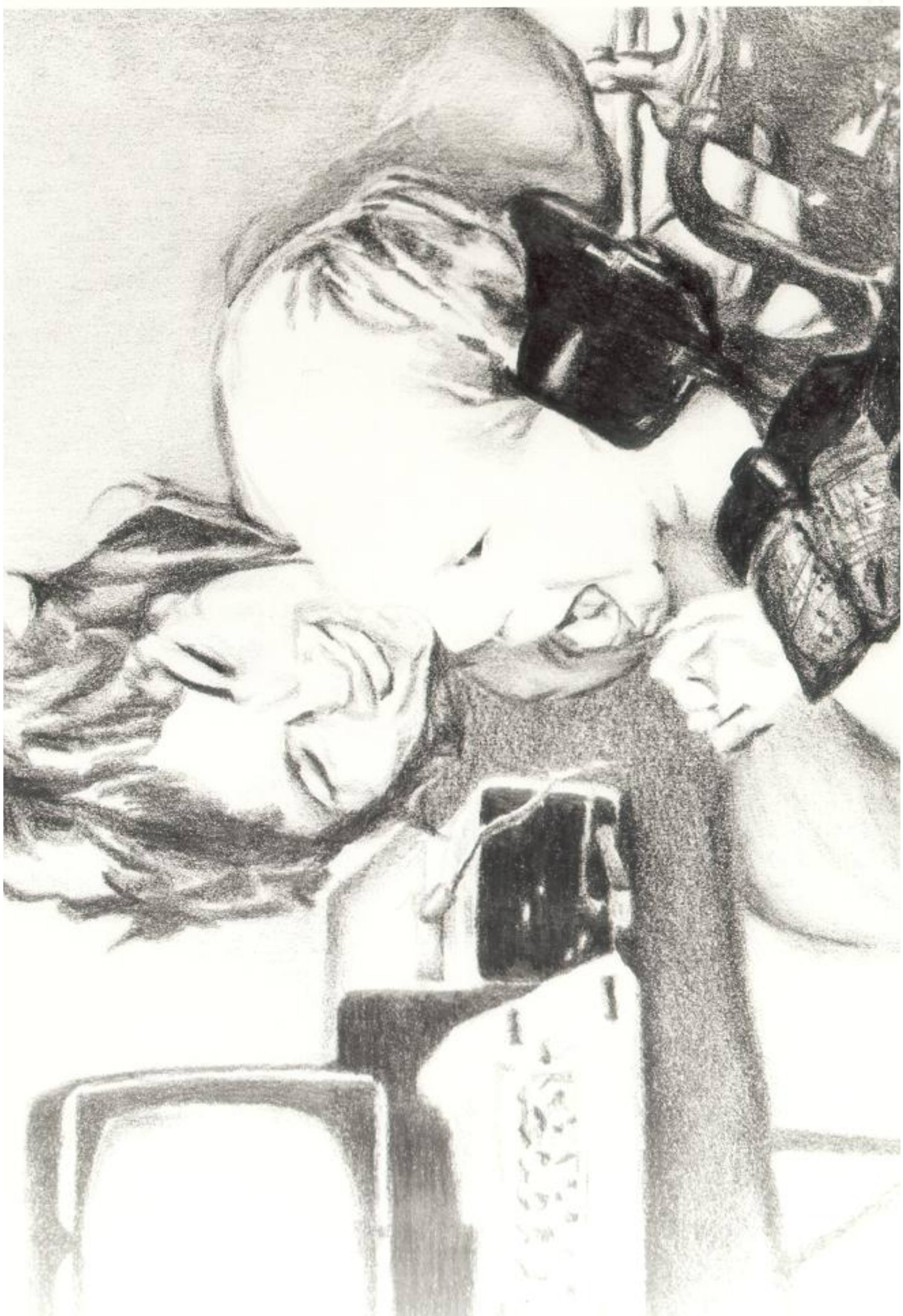
Static and fatigue design were conducted on the hollow rod. A factor of safety of 1.8 was calculated

Fig. 14.22. Client playing a baby grand piano using the unit.

for a maximum force of approximately 93 pounds of cyclic loading, while maintaining an infinite life. This is acceptable since the maximum force applied by the client does not exceed 50 pounds. Also a factor of safety of 7 was calculated in the cross beam of the frame under 1000 lbs. load; a larger load causes the piano to be lifted.

The total cost of the material is $400.00. The students working on this project posted a detailed description of their design and analysis in the World Wide Web at the following URL address:

http://www.eng.utoledo.edu/mime/design_clinic/design_expo/Fall07Pages/2007-04-06/home.html



CHAPTER 15
VANDERBILT UNIVERSITY

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DESIGN OF A UNIVERSAL CONTROL PANEL FOR A WHEELCHAIR ACCESSIBLE TREADMILL

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INTRODUCTION

Wheelchair users are living longer, fuller lives as the result of innovative medical and technological advances. While the progress has been considerable, there are still areas of significant need in this population. Wheelchair users are at high risk for becoming obese, which can lead to secondary health conditions, such as cardiovascular disease or upper extremity pain and injury. The solution to obesity in the wheelchair user population is the same as it is in the general population, a healthy diet and regular exercise. The limited availability of wheelchair accessible cardiovascular exercise equipment may be contributing to a lack of regular exercise in this population. To address this need of a wheelchair accessible treadmill, a proof-of-concept prototype

Fig. 15.1. The original wheelchair accessible treadmill prototype and control panel.

was developed and then evaluated in a six-week exercise study by three manual wheelchair users. Results suggest that paraplegics can improve cardiovascular fitness and increase push strength from exercise on the treadmill. Results and feedback from the subjects also revealed a need to redesign the control panel to better accommodate both ambulatory and wheelchair user populations.

SUMMARY OF IMPACT

A wheelchair accessible treadmill, one that is universally designed for both ambulatory users and wheelchair users, offers a promising opportunity for a gym to provide accessible cardiovascular equipment that has broad usage expectations across its membership. The development of a new control panel further enhances the overall design and accessibility of the treadmill.

TECHNICAL DESCRIPTION

The new control panel represents a significant advancement in the design of the wheelchair accessible treadmill. The most notable difference between this and others are the buttons to distinguish between ambulatory and wheelchair users (top to either side of the MAX logo). The maximum speeds and grades appropriate for wheelchair users are considerably slower and lower than those of ambulatory users. This may not seem like a problem since users only go as fast or as steep as they are capable of going. This is true if the users are in manual control mode but it may be out of their control for the random, hills, sprints, fat burn and max exercise programs. By differentiating between ambulatory and wheelchair users, it allows for the development of exercise programs that are distinctly designed to accommodate the two types of users.

The original control panel incorporated a work level control that changed the speed and grade settings

Fig. 15.2. The new treadmill control panel.

together at the same time. Ideally, if the grade is increased, the speed should stay the same or even be reduced to allow the user to keep up. To address this concern, the work level control was eliminated and replaced with independent speed and grade controls, resulting in a more appropriate system for wheelchair users.

The control panel and grab bar structure was completely redesigned. The original design is similar to most commercial treadmills consisted of a bridge across the width of the treadmill. While this makes sense for a standard narrow treadmill, it is less ideal for a wide treadmill because the span is significantly increased. Ours has a single upright structure that is simple, aesthetically pleasing and structurally sound. The design is widest at the base where the moment is greatest and narrow at the top, resulting in minimal material and weight.

The estimated costs of the prototype are $4,300.

RESEARCH AND DEVELOPMENT OF THE STAYCLEAN DIAPER

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INTRODUCTION

Incontinence or loss of bladder or bowel control is a serious medical issue experienced by a large population of individuals with disabilities. Extended exposure to such wastes places these individuals at high risk for the development of skin breakdown, ulceration, and infection.

SUMMARY OF IMPACT

Incontinence is likely to lead to the development of self-esteem problems, feelings of shame or humiliation, disruptions in work life, and social withdrawal and isolation. For cases in which medical treatment can not completely eliminate incontinence or for periods of time until a treatment takes effect, protective under-garments such as diapers can provide relief in incontinence management.

TECHNICAL DESCRIPTION

In order to address the issue of maintaining a high level of skin integrity, the StayClean Diaper prototype was developed. The StayClean Diaper has an additional liner on the interior of the diaper that creates a layer between the waste and the skin. This layer keeps the individual clean and prevents diaper rash as well as "blow outs". Multiple design iterations led to a prototype that includes a small rectangle with a thin strip of light adhesive in a U-shape that seals the liner to the skin. This adhesive is a hypoallergenic porous medical tape made by 3M adhesives. The prototype is scaled down to the size of a baby diaper for evaluation. With parental consent, the diaper prototype was evaluated on 10 babies at a local child daycare. The results were split between successes and failures leading to the confirmation of the quality of certain design characteristics, while indicating other weaknesses and areas of needed improvement within the design. Specifically, there is a need to optimize the adhesive such that it removes easily for dry diaper conditions, but can remain in place under conditions of low viscosity solid waste.

Fig. 15.3. StayClean diaper prototype.

The estimated costs to develop the prototype are $450.

Fig. 15.4. Waste isolating pocket.

DEVELOPMENT OF AN INSTRUMENTED WHEEL FOR MANUAL WHEELCHAIR PROPULSION ASSESSMENT

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INTRODUCTION

The development of upper extremity (UE) pain and/or injury is a prevalent health concern amongst manual wheelchair users. The UEs serve as the principle means for mobility, therefore, any impeding factors, such as pain or injury, leads to a decreased quality of life. The development of UE pain and injury may be a result of improper propulsion biomechanics or poor wheelchair seating configurations. To quantitatively assess a manual wheelchair user's propulsion technique for training or seating purposes, there is a need for an affordable instrumented assessment tool.

SUMMARY OF IMPACT

The goal of the project is to develop an instrumented wheelchair wheel utilizing strain gauges that has the capability of quantitatively measuring resultant force during propulsion. Essentially, the instrumented wheel serves as a means to quantitatively compare various wheelchairs and seating configurations to optimize the degree of comfort and propulsive capabilities of MWUs. With comparative propulsion data, the instrumented wheel also serves as justification for the selection of particular wheelchair equipment.

TECHNICAL DESCRIPTION

Strain gauges are placed on the top and bottom of each of the three push rim tabs that couple the wheel to the push rim. The strain gauges are then wired into a Wheatstone bridge circuit. When force is applied to the push rim, the strain gauges go into tension or compression based upon their position in relation to the location of the applied force. This results in changes in the resistance of the strain gauges, which are reflected in changes in the two voltage outputs from the Wheatstone bridge. These

Fig. 15.5. Strain gauges attached to the push rim tabs.

changes in the output voltages are then amplified through an instrumentation amplifier. The Wheatstone bridge circuits and instrumentation amplifiers for the three tabs are contained on a single printed circuit board. The amplified output voltages corresponding to the three push rim tabs are then sent, via a data acquisition unit with Bluetooth capabilities, to a local computer to be recorded, processed, and analyzed in LabView. A standard curve was created relating resultant force to output voltage.

The prototype wheel developed demonstrates the ability to assess wheelchair propulsion by measuring strain created by resultant force. Small changes in voltage created by flexion in the push rim are sufficiently amplified in order to gain the appropriate sensitivity to clearly track the resultant force applied to during propulsion.

The estimated cost to develop the prototype is $1,850.

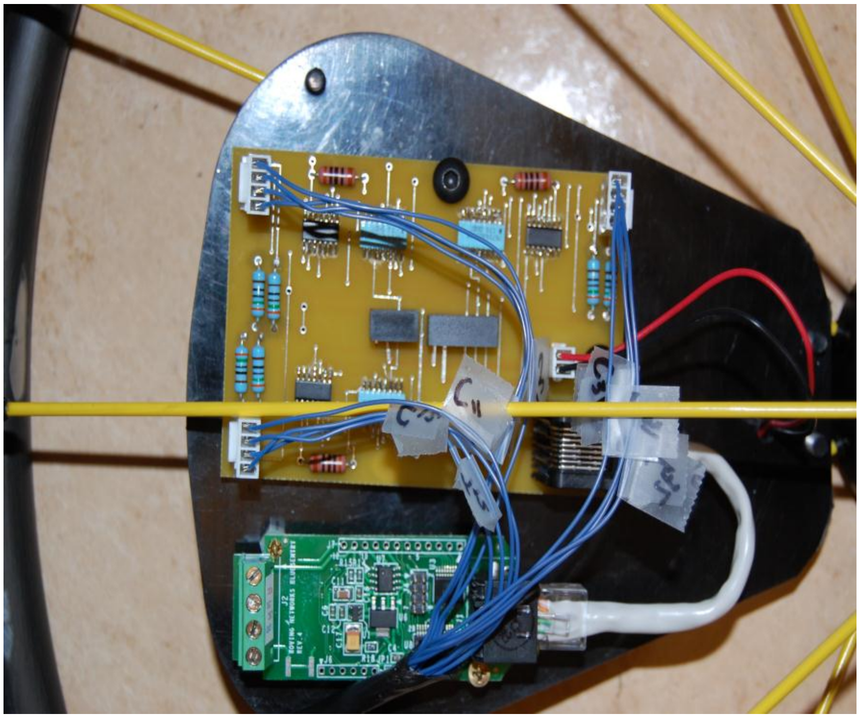

Fig. 15.6. The printed circuit board and data acquisition unit mounted to the wheel.

Fig. 15.7. The instrumented wheel prototype.

CROSS SLOPE COMPENSATION FOR WHEELCHAIRS

Designers: Alex Abraham, Marc Moore, David Dar, 2007-2008
Supervising Professor: W Mark Richter, Ph.D., Instructor Paul King, PhD, PE
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INTRODUCTION

The ADA requires public walking areas not possess a cross-slope greater than 1.1°. This stipulation often goes unenforced, creating troublesome surfaces for wheelchair users. As a result of the slanted condition, more torque needs to be applied to one wheel to maintain straightforward motion. Thus, the manual wheelchair user spends a significant amount of time exerting a greater pushing force with one arm, or the other, when outside. As a consequence, prolonged usage increases the potential to cause damage to the arms due to overuse. Due to a large target market (more than 1 million manual wheelchair users in the United States), a solution is needed.

SUMMARY OF IMPACT

The development of a cross slope compensation mechanism allows users to self-select normal flat-surface movement or constrained sloped surface movement with decreased need for corrective re-centering motions involving (typically) the downhill arm. Use of such an item will improve the quality of life for wheelchair users.

TECHNICAL DESCRIPTION

The following design criteria were applied:

- Add-on application to existent wheelchairs
- Inexpensive (<$150 per mechanism)
- Aesthetically appealing
- Lightweight (<1 lb. per mechanism)
- Mechanically simple
- Robust, durable, must withstand 7.3 N*m torque - calculated downhill moment on 6° cross-slope, mean plus standard deviation (5.2+2.1 N*m)

The final design includes a locking pin mechanism that restricts rotational movement of a front wheel. It forces the wheelchair to travel in a single direction without deviation. It is applied only when the subject deems it necessary. Upon activation, the pin snaps down and interlocks with the lower plate due to a preceding spring loaded potential. The mechanism is initiated by a lever, transmitted via a bike cable through a sleeve, which attaches to the top of the pin housing. The released cable allows for the spring to move a stroke length of 0.6 in., pushing the pin down through the rotor.

The cost of the prototype (labor and materials) is approximately $1,000. Estimated cost per manufactured item will be less than $200.

Fig. 15.8. Image of the cross-slope compensation mechanism.

SMART ANTI-TIP SYSTEM FOR MANUAL WHEELCHAIRS

Designers: Harrison Lamons, Nick Burjek, Austin Dirks, Katie Gallup, Andrew Dawson
Supervising Professor: W Mark Richter, Ph.D., Instructor Paul King, PhD, PE
Department of Biomedical Engineering
Vanderbilt University, Nashville, TN 37235
MAX mobility, LLC. Nashville, TN 37211

INTRODUCTION

Manual wheelchairs are traditionally outfitted with anti-tip bars; bars that protrudes from the rear of the chair and prevent the user from flipping over. The bars are very effective in preventing tips in situations such as inclines, drop-offs, and unintentional wheelies. However, while the traditional anti-tip bar is advantageous from a safety standpoint, it greatly hinders the mobility of the user. The standard anti-tip bar may catch when moving on uneven terrain or off a curb. It can also prevent the user from maneuvering in tight areas. Many beginner wheelchair users may feel unsafe and unstable in their wheelchair while trying to

Fig. 15.9. New anti-tip system.

become comfortable with it. The problem remains however that these new users remove anti-tip mechanisms from their wheelchair because of hindered movement. Without these tip bars, a sense of security is lost.

SUMMARY OF IMPACT

This effort developed an innovative anti-tip system that maintains the functional safety of the current anti-tip bars but will not hinder the mobility of the user in performing common maneuvers and day-to-day obstacles, leading to improved mobility and safety, while performing normal wheelchair activities.

TECHNICAL DESCRIPTION

The design solution consists of a three position replacement bar and contact ball system that replaces the current anti-tip mechanism. It consists of:

- An anti-tip bar leg attached to a collar fitted with side plates with guiding grooves designed to provide stopping points to the tip system.
- Addition of copper springs to solenoid system allowing the solenoid to return to the extended state when de-energized.
- A collar designed to attach the anti-tip system to the wheelchair.
- Bar leg length was determined by measuring the distance between the wheelchair axle and the ground, while maintaining an angle designed to keep the tracking wheel flush against the ground at all times.
- Aluminum side plates are attached to the sides of the collar. Each plate has a custom designed groove through which the solenoid pins travel.
- A 90 degree torsion spring of 42 in-lb. force attached to the anti-tip system via the shoulder bolt to provide resistance to the user and to bring the system back to the ground after wheeling off a curb.
- Solenoids are attached to U-brackets bolted to the anti-tip leg.
- Tipping measurements were made and traced on side plates to determine slit locations for standard and hill settings. Side plate slits cut accordingly.

Stress/strain and maneuverability tests were performed to ensure safety and proper functionality of design.

New design allows for 3 settings (standard, hill, curb) for flexibility, while maintaining safe operation.

Estimated cost of the device is $203.

IMPROVEMENTS IN INDUSTRY FOR DISABLED WORKERS

Designers: Brian Piazza, David Sharvin, Walter Yehl, Austin Healy, 2007-2008
Supervisor: Tommy Hall, New Horizons, Inc., Nashville TN
Instructor: Paul H. King, PhD, PE, Vanderbilt University

INTRODUCTION

The purpose of this project is to enable persons with disabilities to perform tasks that were previously not feasible and to improve the performance of the workers. This project involves working with New Horizons to explore a solution for persons with disabilities to assemble cardboard boxes. The cardboard inserts, initially are flat and require the worker to bend, fold and insert tabs to form it into a box (15 steps). Currently, people with limited cognitive and dexterity skills can assemble the basic design, but the goal is to improve the performance by examining ways to assist and stimulate the workers.

SUMMARY OF IMPACT

This project was one of several suggested by an engineer at NISH. The students were given an introduction to the supervisor at New Horizons Inc. in Nashville TN, the goal of the work was to:

- Improve of the performance of workers assembling cardboard box inserts; improvement of their income was a resulting impact.
- Improvement of the quality of work environments for the severely handicapped via assistance in the completion of tasks assigned was another impact.

TECHNICAL DESCRIPTION

Some of the workers at New Horizons are given the task of folding boxes for a local computer manufacturer. The unfolded box is of a fairly complicated shape, as seen in Figure 15.10.

The final assembled box may be seen in Figure 15.11.

The final device consisted of a combination of a folding device, here shown as a section of plywood with metal bending points, a series of clips to hold the partially folded box structure during various of the steps involved in the folding process, and a laptop computer with a series of graphics, which when initiated, showed the worker the next folding stage to try to achieve. The prototype device (prior to cleaning up and painting) is shown in Figure 15.12.

Fig. 15.10. Unfolded box.

Fig. 15.11. Folded box.

The device was tried by the students, then taken to New Horizons

http://www.newhorizonscorp.com/

and used by three of their workers. Improvements in assembly speed were documented in two of three workers; the third was one of the few already proficient workers.

The cost of materials for the prototype is approximately $50. The computer system is a retired Vanderbilt laptop system, the system was donated to this project and New Horizons.

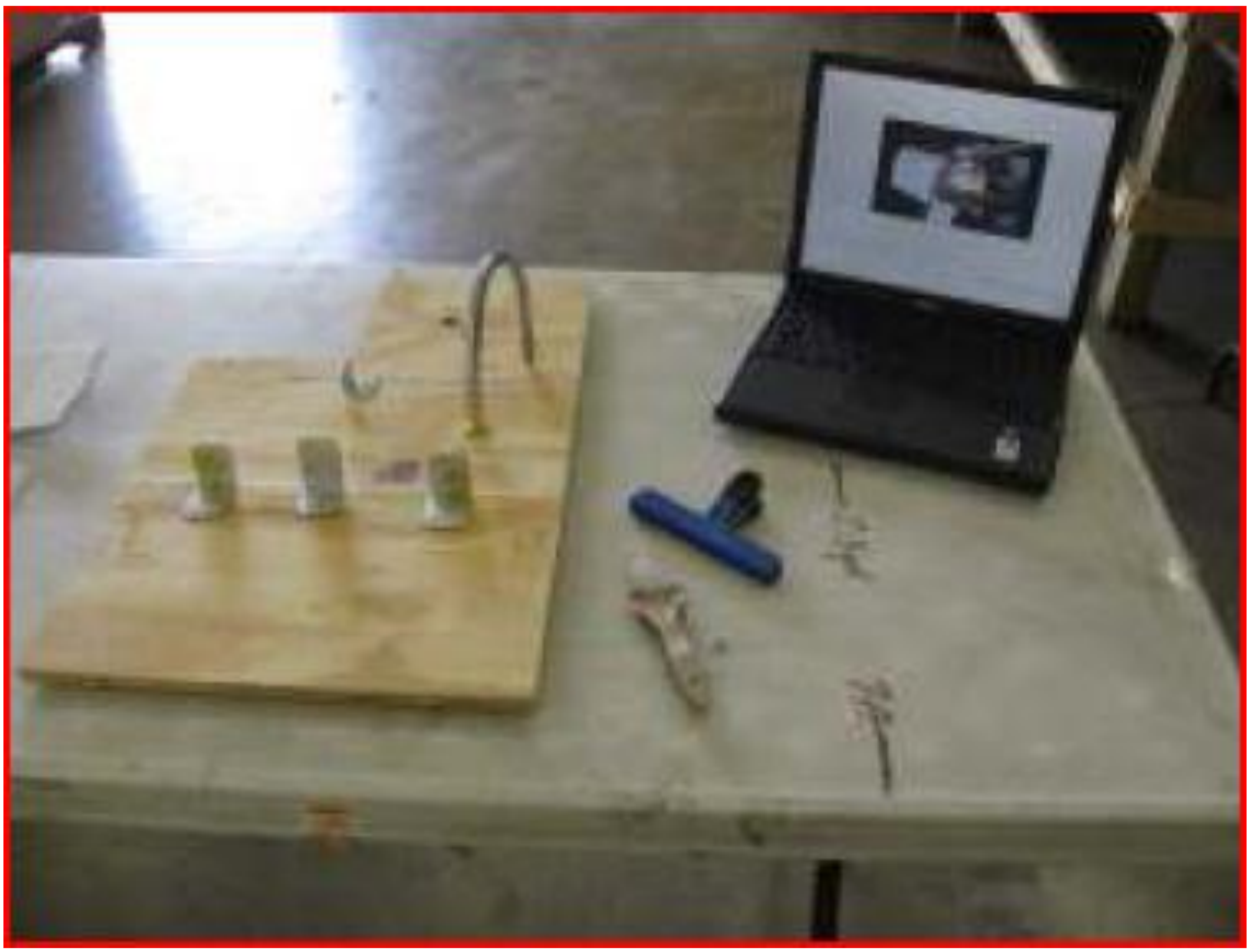

Fig. 15.12. Prototype folding device on left, clips and computer system on right.

WALKER REDESIGN

Designers: Tanya Holubiak, Jordan Landreth, Sam Barclay
Supervisor: Teresa Plummer, OT, Vanderbilt University., Nashville TN
Instructor: Paul H. King, PhD, PE, Vanderbilt University

INTRODUCTION

Current walker designs do not account for the fact that individuals need to go up and down stairs. When trying to navigate stairs, these walkers have to be carefully positioned. However, walkers are often too wide to fit on a single step. Stability is the key when trying to ascend and descend stairs, and current walkers are very unstable. Also, using a walker in this manner requires the use of a handrail and often there are not hand rails on stairs, which further takes away from stability. As a result, individuals who use walkers feel dependent on individuals to aid them in climbing stairs. This feeling of dependence may hinder and individual's progress in rehabilitation.

SUMMARY OF IMPACT

If walkers can be redesigned such that users may safely ascend and descend stairs, the quality of life for walker users may be enhanced. Further, as the need for elevators may be diminished with a successful solution, patient mobility and overall health may be improved. No similar products are generally available, though there are over 6 million people per year who use walkers. This work represents a first attempt at a solution. This project will remain on the list of potential projects for next years' design classes.

TECHNICAL SOLUTION

The final prototype developed by this team involved the development of a walker with an adjustable parallel column for the back legs of a standard walker's back legs, such that these legs may be extended. To keep the legs in place during normal or stair mode the device utilized a hook-locking system, with a hand brake lever system to attach/detach the detents. Industrial springs are used to power the extension of the legs when released.

A photograph of one mode of ascending stairs with current technology is shown in Figure 15.13. A proposed method, using the above technology, for descending stairs is shown in Figure 15.14.

Costs for the prototype are approximately $200 in parts, including a standard walker from Ed Medical.

Fig. 15.13. One method of ascending stairs with a walker.

Fig. 15.14. Walker with extended legs for descent.

CHAPTER 16
WAYNE STATE UNIVERSITY

Electrical and Computer Engineering
College of Engineering
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Principal Investigator:

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RFID TAG BASED LAUNDRY SORTING SYSTEM

Designers: S. King-Monroe, V. Aggarwal, S. Avasthi, P. Narain, A. Joshi, A Fuloria
Client Coordinator: Dr. Donna Case, OT, Cooke School, Northville, Michigan
Supervising Professor: Dr. Robert F. Erlandson,
Electrical and Computer Engineering Department,
Wayne State University
Detroit, MI 48202

INTRODUCTION

Cooke School is an educational center for students with cognitive impairments. The school serves nearly 150 students from 16 school districts in Western Wayne County, Michigan. The students may be severely cognitively impaired, severely multiply impaired, and dual diagnosed with emotional and cognitive impairments. Staff at Cooke School wanted to redesign and enhance their laundry oriented vocational training activities.

Staff wanted students to collect used smocks, aprons, coveralls, and other articles of clothing that needed to be washed from the twenty-one (21) classrooms in the building. After washing and drying the articles of clothing, the clothing must sorted and returned to the correct room. Based on discussions with Dr. Case, an Occupational Therapist at Cooke School, and her colleagues, the laundry area would need to be wheelchair accessible, with mobile and adjustable workstations to accommodate the physical demands of the students and the relatively small space available for the laundry operations. Additionally, any cognitive aid for sorting would have to eliminate the need for reading or number recognition. The system should provide the environmental support required for a worker with cognitive impairments to independently perform sorting based on color, size, names, destination of the clothes (a laboratory, classroom, or business), or any other requirement.

These requirements resulted in a redesigned laundry room, incorporating a number of inter-related design projects. These inter-related projects are briefly described within the context of the overall laundry room project. The key decision was to use a passive RFID tag system for clothing identification and sorting. This decision drove the design requirements and needs for the rest of the facility. The project spanned two consecutive semesters.

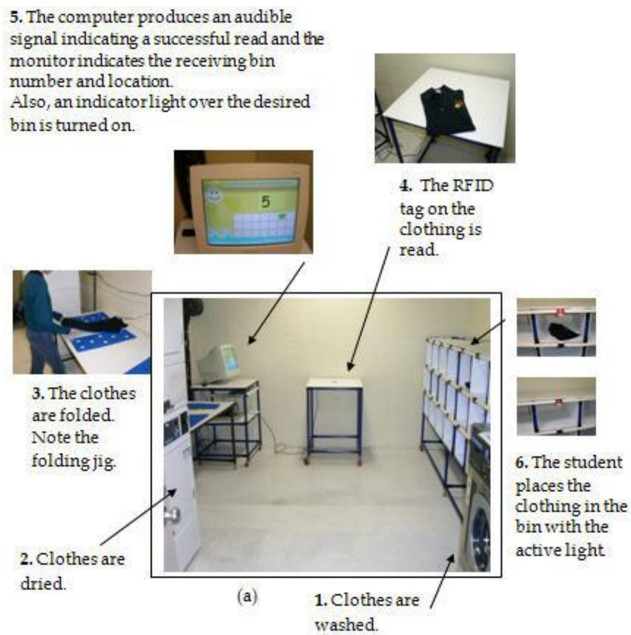

Fig. 16.1. The overall process.

SUMMARY OF IMPACT

The new laundry facility has been fully operational for over six months. Students are eager to work in the laundry, and the system supports the variety of physical and cognitive disabilities presented by the Cooke student population. Staff like the system and appreciate the level of independence it provides the students.

TECHNICAL DESCRIPTION

The goal of the project is to design a laundry sorting system that enables the students to independently perform the laundry sorting operation. The system provides the necessary environmental supports, both physical and cognitive, for independent work. Agile workstation design, coupled with CREFORM technology, provide the physical support and RFID passive tag technology provide a method to achieve the desired cognitive support.

Every garment has an RFID tag that is read (identified) by a reader, which communicates the tag's ID to a control computer. Special computer software associates the tag ID with a specific article of clothing through a database system. Once the association is established, sorting by classroom informs the worker as to the designated bin to place the garment.

There needs to be 21 classroom bins. Each bin requires an indicator light to instruct the worker where to place the garment. To eliminate long cable runs, a wireless Zigbee protocol is used to communicate between the control computer and a Bin Controller Module, mounted on the bin rack, to control the LEDs.

The room's plumbing dictated placement of the washer and power and venting options dictated placement of the dryers. An adjustable and mobile cloths folding workstation was designed and built as was a mobile RF reader cart, a mobile PC controller cart, and of course, the mobile instrumented bin frame that housed the 21 storage bins.

Figure 16.1 shows the overall process. Step 1 and Step 2 show the washer and dryers in the laundry room. Just behind the dryer, along the left wall, is the folding and sorting workstation. Behind that is the PC controller cart with computer. The RFID tag reader is mounted under the top of a mobile workstation. It is straight ahead as you look through the laundry room door in the central image. As a folded article of clothing is passed over the top of the reader workstation, the RFID tag affixed to the clothing is read and information passed to the PC controller. The controller provides visual and auditory feedback to the worker, but also sends a wireless message to the Bin Controller Module, which turns off the previous light and turns on an indicator light over the bin where the clothing needs to be placed.

Every garment has a RFID tag that is read (identified) by a reader that communicates the tag's ID to a control computer. Special computer software associates the tag ID with a specific article of clothing through a database system. Once the association is established, sorting by classroom informs the worker as to the designated bin to place the garment.

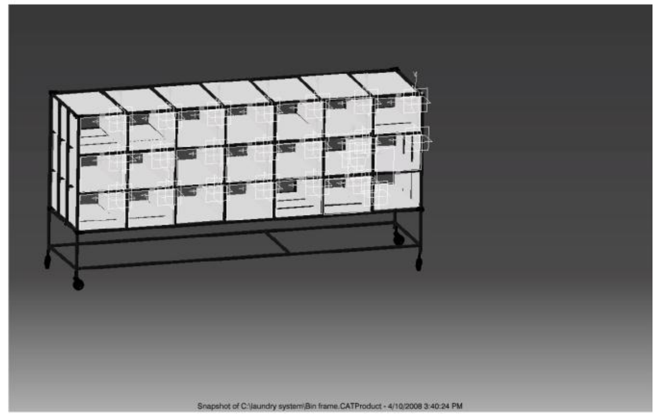

Fig. 16.2. A CAD 3D representation from CATIA and the actual rack at Cooke School (from top to bottom: A and B, respectively).

Workstation Design:

The workstations are all constructed from CREFORM, which is a pipe and joint technology [1]. CREFORM is used worldwide in industrial material handling, workstation, and storage systems. CATIA was used to design four devices; a clothes folding table, computer cart, reader cart and bin frame. CATIA is a powerful CAD system and produces all of the CAD documentation required for replication of the devices [2].

All the devices have casters and are mobile. Only the folding table is required to be height adjustable for improved wheelchair accessibility. Students do not use the computer or access the computer cart, and the reader cart is accessed by someone in a wheelchair since it is relatively small. The collection bins are all wheelchair accessible. Figure 16.2a shows a CAD 3D representation from CATIA and Figure 16.2b shows the actual rack at Cooke School.

Software–Operating System:

An application program was written using VB 2005.net. Figure 16.3a shows the main screen. The program has two major sections: setup and operation. Upon starting, the program checks all 21 bin light control modules to make sure they are operational. If the system is OK, the second screen appears, Figure 16.3b. In the Setup mode, the users can add a new RFID tag and make a bin assignment, edit a current tag Assignment, or delete a tag ID. Figure 16.3c shows the add tag screen.

To add a tag the user scans the tag from the reader. A dialog box shows its vendor supplied ID number and requests a bin assignment and description. When this information has been added, the user saves the data into an Access database. After all Setup functions are done, the user returns to the 2nd screen (Figure 16.3), and activates the Start window. The operational window will be shown in a subsequent section.

RFID tag Electronic Components:

The electronic components include: the Bin Light Controller Module, a PC Communications Module, a Bin Controller module, and the wiring harness that supplies the bin light power and "on" "off" control signals. Altium Designer, an electronic CAD system, is used to design the circuit, run simulations, and layout the printed circuit board (PCB). The printed circuit boards are fabricated by a professional vendor using files provided from Altium Designer. All PCBs are visually inspected for defects prior to assembly.

RFID Reader/Antenna:

A Texas Instruments TRF7960 RFID High Frequency reader is used to detect the garment tags [3]. The TI reader is mounted in a box under the top of the reader cart. This interrogator transmits a 13.56 MHz signal to the passive tags sewn into the garments, and charges the tags using inductive coupling. The tag then transmits a unique code to the reader using the information contained in its sidebands. The reader is connected to the computer through a USB connection. It also has the capability of adding an external antenna through a SMA connector.

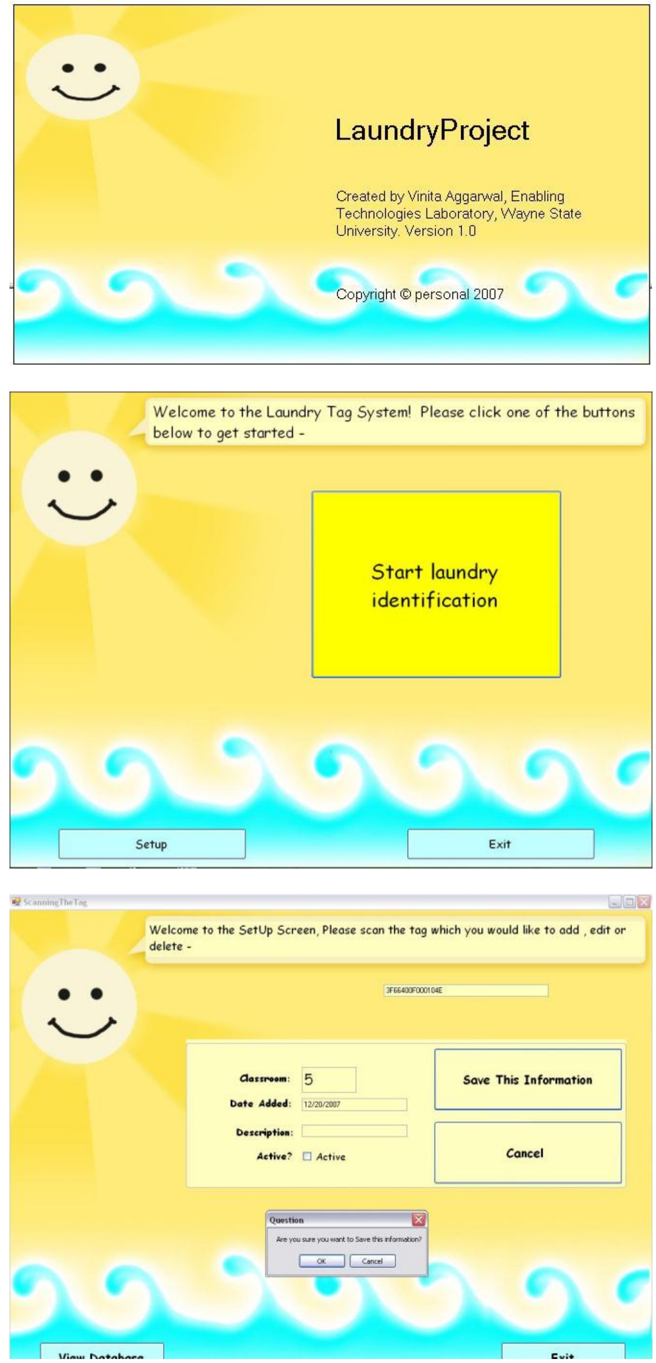

Fig. 16.3. The main screen, the second screen and the add tag screen (from top to bottom: A, B, and C, respectively).

Bin Light Controller Module:

Twenty one (21) of these modules are required – one for each bin. These modules use a simple circuit containing two connectors, a flip-flop, a resistor and LED. A temporal assignment of clock and data pulses will turn the bin LED "on" and "off." The PCB's are populated then individually tested using the power supply and frequency generator functions. Once they are found to function properly, the light modules are connected to the ribbon cables and the bin light controller and tested.

Figure 16.4 illustrates the design power of the CAD systems. Once the PCB is complete, a 3D rendering of the PCB is created in Altium and exported to the CATIA package. The CATIA system handles the mechanical and packaging design. Figure 16.4a shows the 3D PCB from Altium inside the case in a 3D CATIA rendering. All the electronic circuits are designed in this way.

Wiring Harness:

As seen in Figures 16.4b and 16.4c, ribbon cables connect the Bin Light modules together. The wiring harness consists of 22 individual ribbon cables with connectors. The cable has four signal lines, ground, VCC (5 volts to power the bin LEDs), a clock signal and a data line. After assembly each cable is tested.

Zigbee wireless transmitter/receiver:

The bin destination data is transferred from the PC Communication Module to the Bin Controller through the Jennic JN5139 wireless communication module [4]. The Jennic is a high performance 2.4GHz transceiver with Zigbee wireless protocol capabilities. The modules are a low cost, low power solution for transmission of bin destination data.

PC Communications and Bin Controller Modules:

Both the PC Communications and Bin Controller modules are basically the same circuit. Both contain a Jennic 5139 chip, but differ on additional functional components. Because of the similarities we designed one schematic and one PCB configuration. The PCBs are populated differently to yield different functionality. Use of common structures is a standard industrial approach to reduce fabrication costs.

The PC Communication module communicates information from the control computer to the Bin Control Module, i.e., which bin LED to turn "on" and which to turn "off." At the Bin Controller the Jennic receives the information, constructs the series protocol that is sent over the wire harness and then sends the appropriate clock and data signals.

[1] CREFORM, "CREFORM North America Home Page," http://www.creform.com/defaults.asp, 2008.

[2] Dassault Systèmes, "CATIA, the Dassault Systèmes flagship PLM solution," http://www.3ds.com/products-solutions/plm-solutions/catia/, 2007.

[3] Texas Instruments, "TRF7960 Evaluation Module - TRF7960EVM, Status: ACTIVE ", 2007.

[4] Jennic, "Jennic: enabling the emerging market for wireless sensor networks," http://www.jennic.com/, 2007.

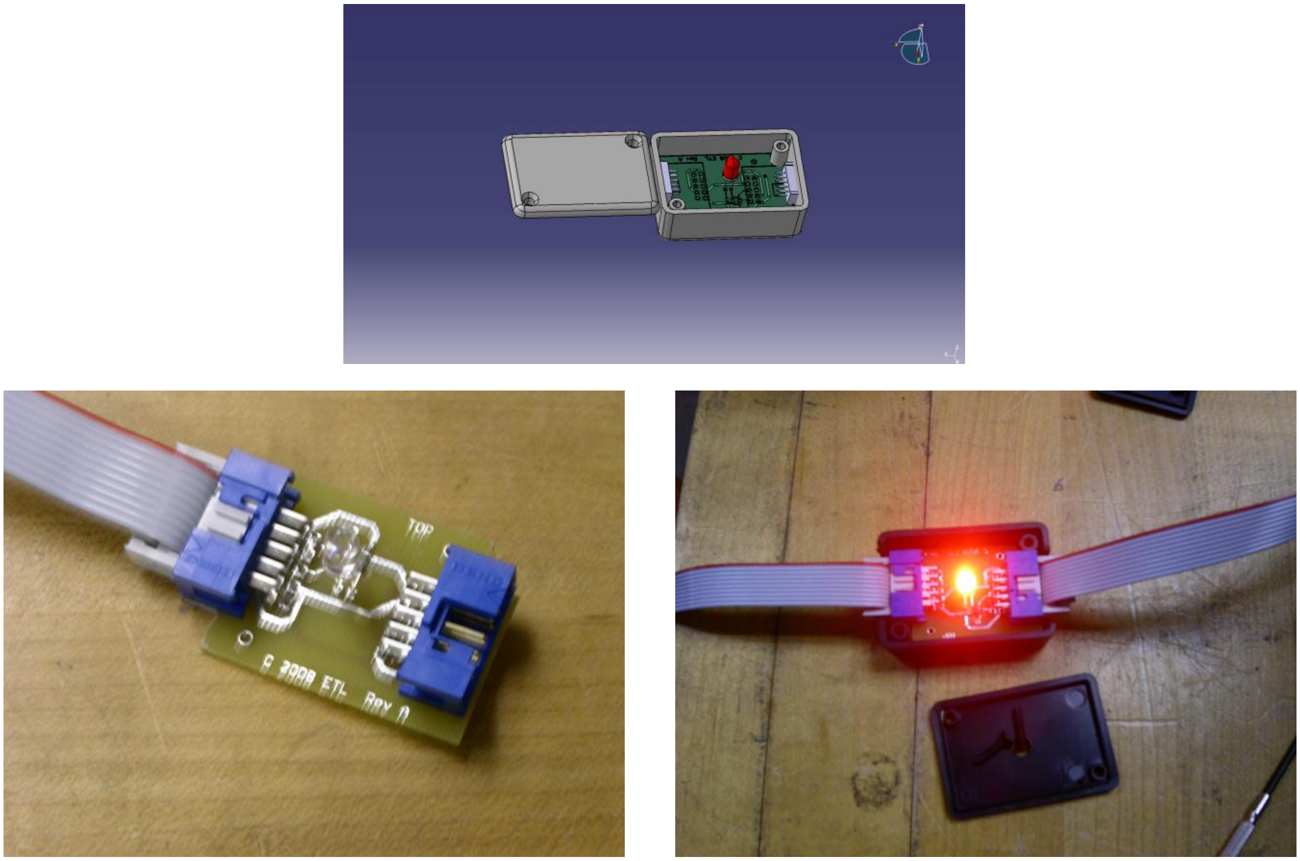

Fig. 16.4. The design power of the CAD systems (top: A; bottom: B and C from left to right, respectively).

CHAPTER 17
WRIGHT STATE UNIVERSITY

College of Engineering and Computer Science
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MULTI-DIRECTIONAL SCOOTER

Designers: Peter Anderson, Ben Ausdenmoore and Jason Monnin
Client Coordinator: Carol Steinsick, Montgomery County MRDD
Supervising Professor: Dr. Ping He
Biomedical, Industrial and Human Factors Engineering Department
Wright State University
Dayton, OH 45435-0001

INTRODUCTION

The client coordinator expressed a need for a scooter that is usable by children with disabilities. All of the students have at least one disability that has an effect on their motor control and/or mental capability. The overall goal is to provide a means of allowing the student develop their hand-eye coordination and short-term memory. The students also gain a body-in-space relationship through the movement of this scooter. Some commercial

Fig. 17.1. Client using the multi-directional scooter.

manufacturers have marketed motorized scooters for students with disabilities. These scooters lack two desired features. The client requires the seat to be roughly two feet above the ground and for the scooter to be controlled by a remote device, as well as the local joystick. The market price for commercial devices is also cost-prohibitive for the client.

The final product is a scooter, controlled both locally and remotely as desired. The seat is able to recline and legs are stretched out over the front of the scooter. The product has a top speed just above a normal walking pace of 3 mph, but is easily adjusted to the desired speed. The product is also safe to use.

SUMMARY OF IMPACT

The final design met and exceeded all required and desired design specifications. The client coordinator and the users expressed satisfaction and excitement over the scooter. While using the product, the supervisors remarked that it was the calmest that they had ever seen some of their students. The client coordinator didn't have any recommendations for further work, as the scooter it met and exceeded their requirements.

TECHNICAL DESCRIPTION

The multi-directional scooter is primarily based on the controls of an electric wheelchair. There are two basic controls for which the scooter is operated. The first control is a local joystick located in front of the user. Pushing the joystick forward and backward powers the product forward and backward, respectively. And similarly, left or right the joystick causes left or right movement. There is a sliding switch on the transmitter for switching between local and RC control. On the transmitter is a single stick that is able to move in the forward/backward and left/right directions, with corresponding movement of the scooter. Speed control is achieved based on the amount of deflection of the transmitter stick or local joystick. However, a master speed control is located on the back right side of the scooter. This is a rotary knob, which can vary the master speed from a crawl to roughly 4.5 ft./s. Located directly next to the speed control is the master power switch. The switch, when in the off position, cuts all power to scooter, preventing power to drain from the batteries.

Another switch on this control panel turns the sensors on and off. Four infrared proximity sensors,

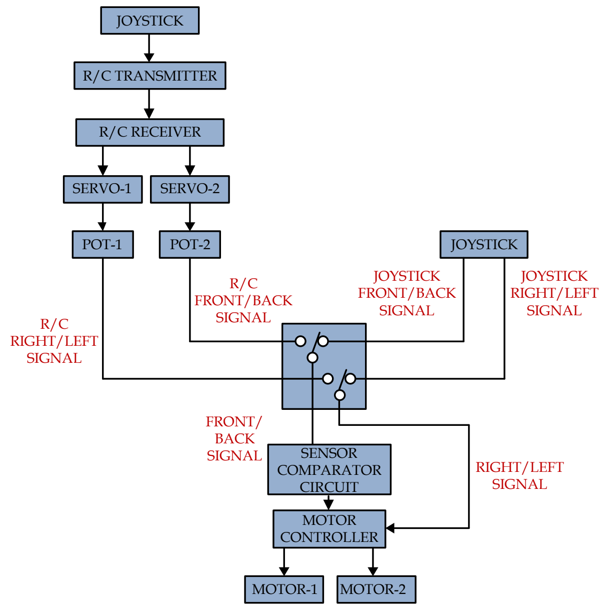

Fig. 17.2. Control diagram.

two on the front and two on the back, sense if the scooter is too close to an object. When an object is within five feet of the front or back of the scooter, the sensors do not allow the scooter to move in the direction of the object, only in the other three directions. Once the object is out of the five feet range, the scooter is allowed to once again move in that direction. There is also a three pin connector locater next to the previously mentioned switches and knobs, which is the battery charger plug. An external battery charger plugs directly into this plug and also into a wall socket, charging the batteries. Charge of the batteries from near half power takes about an hour. With full battery power, the scooter has an operating period of 4 hours, until the batteries need recharged. Operation after 4 hours may cause irregular operation and malfunction.

When a child is ready to use the product, they are placed into the seat of the scooter. The seat is able to recline to both adjust and allow the user to lie back, while the scooter is being used (primarily when the R/C transmitter is in use). The child is held in the seat with a 5 point harness. Two straps come across the top of the shoulders to the waist, two other straps come across the side of the user to the waist, and a final strap comes up between the legs to the waist. All five straps connect together through a buckle and lock into place. These straps are adjustable to accommodate for children of different heights and sizes. The joystick box is attached to a rod that is also adjustable, allowing for the local joystick to slide closer to the user or farther away, depending on the user.

The scooter sits 5 feet long by 2 feet in width, with the back tires extending out from the sides an additional 3 inches. The top of the frame sits 2 feet off the ground and the chair itself is 2 feet tall. The frame itself is constructed from steel and a sheet of plywood, lays in front of the chair on the top section of the frame. The frame is based on a truss design from which a force analysis, bending stress and safety factor are determined. Black vinyl covers the top and side sections of the frame, leaving the bottom open. A 2 foot by 1 foot section of plywood lies inside the frame behind the chair for circuit boxes and batteries.

There are many safety considerations taken into account when creating the product. The user needs to be safely secured in the scooter. An important safety consideration is to not allow the user to grab loose wires and increase the potential of electrocution. Driving the scooter into another object or person is also taken into consideration.

The scooter also needs to be reliable. The same performance from the product has to be obtained each for each use. Considerations relating to reliability include the ability for the batteries to withstand frequent recharging and not cause a decrease in performance. The frame is designed to be reliable after many uses at different weights and uses. The joystick and R/C transmitter are selected to endure the predicted stresses placed on them.

The total cost of parts and labor is $1,245.

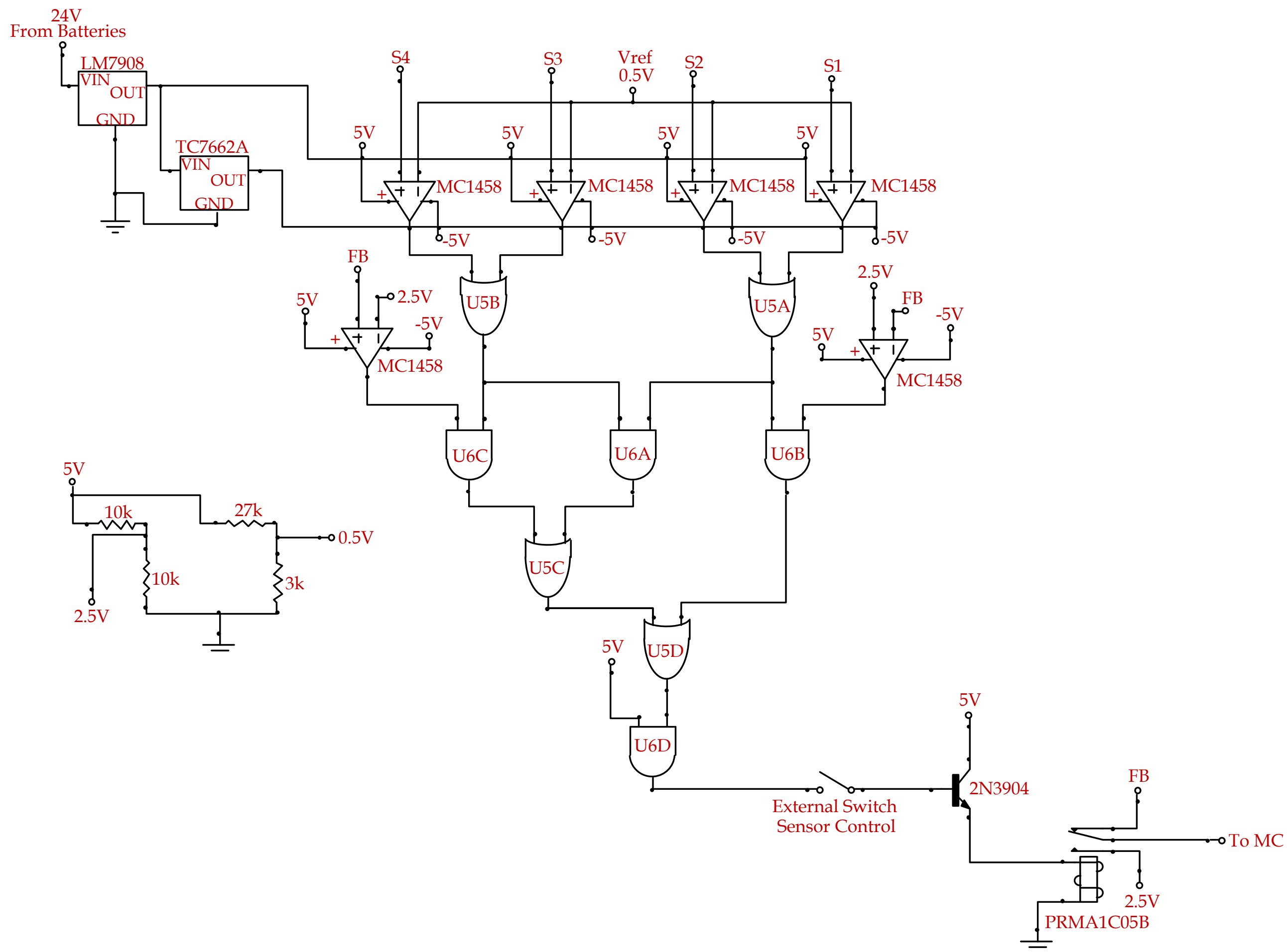

Fig. 17.3. Sensor control circuit.

ADAPTIVE CAN CRUSHER

Designers: Amit Saini and Jason Seidler
Client Coordinator: Tim Jones, United Rehabilitation Services
Supervising Professor: Dr. Thomas Hangartner
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INTRODUCTION

At United Rehabilitation Services, many of the residents are able to earn money by crushing collected empty cans. They are assisted by a social worker and paid per crushed can. Currently, the can crusher being used is a commercial, wall-mounted, hand-operated, single-can crusher. It is very difficult and time-consuming for the residents to make money because they are not able to operate it themselves. United Rehabilitation Services requested an automatic can crusher that makes it easier for the residents with mental and physical disabilities to crush cans.

The final product is an adaptive can crusher that is completely automated, able to be operated by a person in a wheelchair, hold and crush approximately 50 cans per session, safe for people with varied disabilities, simple to use, and counts the crushed cans as they fell through the crusher. All these constraints are met in one enclosed apparatus that consists of two 15-inch tractor tires, a 0.5 hp motor connected to the tires by a chain pulley system, and a funnel hopper complete with a sorter to allow approximately one can at a time to fall through the system.

SUMMARY OF IMPACT

All design goals are achieved with the final product design. The hopper holds more than 50 cans, the crusher sufficiently crushes cans in a timely and safely manner, the photoelectric sensor counter counts each can as it passes through the chamber, and the entire device is operated by a single plug and single switch. The client coordinators are very impressed with the machine and its function. The demonstration they witnessed was "exactly what they were looking for."

TECHNICAL DESCRIPTION

The Adaptive Can Crusher is set on a 5-foot by 3-foot table with the crushing system mounted on top of it. The table has a 1-foot by 1-foot hole in the middle to allow crushed cans to pass through and fall into a recycling bin below.

Fig. 17.4. The adaptive can crusher.

The crushing system consists of a 2-foot by 2-foot welded steel frame that provides a mount for two 15-inch tractor tires that spin in opposite directions to crush the cans. The two wheels are attached to the frame with a steel rod that is welded to the middle axis of the wheel and runs through a sleeve that is welded onto the top of the frame. The sleeve and rod are lubricated with grease to reduce friction and heat. This entire crushing system is set into motion with a single motor (0.5 horsepower, 1725 revolutions per minute, single phase power and runs at 115 volts, 7.8 amperes at 60 hertz) connected to a chain pulley system that runs from a sprocket on the shaft of the motor to 20% larger sprocket on the end of the steel rod on the wheel. The larger sprocket on the top steel wheel rod reduces the revolutions per minute by 20%, from 1725 revolutions per minute on the motor end to 1380 revolutions per minute on the wheel end. It is entirely enclosed in a wooden box to hide all the moving parts and reduce noise as much as possible.

On top of the wooden box is the hopper cradle, which holds the hopper funnel. The cone-shaped hopper funnel is 25 inches tall with a top opening diameter of 39 inches and bottom opening diameter of 3.5 inches. The material used to make the hopper funnel is aluminum flashing. Mounted on top of the hopper funnel is the sorting mechanism that consists of a windshield wiper motor from a 1997 Jeep Grand Cherokee Laredo. The motor shaft has a 2-foot steel rod welded to it end-to-end with a 1-foot piece of angle iron welded perpendicularly to the end of the steel rod. This mechanism mixes the cans and feeds them through a hole nearly on at a time to the crushing chamber.

A photoelectric sensor and counter are mounted near the top of the back side of the wooden box. The sensor is placed directly over the space between the bottom of the hopper funnel and the top of the crushing chamber. Opposite of the sensor is a 60-watt light bulb. When the light from the bulb is blocked by a passing can, the sensor sends a signal to the circuit to a counter, which is recorded cumulatively on a three-digit digital display. The count can be reset by either pressing the red reset button or turning off the device.

All electrical devices, such as the motors and the sensor/counting system, are plugged into a four-way outlet mounted under the table. The power outlet is regulated by a single switch mounted on the side of the table. Figure 17.5 shows the circuit diagram for the electrical components and the wiring.

The total cost of parts and labor is $1,121.

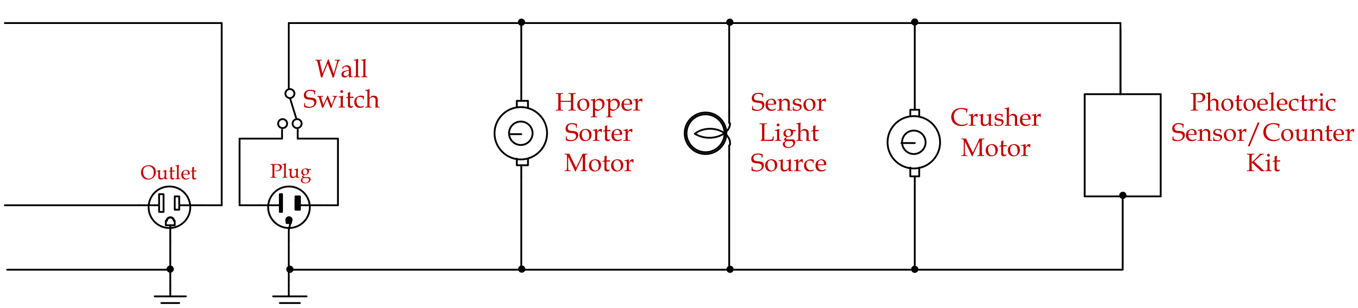

Fig. 17.5. Circuit diagram of electrical components.

LIGHT EFFECTIVE DISPLAY

Designers: Susan Schweitzer and Jennifer Wright
Client Coordinator: Brenda Anderson, Ankeney Middle School
Supervising Professor: Dr. Julie Skipper
Biomedical, Industrial and Human Factors Engineering Department
Wright State University
Dayton, OH 45435-0001

INTRODUCTION

The client coordinator is a teacher at Ankeney Middle School and heads the special education resource room. The school has a special lighting room that is located between two of the special education rooms. This room provides a place for the teachers to change student's soiled clothing, and it also has a designated 8′ x 8′ area that has numerous lighting displays. With all of these lighting displays being in one concentrated area, the need to circulate air is greatly desired. The current means of providing air flow is a basic oscillating fan. The fan does not match fit in with all the other lighting décor. The client coordinator requested a fan device that integrates a lighting display.

The final product, the Light Effective Device, is a modification to a basic oscillating fan. The addition of light emitting diodes (LED's) to the fan blades creates an array of lighting effects to attract the attention of those children in the room. This device is best used by those students who have Sensory Integration Dysfunctions, often present with children who have autism or cerebral palsy.

SUMMARY OF IMPACT

All the design goals are achieved. The client coordinator is satisfied with the final product. Users enjoy the colorful lights and breeze generated by the fan. Recommendations for future work include a way to make it quieter and to revise the slip ring design so that there isn't metal on metal contact.

TECHNICAL DESCRIPTION

The final product includes a 12″ oscillating table fan and a project box (which is below the fan). The total height of the final product is about 24.75″ tall. The total width of the final product is about 14.5″. The total depth of the final product is about 11.625″. The project box is made of wood, assembled using wood screws. There are a few layers of white paint on the box. Circuitry for the project is in the project box.

Fig. 17.6. User interacting with the light effective display.

The fan is mostly made of plastic, excluding the motor parts and the bolts that hold it all together. On the fan blades are LED lights. Behind the fan blades is the slip ring that is made out of PVC pipe, with desoldering braid in the grooves. The actuators are micro switches that have wire heat shrunk to them which goes through the base shaft into the project box. Also behind the fan are bolts, nuts, and washers these are to act as spacers and to hold the cage in place.

The total cost of parts and labor is $556.

Fig. 17.7. Close up view of the slip ring and actuators.

PORTABLE CHANGING TABLE

Designers: Mathew Thomas and Nishant Vyas
Client Coordinator: Joanne Crowson, United Rehabilitation Services
Supervising Professor: Dr. David Reynolds
Biomedical, Industrial and Human Factors Engineering Department
Wright State University
Dayton, OH 45435-0001

INTRODUCTION

The clients are outpatients who come to use the therapy rooms at the United Rehabilitation Services (URS). They have mild to severe cognitive disorders and physical disabilities. They need help from caretakers, usually their parents, to change themselves. The changing is presently done on a bed. This bed has an adverse effect on the backs of the caretakers, because the bed is either too high or too low. The client supervisor requested a changing table that is height adjustable. The adjustability makes the changing and transferring process much more efficient and less painful, as well as less time consuming. It should also be portable so that it can be moved from one part of the facility to another, instead of having to bring the patients to one room in the facility. The final goal of the project is to create a table which can accommodate an adult.

The final product is a portable changing table capable of adjusting from a height of 32 inches to 48 inches using a hydraulic scissor lift. It is capable of supporting an adult weighing up to 250 pounds. The table has a padded, cleanable surface and a safety strap.

SUMMARY OF IMPACT

The specifications requested by the client

Fig. 17.8. User on the portable changing table.

coordinator were met. Additional changes are also made to ensure more comfort and safety, such as the mattress/bed sheet, as well as the safety belt. The device has been tested by the students and performed as expected. The client coordinator is satisfied with the design and commended the design team on their work.

TECHNICAL DESCRIPTION

The top of the table is 6 feet in length and 2.5 feet in width. It has a thickness of half an inch. The table top is made of a composite material. Below the table top is a platform made of plywood. The dimensions of the platform are 32 inches in length and 19.5 inches in width. It has a height of 7 inches. These are the dimensions of the surface areas of the platform on the top and bottom. The thickness of the sides is three quarters of an inch. Below the platform is the main body of the hydraulic cart. The cart is made of steel. The hydraulic cart has a variable height range from 11 inches to 34.5 inches with a hydraulic ram as the method of adjustment. The hydraulic ram is operated using a manually operated foot pedal. The table has a lever that lowers the height in a controlled fashion. This lever is positioned on the top of the cart handle.

When the table top is placed on top of the hydraulic cart, there is approximately an overhang of 19 inches from the cart handle. The cart handle thus had to be extended by 19 inches to accommodate for the overhang. This is done by placing an extension on the rear of the cart, which extended the cart handle by 19 inches. There is a memory foam mattress on top of the table top, a mattress pad and a bed sheet on top of the table top. A safety strap is attached to the middle of the platform to provide additional safety. An accordion guard made of rubber has also been bolted to the table to prevent injuries originating from the hydraulic scissor arms.

The total cost of parts and labor is $1,097.

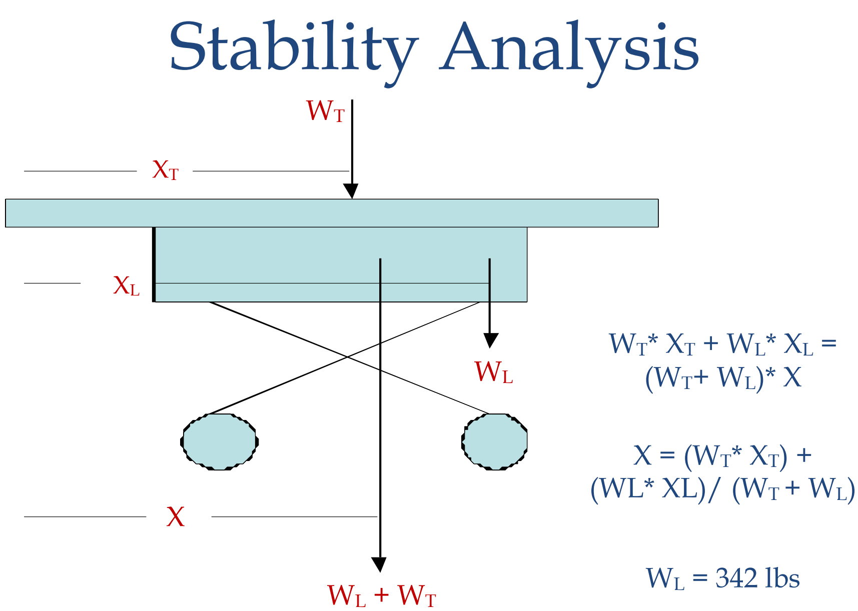

Fig. 17.9. Stability analysis model.

SENSORY MOUTH OBJECT

Designers: Abdul-rahman Abu-taleb and Akou Dossa
Client Coordinator: Carol Steinsick, Montgomery County MRDD (Southview Special School)
Supervising Professor: Dr. Chandler Phillips
Biomedical, Industrial and Human Factors Engineering Department
Wright State University
Dayton, OH 45435-0001

INTRODUCTION

The client coordinator requested a toy that a child could bite when stressed, which then plays a sound. The playing of music is thought to be beneficial for children with physical and/or mental disabilities that experience stress. While many soothers exist to stimulate the mouth and pacify children, the facility did not have a device that would also play soothing musical sounds to complement the calming process. The client coordinator required a device with the following characteristics: hygienic, chewing parts detachable from hand part to allow cleaning, free motion for the handle (the child must be able to swing it around freely), varied texture for stimulation.

The final product consists of a pacifier-like object that has a momentary grasp switch attached to a grip handle. The pacifier object is multi-textured. A project box emits the sounds triggered by the depression of the switch. The system runs on rechargeable batteries.

SUMMARY OF IMPACT

The final product met most of the required specifications. Upon review by the client coordinator, the designers determined that the project accomplished its objectives. Trials with two children [age 3 and 6] gave very positive results, with each child expressing satisfaction with the functioning of the toy. A recommendation for future work is the inclusion of a light display to further aid in the calming process for the child.

TECHNICAL DESCRIPTION

The mouth simulation system consists of the following components: one momentary grip switch, one battery charger, elastic band, one black plastic sound box with a three position toggle switch, two Raz-Berry® teethers, and a carrying case. The teethers are made of medical grade silicone, with multi-textured surfaces. The triggering of the momentary grip switch activates the musical sounds. Voltage divider equations are used to determine the value of R and the potential current draws from the batteries. Figure 17.11 shows the electrical circuit that controls the system.

Fig. 17.10. Child using sensory mouth object.

The batteries have a maximum continuous charging time of six hours. The charger delivers a 1000 mA current draw and each battery has a capacity of 2 Ah. The calculation for the charging time for the eight batteries in the system comes to 2 hours per battery. But charging the batteries generates heat within the sound box. Safety considerations include: making sure that the charger is never plugged in the box while the system is in use, charging the system under supervision to avoid overheating and damage to the batteries, keeping the teethers hygienic by cleaning them up before and after each use.

The total cost of parts and labor is $622.

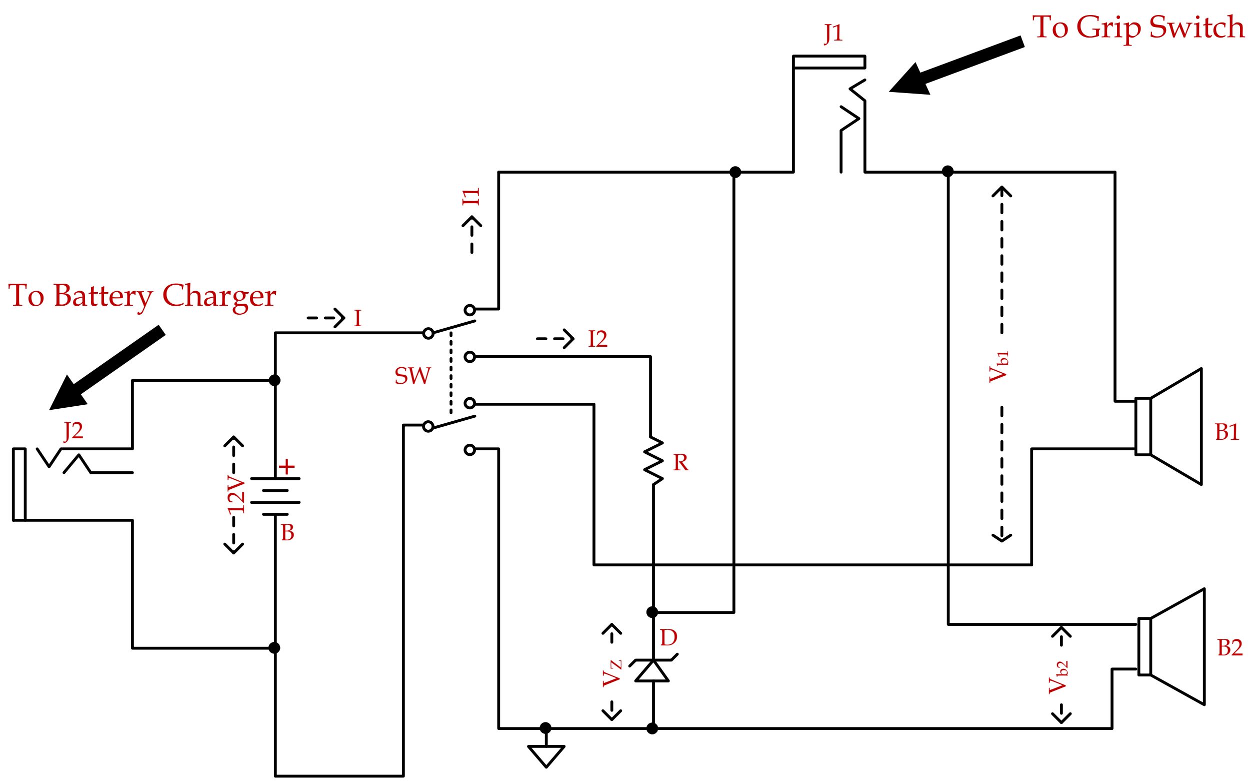

Fig. 17.11. Circuit schematic for sound box.

SUPERVISION ADAPTIVE READING STATION

Designers: Bridget Cassidy and Alex Revelos
Client Coordinator: Katherine Myers, Wright State University Office of Disability Services
Supervising Professor: Dr. Julie Skipper
Biomedical, Industrial and Human Factors Engineering Department
Wright State University
Dayton, OH 45435-0001

INTRODUCTION

The Office of Disability Services at Wright State University reports approximately five to six students on campus during a given academic year whose vision is significantly impaired. Low vision reading aids are often the only alternative for those with significantly impaired vision. The products commercially available do not meet the need of these students because of their associated high cost. Many offer low portability and are not even capable of enlarging figures. The client coordinator requested that the design team develop a vision enhancement station at a fraction of the cost of the present commercialized low vision readers with the possible capabilities of being portable and enlarging figures. A characteristic of the targeted client group is that their fine motor skills are often limited. A track ball type control, with large buttons, should thus be implemented to control the variable text speed.

The final product is a device is that scans text into a document and displays the text in a more clear and readable format. The program, written and implemented by the design team, formats the text into large black and white text that can be seen by the student. The users are able to set the speed of the scrolling text, the contrast options, the direction of the scrolling, and the size and zoom of the font.

SUMMARY OF IMPACT

The design goals are completely achieved – the program scrolls clear and large text in order to ease reading for those with low vision. One user said he was truly impressed with what the design team had accomplished. He remarked that he would use this program every day because it seems much better than other options that are currently available. The user liked that it showed only one row of text at the time so it was easy to focus on the words on the screen. The client coordinator also expressed satisfaction with the final product design.

Fig. 17.12. Client using the supervision adaptive reading station.

Recommendations for further work include: more exact text processing, perfecting figure detection, improving the graphical user interface.

TECHNICAL DESCRIPTION

The SuperVision system consists of a computer, scanner, DVD drive, keyboard, and mouse. The most critical component of the design is the user interface program, which is written using MATLAB. MATLAB is a high-level computing language and interactive environment for algorithm development, data visualization, data analysis, and numeric computation. The interface uses the image processing capabilities of MATLAB to display the text as an image onto the screen, while prompting the user for its choices for the various display options.

A scanner is used so that the text can be entered into the computer system. The document with the scanned text is used as an input into the interface so the text and figures within the document can be displayed. After the document is scanned into the computer operating system, MATLAB is used to analyze the text using many different functions and techniques. The flow chart (Figure 17.13) describes the exact test processing that occurs.

The user controls the program using a track ball mouse. The mouse allows the user to choose the zoom settings, move the ball in one direction to zoom out and the opposite for zooming in. The control is located in the front of the system so that users with limited range of motion are able to employ the system with ease. The trackball mouse was chosen because it allows users with limited dexterity to be able to control the system. The text displays on a screen, either a computer monitor or projection screen, depending on the use of the program.

A key feature of the design is the scrolling text capabilities of the program. The text is able to scroll, line by line, from the right side or the bottom of the screen. To ensure that the text is clear and readable, the font size is 24 point or larger, which should be sufficiently large for all users to read. The contrast and boldness of the font is variable. For some people reading a black font on a white background strains the eyes, therefore, there is an option within the program for white font on a black background. The font becomes unclear if the font size is too big, 32 size font is the maximum font size option within the program. The Arial font style is typically the easiest font to read because of its lack of serifs, so the text is converted to Arial within the MATLAB interface.

The total cost of parts and labor is $563.

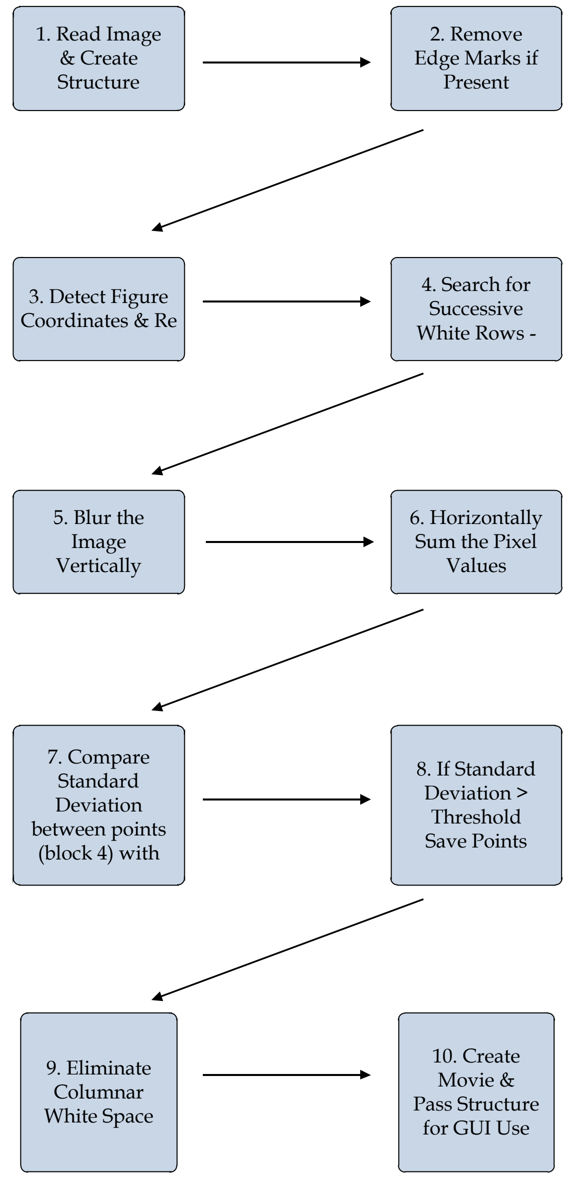

Fig. 17.13. Text processing flow chart.

VIBRATING MAT DESIGN

Designers: Danielle Borrero and Mohammed Redha
Client Coordinator: Carol Steinsick, Montgomery County MRDD
Supervising Professor: Dr. David Reynolds
Biomedical, Industrial and Human Factors Engineering Department
Wright State University
Dayton, OH 45435-0001

INTRODUCTION

The client coordinator requested a device to help children with special needs improve their ability to process sensory information. They requested a mat that vibrates in nine different areas, under the control of the wireless remote, as the user moves from one section of the mat to another to feel the vibration. This kind of physical therapy gradually helps the user establish a better sensory system, with the hope of improving independent movement.

The final product is a mat that is divided into nine sections with all nine sections vibrating. Three sections of the mat vibrate under the control of one switch allowing for three switches total. The vibrating sections of the mat are 4 feet by 4 feet and contain nine motors spread out per square foot. The sections are all built separately are laid down side by side in order to make the final product. Each section is powered by rechargeable D batteries, which is able to be removed from the mat, recharged and reinserted by opening the bottom flap of each section. The battery power for each section vibrates strongly for approximately three hours, with its power decreasing over an additional three hours until it finally runs our out of power.

SUMMARY OF IMPACT

The product functions well, with all parts are operating as they should. The client is very pleased with the performance of the final product. The users are pleased with the vibrating mat, appearing delighted with the mat's functions. Figure 17.14 shows several children using the mat.

TECHNICAL DESCRIPTION

The vibrating mat is 12 foot by 12 foot when all pieces are assembled in a square pattern on the floor. Each mat piece is 4 foot by 4 foot and has thickness of 2 inches. Each mat contains 9 Motorola pager vibrators (model MXV4302). The vibrators operate from 1.5 V to 6.5 V. Three 1.5 D batteries are used in each mat for the vibrators. Receivers and transmitters from remote control cars are used for

Fig. 17.14. Clients using the vibrating mat.

the wireless communications components. As the transmitters operate on two frequencies, and each frequency has two signals, three separate signals are used to operate the mats as three sections are controlled. Each receiver needs 4.5 V to function correctly, which necessitated the use of 1.5V D batteries.

Each mat contains six sheets of cardboard, 4 foot by 4 foot. Four Cardboard pieces are attached by duct tape and nine holes, 2 inches in diameter, are cut proportionally into the cardboard stack. The vibrators are placed into these holes, to prevent them from ceasing vibration if they are stepped on. The circuitry is concealed in another cardboard piece, which is placed under the stack. The sixth piece of cardboard is used as a cover. To ensure softness 80 pound carpet padding is used for the sub-surface of the mat. This is a quality carpet padding that feels as soft as expensive Ethofoam (a material that was originally considered for the mat cushioning). In each mat, a 4 foot by 4 foot, 8 pound carpet padding is used. To keep the mats flat, level and in place, hard board is used. Each mat contains one section of 3/16 inch hardboard.

The entire mat is covered with a washable vinyl fabric. The vinyl is the marine-rade vinyl which is used mostly in boat seat covers. It can be washed with water and soap. Each mat used 3 yards of Marine Vinyl. The vinyl opens and closes for an easy access to change the batteries.

The total cost of parts and labor is $1,175.

GREAT TOE CAPSTONE PROJECT

Designers: Alexander Sheets and Allison Van Horn
Client Coordinator: Orthopedic Services, Miami Valley Hospital
Supervising Professor: Dr. Tarun Goswami
Biomedical, Industrial and Human Factors Engineering Department
Wright State University
Dayton, OH 45435-0001

INTRODUCTION

Approximately 43 million Americans today experience painful foot problems. Some of the conditions causing the pain are hammertoes, calluses, bunions, or hallux valgus. There are many different solutions to these conditions, including nonsurgical treatments such as changing footwear and braces. Unfortunately immobilizing the great toe only causes increased stiffness. There are surgical solutions available that include toe joint replacement implants. These implants also have drawbacks, which include mechanical failure, grinding against healthy bone, and inflammation. The supervising professor asked the team to create a new brace design and a new implant design to decrease discomfort for individuals with severe hallux valgus deformities.

The designers presented several new designs for braces and surgical implants. Two brace designs were presented, depending on the severity of the great toe deformity. Each brace was designed for inexpensive materials and more expensive materials, for a total of four brace designs. Using a two component base model, four different designs for surgical implants were also presented.

SUMMARY OF IMPACT

The final designs met the design requirements defined by the supervising professor. The project as a whole includes many different aspects of joint treatment options. The splint helps to maintain and correct the outward angulation of the Hallux Valgus. The brace design has a metatarsal pad added to help runners along with people with MTP joint problems. The MTP total joint designs are all 3-D modeled and prototyped. The possible materials were all analyzed using finite element analysis to ensure they were durable enough for a patient. After the prototyping stage, a review showed the need to redesign a MTP joint replacement. In the slide design, the articulating surface appears a little too small after looking at the prototypes. Nevertheless, the articulating surface can't be enlarged because there would be no structure to support the wider surface area. These issues may be addressed during future work.

Fig. 17.15. Short reinforced brace.

TECHNICAL DESCRIPTION

For the non-surgical solutions, two different braces were designed. The first brace is very durable and cushions the toe lessening the pain. The brace also corrects the hallux valgus angle of the toe. It can be worn with most shoe types and is visually attractive. A second brace design was created for slightly more severe cases. The base of the first design is taken and the part that covers the great toe extends to the end of the toe. Therefore, the brace does interfere with the joint mechanics of the foot, yet the great toe is completely enclosed providing support for the entire toe. These two braces were then designed to fit into two different price ranges, a relatively inexpensive price range and a slightly more expensive price range. The more expensive braces are reinforced at the MTP joint with a different material that allows for extra cushioning and support.

For the surgical treatments, a two component design was deemed the most successful. Therefore, the design options are all two component implants. The first design consists of a total of four parts. The metatarsal component contains a tapered metal insert and a UHMWPE insert as well as the phalange component. The UHMWPE part is designed to snap to the inside of each of the metal parts using an O-ring method. The metal parts have wedges on the outside for a non-cemented press fit. To give a surgeon options when picking the perfect implant for a patient, several varieties have been introduced. The metal component options are to have the tapered implant without the wedges, for cementing or to have no tapering or wedges, also a cemented design.

In addition to the snap design, a slide design was also proposed. This design has more metal, which absorbs the forces better than a plastic would. The plastic articulating surfaces contain a circle that slides into a depression on the metal components, allowing for easy assembly by the surgeon. This design also has the three options for the metal components. There is a tapered and wedged version, a tapered and not wedged version, and a not tapered and no wedges version.

There are also two more implant designs to help correct the hallux valgus condition. There is a double hemi design that contains two metal components that are symmetrical and each can screw into the intramedullary canal of the metatarsal and phalange. The last set of designs is revision designs. Since there are so many difficulties with currently available solutions, many of the previous surgeries need to be redone. The revision designs allow for either one or both parts of the metatarsophalangeal joint to be replaced again. The revision designs consist of a metal insert that holds a screw. When the screw is inserted, the metal component expands and is press fit into the intramedullary canal. The articulating surface is either snap onto the metal insert and screw assembly or it can screw on to the assembly.

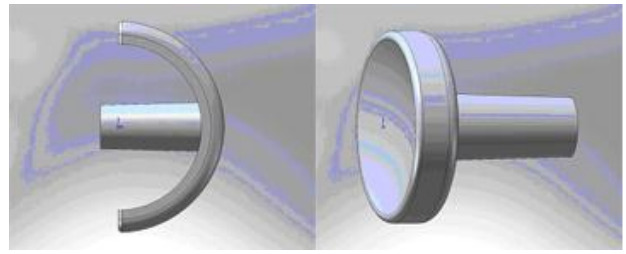

Fig. 17.16. Pyrocarbon MTP.

The final design uses a new material called Pyrocarbon that has very similar prosperities to human bone. The design is a non-constraining, two component design. The articulating surface of the phalange component is modeled after the human phalange bone. The articulating surface for the metatarsal component is also modeled after the human metatarsal bone. The components are designed so they would restore normal joint function. Pyrocarbon has shown great results as a joint replacement, but does not offer a good history of fixation. This problem is resolved by coating the pyrocarbon implant design with a thin layer of hydroxyapatite on the seams to insure proper fixation.

The problem of an implant slipping out is solved by either cementing or non-cementing the implant. The decision can be made individually for each patient by the surgeon. The materials are strong and durable enough to prevent fracturing, breaking, and wear. The designs for both the braces and the implants are the proper size. Each of the designs has different sizes to account for the differences in body types. The materials chosen are all FDA approved, and therefore are biocompatible and safe for the patient long-term. Given the constraints, the designs provide an optimal solution to the hallux valgus condition.

The total cost of parts and labor is $425.

CHAPTER 18
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