CHAPTER 17
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

rlg@bme. unc.edu

TIME CARD PACKAGING SYSTEM

Designers: Akshay Ahuja, Matthew Bostian, Katy Millay, and David Skwerer
Client Coordinator: Gena Brown, Goodwill Industries
Supervising Professor: Richard Goldberg
Department of Biomedical Engineering
Room 152 MacNider, CB # 7575
University of North Carolina at Chapel Hill
Chapel Hill, NC 27599

INTRODUCTION

Goodwill Industries is a non-profit organization that offers specialized job training and placement services for people with disabilities. They have a longstanding contract with a company that produces timecard-punching machines. For this contract, one of the tasks is to package user manuals, timecards, keys, and hardware into small Ziploc bags, which are then boxed and sold with the machines. This is a challenging task because of the small size of the bags, which are barely large enough to fit the enclosed items. Our client has Cerebral Palsy and experiences frequent spasms in her hands. It is difficult for her to handle and package these items independently. Furthermore, our client uses her dominant hand while working and has trouble controlling her opposite hand, which can hinder her efforts.

The objective of this project is to design and manufacture an assistive device that enables the client to perform the bag filling task with one hand. This device should enable our client to easily, neatly, efficiently, and independently insert the materials into the Ziploc bags. It should be durable, portable, and accessible for use by a number of Goodwill employees with other disabilities.

SUMMARY OF IMACT

With the Time Card Packaging System, our client can insert time cards and pamphlets into a Ziploc bag within the desired industry standard time period. This device will have an enormous impact on our client's efficiency and versatility in the workplace. One of the Goodwill staff members, Jeff Fleming, stated that, "on the work floor we have only a few jobs that this client is able to perform, and though she can do these jobs she does not complete them in a timely manner (the minimum time standard). With this device, she can not only do

Fig. 17.1. The Time Card Packaging System.

Fig. 17.2. Client loading the papers and bag into the device.

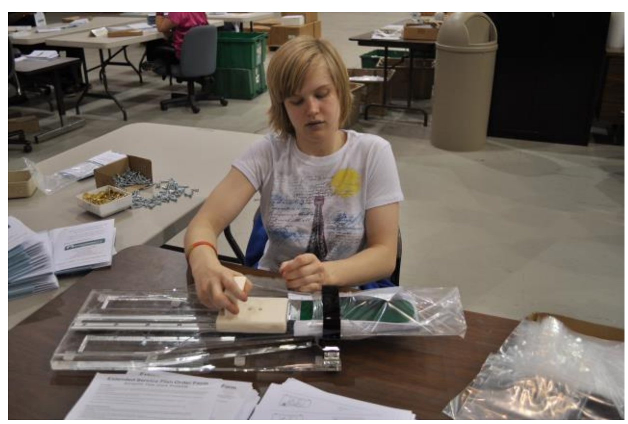

Fig. 17.3. Client using the device; the papers are now in the bag.

another job, but she can perform the job within the minimum time period."

TECHNICAL DESCRIPTION

There are two important steps to this task: holding the papers together, and sliding the papers inside an open Ziploc bag. The device consists of (a) a funnel-shaped piece of acrylic; (b) a linear guide block that glides along a rail below it; (c) a Ziploc bag securing mechanism; and (d) a hand stabilization bar. In order to perform the task, our client pushes a Ziploc bag over the funneled end of the acrylic, secures it in place, and then drops her stacked materials onto the loading platform directly in front of the guide block. Next, using the guide block, which is attached to the rail, she slides the papers into the tapered, funneled section of the acrylic. At this point, the edges of the papers begin to curl, temporarily reducing their width and allowing them to easily slide into the opened Ziploc bag. Once out of the funnel and inside the bag, the papers will return to their full, original width. The filled bag is then removed and replaced by another empty one, allowing our client to perform her tasks in quick succession.

The funnel and base are made of acrylic and cut with a laser cutter to the proper shape. Using a heat gun, the acrylic was warmed until soft and malleable. It was then bent around a prefabricated mold in order to achieve the desired funnel shape. Methylene chloride was used as a solvent to fuse all of the acrylic pieces together into one solid unit. This manufacturing process ensures that the funnel surface is free of scratches, bumps, cracks, etc., to reduce friction and allow smooth and unhindered transfer of the papers into the Ziploc bags.

An anodized aluminum guide rail is mounted onto the base of the device. A zinc-chromate steel guide block with a self-lubricating PTFE liner comprises the piece that slides along the rail. Attached to the top of this guide block is a plastic pusher, made using a Fusion Deposition Modeling (FDM) system, designed to be ergonomic by offering the user multiple gripping options. There is an acrylic loading platform attached to the front of the guide block, and a hinged acrylic flap that the client lowers on top of the papers. Because the papers are sandwiched between these two layers of acrylic, they stay organized as the client pushes them through the funnel.

A securing mechanism to prevent the Ziploc bags from slipping off the end of the funneled acrylic while the materials are being loaded is utilized in this design. This simple yet effective mechanism, which acts like seatbelt for the bags, consists of a thin strip of molded acrylic, self-adhesive foam padding and Velcro. To secure a Ziploc bag on the end of the funnel, the clients flips the acrylic strip across the bag and funnel, and attaches it to the opposite corner of the base with Velcro. When finished, our client can simply release the Velcro connection to remove the bag and packaged materials.

Our client has trouble controlling her non-dominant hand, which can hinder her work efforts and slow her overall progress. Our device employs a hand stabilization bar to occupy her non-dominant hand. The bar was manufactured from a 1-3/4" diameter acrylic dowel rod. This gives her more control over her movements as well as a counter-force while she is loading the materials into the Ziploc bags.

The total cost of this device is $100.

WHEELCHAIR ACCESSIBLE MOTION SIMULATOR

Designers: Vishal Parikh, Peter Bohlen, Andrew Pappa, and Ben Wiener
Client Coordinator: Earll Williams
Supervising Professor: Richard Goldberg
Department of Biomedical Engineering
Room 152 MacNider, CB # 7575
University of North Carolina at Chapel Hill
Chapel Hill, NC 27599

INTRODUCTION

Our clients are students at a local middle school who have disabilities. Most of these students use manual wheelchairs that they are unable propel independently. They enjoy movement, as they smile and laugh when their teacher enthusiastically rocks their wheelchair. However, this becomes tiring and for the teacher. The goal of our project is to design a platform that can safely rock a wheelchair under the control of a teacher or aide. The device should produce tilting motion in four directions: left, right, forward and backward. In addition, the device should be capable of being stowed in a crowded classroom.

SUMMARY OF IMPACT

The device will allow the clients at Lowes Grove Middle School to enjoy the sensation of movement while seated in their wheelchair. One of the instructors at the school stated that “this was a real treat for us to watch. I really enjoyed watching [the client] having fun, smiling and laughing, and pushing his buttons. It’s a good sensory activity for the kids since they are limited in their mobility. So it was a real treat, thank you.” Therefore, we believe that our device made a beneficial impact for the clients and will continue to be a great device for future students.

TECHNICAL DESCRIPTION

This device consists of a static base, a moving platform, and a control system to activate the movement. The base is made out of ¾” reinforced plywood with dimensions of 36”x40”. This wide base of support prevents the device from tipping over during use. Metal braces, arranged around the perimeter of the base, are attached to provide extra strength and prevent the wood from warping. A central support is attached to the geometric center of the base, and it supports most of the weight of the moving platform and the client. At the top of the central support is a ball and socket joint, which connects to the moving platform and allows tilting in any direction. Additionally, 12 springs connect from the base to the platform and are used to provide further support of the platform while allowing for its motion.

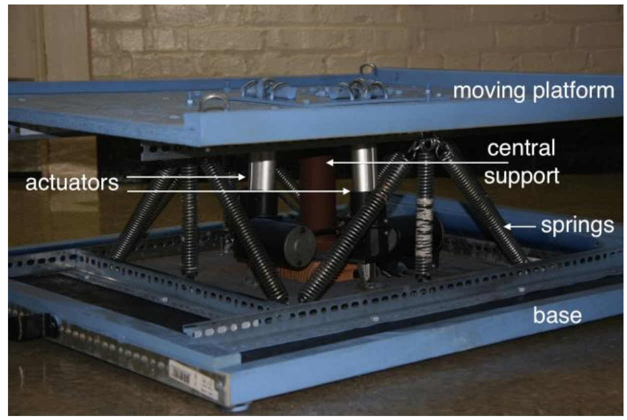

Fig. 17.5. Side view of the Wheelchair Accessible Motion Simulator.

The control system consists of two linear actuators, along with their power source and joystick controller. The actuators are bolted to the base, and the moving arm is attached to the platform with ball and socket joints. As a result, there are three points of support between the base and platform: the central support at the origin, an X axis actuator, and a Y axis actuator. Using the concept that three points create a plane, the device is able to tilt through a range of angles in any direction, while still remaining sturdy.

The actuators are located 4.5” away from the origin. This was the ideal distance to provide the desired range of tilt angles and angular velocity, in addition to providing the required force. These actuators are rated at 400 pounds of force and move at a speed of 0.59”/sec. Furthermore, these actuators have a stroke length of 2”, which provides approximately

12.5 degrees of angular movement front to back and side to side. The actuators are connected to a power supply. The teacher or aide moves the actuator using a joystick, which allows intuitive control of the tilting in all four directions.

The platform, which is made out of ¾" reinforced plywood, is where the client's wheelchair sits during use of the device. The teacher or aide secures the wheelchair onto the platform using straps which are manually tightened with a ratcheting system. In addition, there are metal supports on the underside of the platform, arranged in a geometric rectangle around the connection to the central pivot. This provides extra strength to the platform. There are a number of connections between the base, the control system and the platform as described above. A wooden ramp is also constructed to permit the teacher or aide to easily wheel the students on and off the platform.

The cost of the project is $650.

Fig. 17.4. Client enjoying a ride in his wheelchair.

LIFT ME UP

Designers: Ankit Gupta, Jillian Haac, Nabil Khan, and Vishal Rao
Client Coordinator: Charlotte Hughes, PT
Supervising Professor: Richard Goldberg
Department of Biomedical Engineering
Room 152 MacNider, CB # 7575
University of North Carolina at Chapel Hill
Chapel Hill, NC 27599

INTRODUCTION

Our client is an 8-year old girl who sustained a spinal cord injury two years ago that left her with paralyzed lower extremities and mild respiratory complications. Using her arms, our client can propel a manual wheelchair and move independently on the floor. However, she cannot independently transfer herself between her wheelchair and the floor. As she continues to grow, it now takes two assistants to safely transfer her to the floor and vice-versa. Unfortunately, our client does not always have access to two assistants in a home or classroom setting. This limits her ability to participate in classroom floor activities, and makes it difficult for her to get in and out of her wheelchair at home. There are no current products on the market that can assist our client with getting to and from the floor. While there are devices that are utilized to move loads vertically, most are designed to lift cars or industrial crates and exceed the force needed to lift a person; this renders current products both cost prohibitive and unsafe for human use.

The goal of this project is to develop a device that allows the client to move between her wheelchair and the floor with the assistance of only one other person. Using her arms, she can perform a depression lift to lift her body weight up five inches. Therefore, the device platform needs to get within five inches of the target height of the floor or wheelchair seat. The device must be lightweight, compact and portable so that our client's caretakers are able to easily transport it between school and home.

SUMMARY OF IMPACT

"The 'Lift Me Up' project will allow a young girl with paraplegia to get out of her chair and sit on the carpet with her peers during several activities during her school day. She feels more a part of the group when she is on the floor with them rather than sitting above them in her chair, where she feels more separate. She has adequate sitting balance so she feels safe on the floor but she is only able to get out when there are two teachers in the classroom to safely lift her back into her chair. The student may also use the lift at home so that she can join her younger sibling for play on the floor and then move safely back to her chair with assistance from only one adult" commented Ms. Charlotte Hughes, School Physical Therapist.

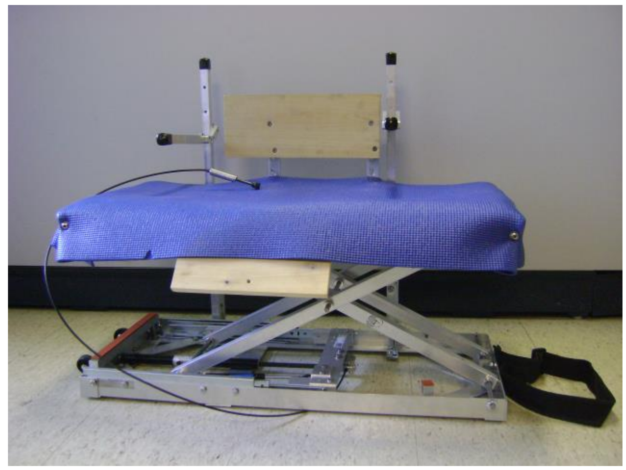

Fig. 17.6. The Lift Me Up device, with the platform about half way between its highest and lowest positions.

TECHNICAL DESCRIPTION

The device has a platform that moves up and down to allow our client to transfer between her wheelchair and the floor. The operation is similar to that of an adjustable office chair, in which the user pulls up on a lever to unlock a gas spring; de-weighting allows the spring to push the chair up, while the weight of the user on the chair will push it back down. In our device, the client pushes a button to unlock the gas spring, allowing the lift to move up when she de-weights herself, or move down when her weight is on the platform.

Our device is based on a scissor lift design, which is often used in an industrial setting in order to lift heavy objects. It consists of two sets of diagonal arms attached to each of the corners of the top and bottom platform. The scissor lift mechanism is efficient because it provides a large vertical height displacement for a small mechanical input force. The lift is made out of 1″ square aluminum tubing with a wall thickness of 1/8″. This provides the device with adequate strength, but is also lightweight. On one side of the bottom and top platform, the crossing, diagonal arms are mounted to heavy-duty drawer slides. This allows the ends of the arms to move horizontally along the top and bottom frames, as the platform is raised and lowered.

A lockable gas spring is used to apply the force needed to control the raising and lowering of the platform. The gas spring sits inside the frame of the bottom platform and it produces the force needed to push the arms of the scissor lift up. The locking action is controlled by a button that attaches to the gas spring via a cable.

Because our client does not have control over her legs, a system is developed in which she pushes on armrests to de-weight herself. The armrests slide up and down a pair of vertical stability bars. These stability bars attach to the bottom platform and they are 30″ tall. They are located to the left and right of where our client sits on the platform. When our client tilts the armrests at an angle, she can slide the armrests up and down along the stability bars to reach a comfortable position, no matter the current height of the platform. When she applies a downward force on the armrests, they do not slide because of friction, and they can support her entire weight. When she de-weights herself, the gas spring can extend to raise the platform.

Aluminum angle-strips are used to create a rectangular frame for the top and bottom platform. A steel wire frame manufactured for cabinet shelving is used to create the surface for the top platform. A yoga mat is attached to this wire frame as a seat cushion to ensure comfort. The surface of the yoga mat allows our client to slide on it while she is transferring onto the platform, but it also has some friction to prevent unexpected slipping.

Fig. 17.7.The device lifts up the client as she de-weights herself.

There is a short ramp, about five inches long, extending from the front of the platform, which will direct our client's legs away from the scissor lift mechanism. This will help to avoid any possible injuries that could occur if her legs went under the platform while it is lowering. This same ramp will assist our client in moving onto the platform from the floor when the device is in its lowered position. There is also a backrest made of a lightweight wood attached to the top platform between where the armrests are positioned. This ensures that our client will not fall back off of the platform while it is moving or during transfer.

To make the device portable, wheels are attached to the short side of the bottom platform. A strap is attached to the opposite side so the parent or teacher can pull the device while it is rolling on its wheels. The device weighs 30 pounds, so an adult can lift it into a car or over steps. The final cost of this device is $545.

ON-TASK TIMER: AN ELECTRONIC SCHEDULING TOOL FOR AN EMPLOYEE WITH AUTISM

Designers: Jakub Dmochowski, Michael Millard, Sergio Olivas, Bradley Brown
Client Coordinator: Gena Brown
Supervising Professor: Richard Goldberg
Department of Biomedical Engineering
Room 152 MacNider, CB # 7575
University of North Carolina at Chapel Hill
Chapel Hill, NC 27599

INTRODUCTION

Our client, a 20-year-old male with autism, works at a plant nursery. This is arranged through Goodwill Industries' placement services and a Goodwill job coach supervises the client there on a daily basis. Our client is assigned a set of specific tasks at work each day, ranging from folding boxes to working on garden chores. While he can independently perform each of his tasks, he has difficulty transitioning between tasks because he becomes engrossed in his current activity. As a result, his job coach has to help him transition throughout the day.

Our goal is to develop a device that improves his ability to transition between tasks, furthering his independence in the workplace. He may also use the device at home to transition between household chores. There are several important criteria. The device needs to be portable without impeding our client's ability to work as the nursery spans a half-acre. An audible prompt to transition would not be effective because the nursery is located next to active train tracks. Finally, due to the fact that the nursery is mostly outdoors, the device must be safe and durable in an outdoor environment.

A device based on an iPod Touch (Apple Computer, Cupertino CA) was developed in this design. The iPod Touch is a handheld computer that has a large touch screen for user interaction. In order to fasten the device to the client, we enclosed the iPod Touch in a custom case that straps to the user's forearm. The case also includes a vibration motor that prompts the user to transition.

SUMMARY OF IMPACT

"The client does a variety of jobs at a plant nursery. This tool will be instrumental in structuring his day and affording him the ability to transition from task

Fig. 17.8. The supervisor programs the day's schedule using an intuitive iPod Touch application.

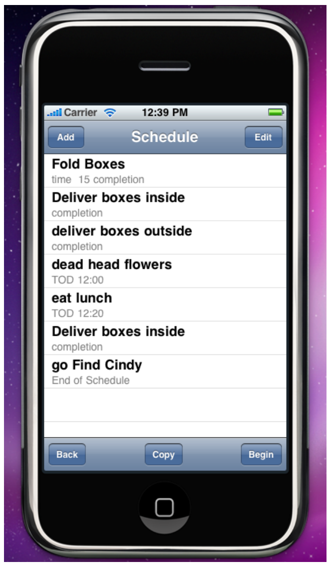

Fig. 17.9. iPod Touch.

to task with little or no intervention from another staff member. This is huge in a place where people are very busy and the client needs to be able to work independently." -Gena Brown, Goodwill Job Coach.

TECHNICAL DESCRIPTION

The iPhone Software Developer Kit was used to develop the application. The software application is divided into two modes: the task scheduling mode for the supervisor and the operational mode for the client. The task scheduling mode allows a supervisor to generate a schedule for the day. In the Task Editor, the supervisor can create or edit a particular task. Parameters include a name, instructions, and a picture. The supervisor can also choose from the following alarm settings: work for a specified length of time, work until a certain time of day, or work until completion (i.e. until entire stack of boxes are folded). In the Schedule Editor, the supervisor can look at the list of tasks stored in memory and use their finger to slide them into their desired order for the day.

The supervisor or client touches the BEGIN button to transition to the Operational Mode, which executes the schedule for the client. Because this is the client's user interface, it has a user friendly layout with a single large button, an image of the current task, and instructions entered by a supervisor. For the alarm settings that are time-dependent, there is a progress bar. When time expires, the client is alerted by vibrations from the case. This instructs him to touch the button, making a check mark appear and turning off the vibration. A new screen displaying a picture of the next task will then appear. The client must then touch the BEGIN button to indicate he has started the next task. This process will continue until all tasks set for the day are completed.

To complement the iPod Touch application, a custom vibrating case is constructed to provide tactile cues when it is time for the client to transition. The application triggers the vibration motors by playing a "song" stored on the iPod Touch, which consists of a low frequency tone. The audio output jack connects to custom circuitry, which uses a comparator to amplify the audio signal and drive the vibration motors. A rechargeable lithium-

Fig. 17.10. Client using the On-Task Timer, mounted to his left forearm.

polymer battery, with a capacity of 1000 mAh, powers the electronics. With the use of a low-power comparator, the fully charged battery will operate for approximately two weeks, assuming daily use of four hours. A built-in recharging circuit based on the MAX1555 integrated circuit is also included in the design.

The structure of the case is designed with two compartments. The front compartment houses the iPod Touch. The case has a large window that provides full access to the iPod Touch screen, while covering the "home" button to prevent the client from using that button to exit the program. The rear compartment houses the electronics and vibration motors. Finally, adjustable Velcro straps are used to secure the case onto the client's forearm.

The case is modeled using computer aided design software and made from ABS thermoplastic on a fused deposition modeling (FDM) system. ABS is a lightweight, durable material that can withstand environmental conditions. To ensure the client's safety, edges of the case are rounded.

The total cost of this device is $250, including the cost of a $107 software license from Apple, but not including the cost of a donated iPod Touch.