CHAPTER 10
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SOLUTIONS TO AID INDEPENDENCE

Designers: Margaret Kelly, Samantha Ratley, and Angela Starner
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INTRODUCTION

The Press-fit Grip (PFG) and the Ready to Roll (RTR) are designed and implemented to help a client with Cerebral Palsy (CP). The goal of each design is to help our client be more independent. The client lacks fine motor control in his hands, which makes it difficult for him to complete daily tasks on his own. One of these tasks is holding the paper cups that are served at restaurants. Several cup holders are readily available commercially, but none of the available options fit his hand well enough to meet his needs. The client also volunteers twice a week at the local Animal Shelter where he unfolds and stacks newspapers so that another volunteer can easily roll them up and store them for later use in the animals' cages. The RTR is designed to improve the client's independence in his volunteer position at the Animal Shelter.

SUMMARY OF IMPACT

The design criteria for the PFG and the RTR are defined by the client's capabilities and the fact that he wants to do accomplish as much as possible independently. Because he lacks fine motor control, it is imperative to keep the PFG and the RTR simple and without intricate parts that may cause him frustration. Not only do these devices allow him to complete the processes on his own, but it also allows the person that would normally be helping him to focus efforts elsewhere. The PFG is essentially a custom-made cup holder that will hold all of the restaurant cups that the client uses on a regular basis and is specifically designed to fit his hand, thereby making it as easy as possible for him to hold. The RTR is a device that allows him to do the entire newspaper rolling process independently. That is, he can unfold, stack, and roll the newspapers entirely by himself.

TECHNICAL DESCRIPTION

The PFG is composed of two pieces: a housing/handle that is rapid prototyped and a piece of washable, viscoelastic memory foam set inside it

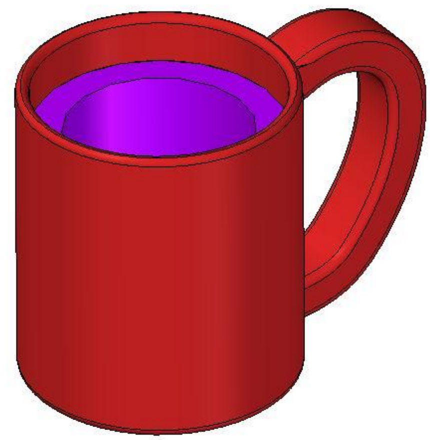

Fig. 10.1. CAD drawing of the final Press-fit Grip (PFG) design.

to securely hold the restaurant cups. This design is a very simple and is chosen over alternative design solutions due to superior performance capacity in the categories of washability, durability, ease of maintenance, and thermal insulation. The PFG was tested and is currently successfully used by the client.

The RTR is composed of three subsystems: the frame, the roller, and the crank. The frame is constructed completely of wood and it is designed to be adjustable in order to fit multiple newspaper sizes. The frame is also designed to be easily broken down, to make the device easy to transport. The roller is made of two parallel dowel rods. The paper can be stacked in between these dowel rods and rolled around both simultaneously. The crank is modeled after the client's silverware in order to ensure he will be able to grip the handle. When the crank is turned, the newspaper will roll around the parallel dowel rods, creating the roll of papers. This design is chosen over alternative design solutions due to superior durability, portability and ease of cleaning. The RTR was tested and successfully used by the client.

The cost of parts and materials for these two systems is about $250.

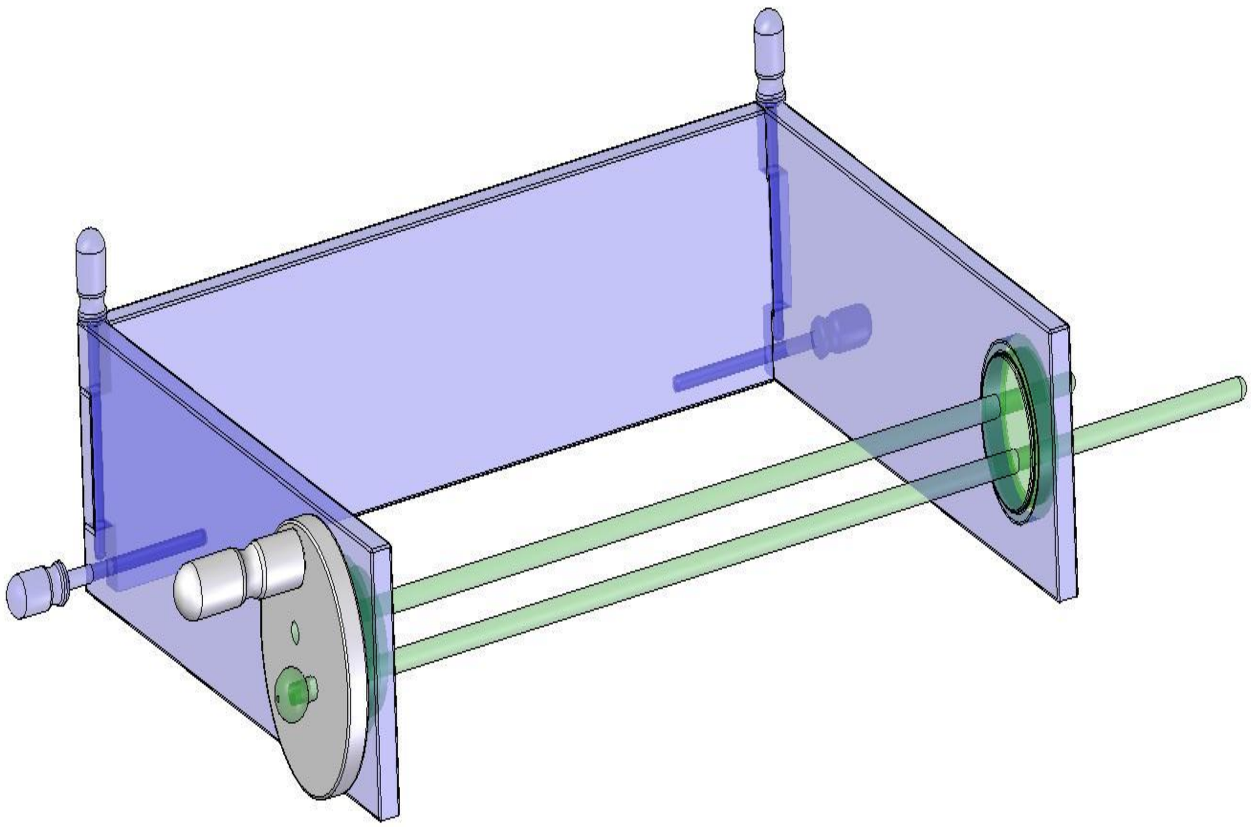

Fig. 10.2. CAD drawing of the final Ready to Roll (RTR) design.

VISION COOKING CHALLENGE: CUSTOM LIGHTING FOR CLIENTS WITH LIMITED VISION

Designers: Lauren Christensen, Sarah Dempsey, and Sabrina Liechty
Supervising Professors: Dr. Kay C Dee, Dr. Renee Rogge, and Dr. Glen Livesay
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INTRODUCTION

The Octopus is designed to provide people with limited visual abilities a custom light source to improve their ability to perform essential daily activities, such as cooking. There are many types of lamps or other auxiliary light sources that may be helpful to persons with limited visual abilities. Our client, however, has tried these solutions without much success. Therefore this design includes a custom lamp with light emitting diode (LED) light bulbs. The device is equipped with four flexible arms, each with an LED light bulb at the end. The flexible arms allow the user to adjust the location of the light. The advantage of multiple arms means that the user can choose to focus light in more than one direction, a larger location, or increase the intensity of the light (by focusing more than one in the same location). Testing with the client was done to determine the best light source for the individual. The lights chosen to test were LEDs, halogen lights, compact fluorescent lights and several different colored lights. The client responded positively to LED lighting as well as yellow and green lighting. The intensities of each light were also adjustable by means of dimmer switch.

SUMMARY OF IMPACT

The Octopus is designed specifically for one client, but the device may benefit many other clients with similar needs. Since the device is easily used and portable it would be able to be transferred to other people with similar vision challenges who would also benefit from such a device. There are also several other applications that may be modified for different types of vision impairments based on the design of the Octopus.

TECHNICAL DESCRIPTION

The Octopus is comprised of three subsystems: the base and stem, the arms and light attachment and the wiring.

The base and stem are made from aluminum. The overall dimensions were 2’x2’x1.2” for the base and

Fig. 10.3. The Octopus design as implemented.

2”x2”x20” for the stem. Located on the stem are four on-off switches and four dimmer switches, allowing for independent control of each of the lights. To better insulate the circuit, the bottom piece of the base is made from Lexan.

The flexible arms attached to the stem by a 4” round weatherproof junction box. The arms are made from flexible steel conduit. At the other end of each arm are customized 48-LED light bulbs. The light bulbs are stock parts that are slightly modified by removing select internal elements.

The circuitry for each of the lights is housed in the base. The lamp, being made from metal, is initially insulated from conducting electricity by having a Lexan base for the circuit where it can attach. Next, there is ample space above the circuit, where the top of the base is. Lastly, the circuit is also grounded through a screw on one side of the base. A microchip is used to produce a pulse width modulation (PWM) signal. Pulse width modulation is a more optimal way to cause the light to dim opposed to the typical method with causes LEDs to flicker. The PWM is a square wave of a fixed voltage but with a variable duty cycle. The dimmer switch is actually a variable resistance, which is used to control the duty cycle.

The overall cost of parts and materials for this device is approximately $350.

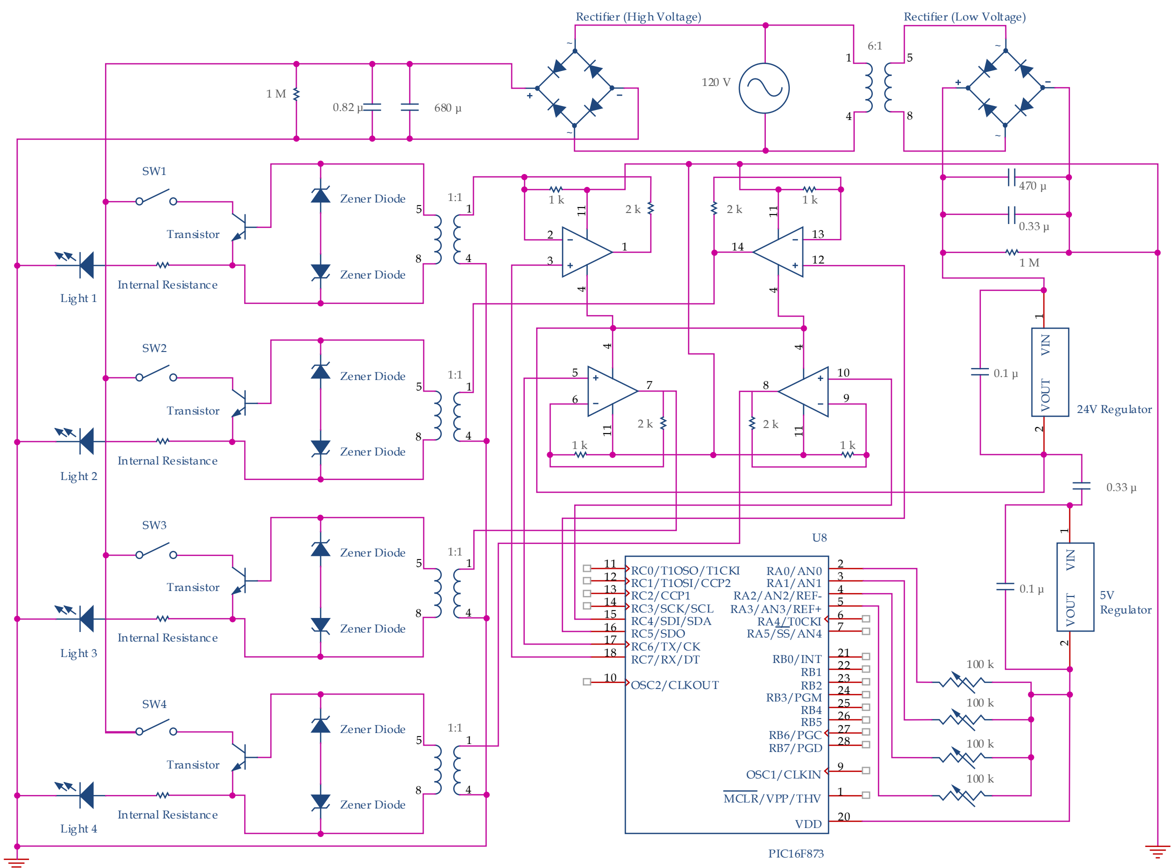

Fig. 10.4. Circuit diagram for the Octopus.

THE GRAVITY ROLLER: A FEEDING DEVICE FOR INFANTS WITH CLEFT PALATE AND/OR CLEFT LIP

Designers: Annie Bullock, Emily Dentler, Bryan Poulsen and Erinn Sheridan
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INTRODUCTION

The Gravity Roller (GR) is designed for infants with cleft palate and/or cleft lip who are unable to create a seal around a nipple while feeding. The GR provides a simple, safe, and cost effective solution to the problems with the current technology on the market. The GR attaches to a regular baby bottle and provides fluid control to both the caregiver and the infant. The regulation valve at the top allows the caregiver to control the rate of fluid flow through high, medium, low, and off settings and the ball valve allows the infant to have off/on control. Infants have natural tongue "flicking" and pressing motion when feeding. This design takes advantage of these instincts, so that when the ball in the ball valve is depressed, formula will flow down the tongue without requiring a seal around a nipple. A proof-of-concept prototype was developed, but is not currently available for use by an infant due to the utilization of materials that are not food-safe.

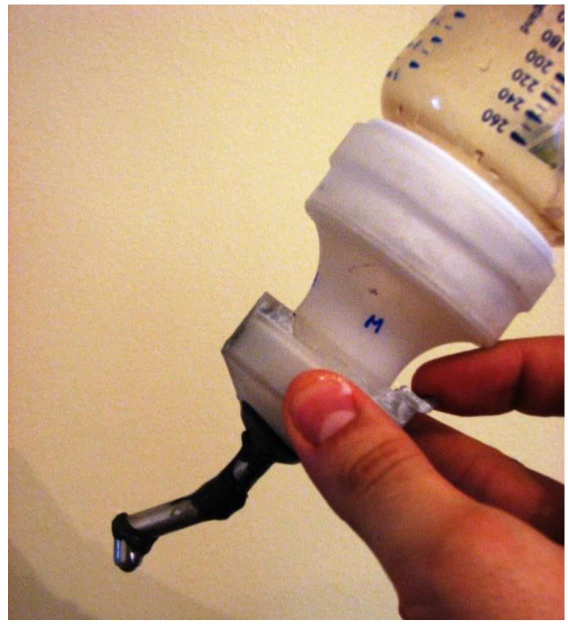

Fig. 10.5. The Gravity Roller

SUMMARY OF IMPACT

The design criteria for the Gravity Roller are defined by the needs and physical constraints of the caregiver and infant. Current devices on the market are either adapted from existing devices for other problems or they are cheap and ineffective. The bottle the client was given to use was simply a thin walled squeeze bottle with a long tube on the end. The tube was inserted into the baby's mouth and formula was squeezed down their throat. This required a lot of practice as the caregiver must know exactly how much to squeeze to allow feeding while also preventing choking of the infant. Also, the thin walls result in rapid temperature loss and the 3oz bottle was inconvenient because it would have to be refilled during a single feeding session.

The client desires a cheap device that would provide a better way to feed her child by giving both the child and the parent control of the formula flow while also retaining heat longer and holding more than 3oz of fluid. It is also desired for the design to have a low learning curve for the caregiver, so if necessary, people other than the primary caregiver may feed the infant.

TECHNICAL DESCRIPTION

The GR is developed as a proof-of-concept prototype and is not food safe. It consists of four subsystems: a standard off-the-shelf bottle, the Regulation Valve (1), the Ball Valve (2), and the Delivery Tube (3). This device is developed to be used with the Avent series of bottles, a popular brand in the United States. The design may also be adapted for use with other bottle brands. Before starting, the formula is prepared as desired by the caregiver. Once the prepared formula is in the bottle, the GR is screwed on. When it is time to feed the infant, the device is inverted and the regulation valve is unlocked and turned to the desired flow setting: Off, Low, Medium, or High. Formula flows from the bottle through the delivery tube and the infant can then roll or push his or her tongue against the ball valve to release formula. The entire GR (without the bottle) is approximately five inches long from the bottle connection to the tip of the ball valve and two and a half inches in diameter at its widest point. The regulation valve is made of rapid-prototyped ABS plastic with the exception of the lock and spring which are machined from stainless steel and aluminum, respectively. The regulation valve consists of interlocking plates that allow for rotation relative to each other but do not allow for the passage of formula (or other liquid) between the inter-locking grooves. A series of progressively larger overlapping holes can be selectively uncovered by releasing the spring-loaded lock from a groove and turning the regulation valve to the desired flow setting.

The regulation valve is connected to the Avent bottles via the Avent lid. The nipple is removed from the commercial product and the lid is cemented to the inside cylindrical surface of the top of the GR, thus providing a threaded, leak-proof interface between the GR and the bottle. The delivery tube and infant controlled ball valve are made of type 304 stainless steel (5/16 inch outer diameter) and are connected together and to the rest of the GR using JB Weld epoxy. The ball valve contains a solid stainless steel ball slightly larger than the opening in the valve (similar to a hamster bottle). The delivery tube contains a 135° angle so that when the bottle is held at 45° (as is normal during infant feeding), the ball valve can be presented parallel to the infant's tongue.

The total cost of the project is approximately $125.00 for materials and supplies.

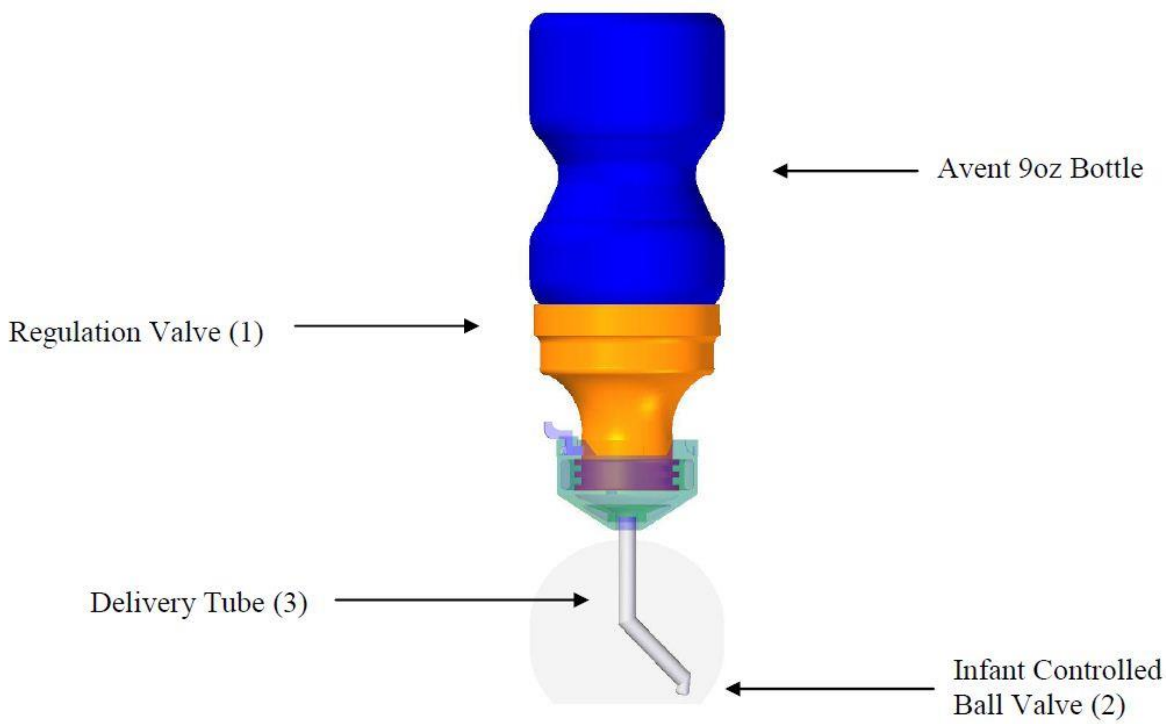

Fig. 10.6. Detailed CAD Drawing of the Gravity Roller.

THE SWIVEL PLOW: A PORTABLE SWEEPING DEVICE

Designers: Lauren N. Griggs, Erin B. Johnson, and Didem Tunc
Client Coordinator: Ruth Tobias, Covered Bridge, Terre Haute, Indiana
Supervising Professors: Dr. Kay C Dee, Dr. Renee Rogge and Dr. Glen Livesay
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INTRODUCTION

The Swivel Plow is an assistive device that allows a wheelchair user to sweep floors without an assistant holding and guiding the broom. The client was diagnosed with Hemimegalencephaly, which is a condition where one side of the brain has a dysplastic malformation. This often leads to severe seizures, and after the client experienced several severe seizures, he underwent a hemispherectomy to remove the right side of his brain. This left a limited range of motor skills in the left half of his body. He has difficulty walking and therefore uses a wheelchair. The client currently holds two jobs: sweeping the hallways at a local school and sweeping the floors at a local business. The client requires a device that can be used with only one hand and offers him a support system other than his assistant. The Swivel Plow attaches to the crossbars of a wheelchair and is currently in use by the client at both of his jobs.

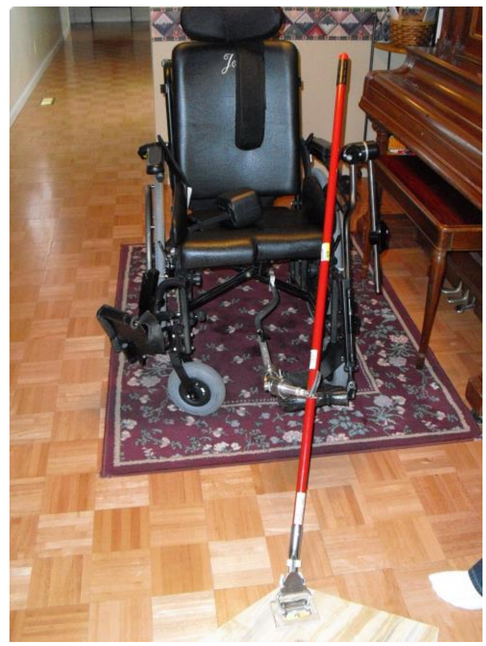

Fig. 10.7. The Swivel Plow.

SUMMARY OF IMPACT

The design criteria for the Swivel Plow are defined by the capabilities and needs of the user. As a result of the HME, the user needs a safe and durable device that is easy to use. The job assistant and parents require a device that is easy to clean and attach, since the user works at two job sites and needs to transport the device between these locations. This device allows for the user to perform his job without the assistant holding the broom.

TECHNICAL DESCRIPTION

The swivel plow has a V-shaped broom to assist the client in sweeping a larger surface area and allows the dirt and debris to be collected at the center. The broom head connects to the broom shaft by a clip that allows the broom to adjust by rotating the clip. The broom has a quick release clamp attached to the shaft. This quick release clamp allows the broom to be connected to a u-joint. This joint provides movement either vertically or horizontally so the user still has control of the broom. However, if the user accidently releases the broom, the broom does not fall to the floor. On the other side of the u-joint is a hollow aluminum rod with through holes drilled into it. A solid aluminum rod is inserted into the hollow rod to create length adjustability on the device by utilizing a drop pin. If the user needs the device to extend further past his feet, his assistant can lengthen the device by removing the drop pin and adjusting the rods to the proper length. The aluminum rod that inserts into the hollow rod connects via a custom made quick install clamp to the wheelchair. This attachment stabilizes the broom, while still allowing the user to maintain control of the broom.

The Swivel Plow is safe for both the client and the people around him. The broom shaft is cushioned with neoprene so the client cannot hurt himself if he accidently hits a part of his body with the device. The clamp that attaches the broom to the u-joint eliminates the risk of the user throwing the broom shaft and hitting someone else nearby. The device is also durable due to the aluminum and steel that comprise the subsystems which will withstand the forces applied by the user. The client was able to control the broom during testing and was able to complete his job tasks without requiring an assistant to control the broom.

The cost of parts and material of this design is approximately $400.

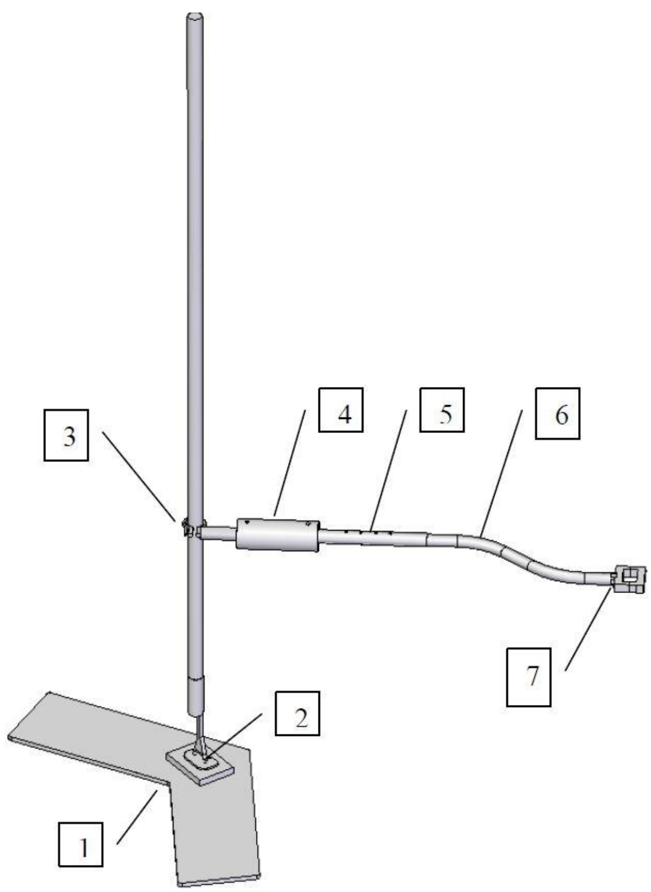

Fig. 10.8. Detailed CAD drawing of the Swivel Plow illustrating the key features.

NICU ACCESS DOOR: A DEVICE DESIGNED TO INCREASE SECURITY AND SANITATION

Designers: Sara Hong, Dan Sullivan, and Darcie Thomas
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INTRODUCTION

The access point to a local Neonatal Intensive Care Unit (NICU) is currently inconvenient for both nurses and parents wishing to visit their child. As it is, the door may be opened by anyone from the inside and there are no strict security measures in place to prevent entry of unauthorized persons. In order for someone to gain access to the NICU, they must wash their hands, then use their freshly cleaned hands to knock on the unsanitary door until a nurse or another parent inside the NICU comes to the door and opens it from the inside. A better design for the NICU access point which addresses each of these critical design flaws of the current system is created in this design. In this new design, visiting parents arrive at the NICU door and step on a foot pedal which activates a notification light inside the room at the nurse's station instead of knocking on the door to gain nurses' attention. Once a nurse inside the NICU sees the flashing blue light located at the central nurse's station and is notified of the presence of a visitor outside the door, the nurse then swipes the barcode on an identification badge and the door automatically opens, waits for a couple seconds, and closes again on its own. This design solves the security issue of the current system because it must be an authorized NICU nurse who activates the door to open for a visitor. Nurses inside the NICU are able to look out through the door's window and make sure it is a visitor they recognize before activating the door to open. This part of the design also makes it quicker and easier for the nurses to identify a visitor and grant them access because the barcode scanner is located at the nurse's station and takes only a second to activate. A prototype of the access system was developed to demonstrate to hospital administrators prior to incorporation of a new security system.

Fig. 10.9. NICU access door.

SUMMARY OF IMPACT

There are two criteria which are required for the design to meet the needs of the client. These criteria are security and sanitation. Without either of these considerations, the final design does not solve the initial problem. The remaining criteria are created based on nurse and parent feedback. These criteria include the amount of time it takes to operate the system, cost, the amount of construction required to install, and the overall sound level of the system.

TECHNICAL DESCRIPTION:

The final prototype is divided into five different subsystems including the opening subsystem, barcode and database subsystem, mounting and power supply subsystem, stability subsystem, and the visitor notification subsystem. The opening subsystem is comprised of a residential automatic door opener and electromagnetic lock system. This eliminates the need for the nurses to physically touch the door handle to open it. The barcode and database subsystem is created by purchasing a barcode swipe card reader. This allows for only the nurses to open the door with their authorized ID badge. The mounting and power supply system is created to ensure the appropriate amount of power is sent to each electrical component and to ensure each element of the final design solution is securely installed onto the prototype. The physical connections are achieved through Velcro and a staple gun. The stability subsystem is created out of plywood board and wood supports. The stability platform supports the entire weight of the system and has wheels which allow for transportation of the prototype during construction. The final subsystem, the visitor notification subsystem, is created through using a blue light and foot pedal which are mounted on top of the door frame and on the stability platform respectively. These components allow for the visitor to catch the attention of the busy nurses working inside of the NICU.

The final cost of the prototype, including a representative door, is approximately $500.

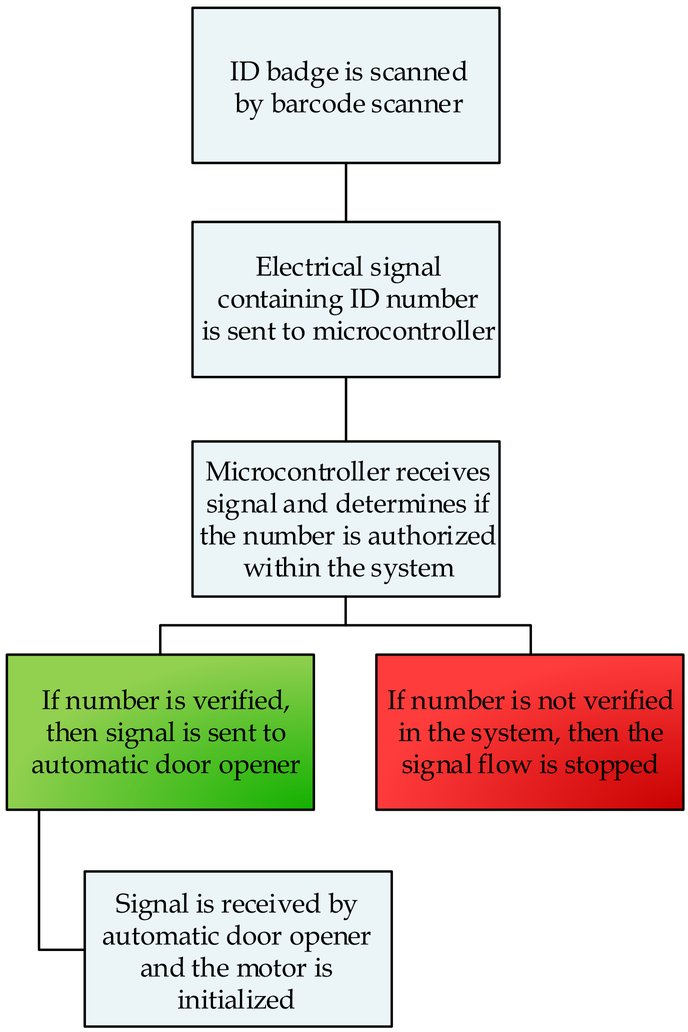

Fig. 10.10. Signal flow for the NICU access door.

GALILEO: A DEVICE TO INCORPORATE A LAPTOP ONTO A WHEELCHAIR

Designers: Cody Austin, Elaine Houston, Leah Howard, Haocheng (James) Zhou
Client Coordinator: Josie Newport, Terre Haute South High School, Terre Haute, IN
Supervising Professors: Dr. Kay C Dee, Dr. Renee Rogge and Dr. Glen Livesay
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INTRODUCTION

The Galileo is a device that aids wheelchair users in independently accessing and storing laptops. The current design completely automates the process because the client has a very limited range of motion and limited physical strength due to a brittle bone condition. The Galileo attaches to the base of a wheelchair and allows for adjustability in its motions as it is deployed. The main subsystems are the track and cart, telescoping arm, laptop encasement, and the electronics with user interface. Currently there are no existing products on the market which meet the needs of our client.

SUMMARY OF IMPACT

The Galileo will improve the quality of life of the client by increasing her independence. Currently an assistant must get her laptop out and then store it for her every time she needs to use it. This automated device will increase her level of independence. Currently the design is not entirely functional. The electronics are the main control of the system which incorporates all of the safety systems of the Galileo. This device needs further testing before it can be approved. After rigorous trouble-shooting, the Galileo should be ideal for those who have limited range of motion and physical strength to access their laptop on a wheelchair.

TECHNICAL DESCRIPTION

The device is composed of many different materials, many of which are custom machined by the team.

The track and cart subsystem of the Galileo performs the duty of moving the armature along a track to working position, or back to storage position in the protective shield. The system is made from aluminum for its good strength to weight properties. The design incorporates a motor for running the cart along the track, and one for controlling the draw arm in the back shield. There are three support bars that fasten onto the base of the power wheelchair through bolts.

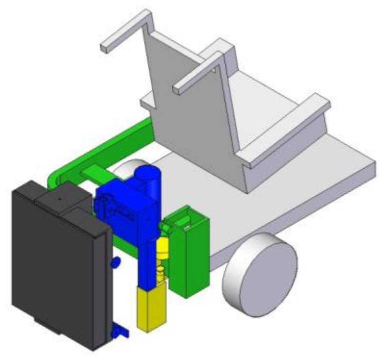

Fig. 10.11. Simplified overview of Galileo attached to a wheelchair in storage position.

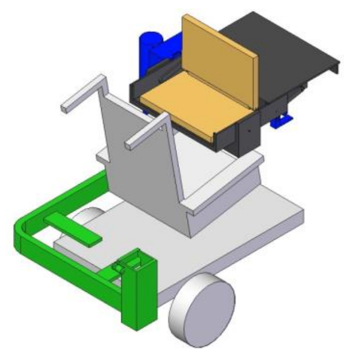

Fig. 10.12. Simplified overview of Galileo attached to a wheelchair in working position.

The laptop is encased in the laptop attachment system by Velcro straps. The laptop attachment system automatically opens and closes the laptop using a tension wire attached to the computer. The automated opening feature allows a user with minimal strength to reach or to open the laptop. The case is made of polypropylene, providing the laptop with a weatherproof and water resistant storage compartment for transportation wherever it is needed without requiring external assistance.

The laptop attachment system connects to the telescoping arm system. The telescoping arm system moves the laptop up and down and through the use of a linear actuator, pulls the laptop horizontal through a pulley system, and rotates the laptop through the use of an internal gear assembly. All these motions are controlled by the user through the user control interface. This system allows for significant variability in the positioning of the laptop relative to the user to enhance ergonomics involved in the usage of the laptop.

All of the above systems are controlled by a user interface that includes momentary rocker switches for controlling all movements and an emergency stop button for safety. The device is powered by a 12V battery for the motors and four AA batteries for the controls. All of the control is mediated by a microcontroller which takes the inputs from the user, the various safety limit switches, IR sensors, and also acts as the motor controller to control the seven DC and stepper motors in this device.

The cost of parts and material for this design is about $3000.

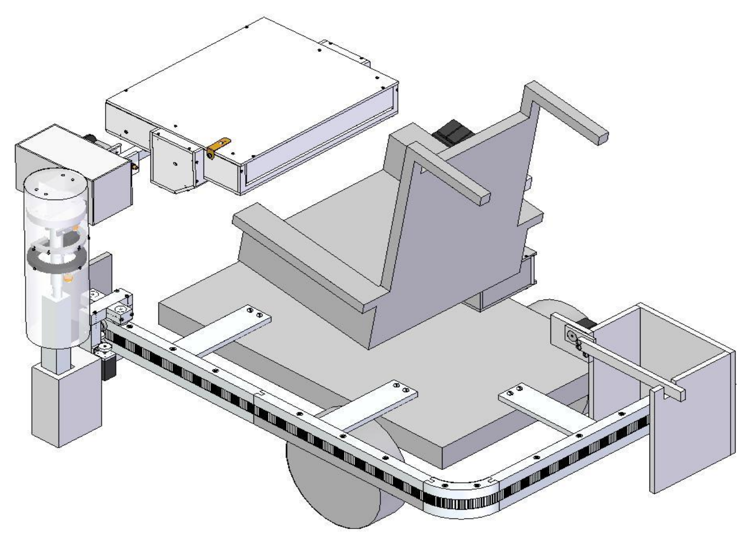

Fig. 10.13. Detailed assembly drawing of Galileo attached to the wheelchair

DYNAMIC TRANSHUMERAL PROSTHESIS: A DEVICE THAT PROVIDES EXTENDED REACH AND GRASP TO A CHILD WITH UNDERDEVELOPED FOREARMS AND HANDS

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Supervising Professors: Dr. Kay C Dee, Dr. Renee Rogge and Dr. Glen Livesay
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INTRODUCTION

The client for which this device is designed has Fryns-Hofkens-Fabry Syndrome. This condition is characterized by congenital underdevelopment of the ulna and radius bones of the forearm. Fryn-Hofkens-Fabry Syndrome is extremely rare and the extent of the symptoms varies from patient to patient. The client has no forearms and has only his middle and index fingers on each hand; therefore, he does not have the ability rotate his hand without moving his shoulder. This condition limits the client's upper extremity functionality because he does not have the ability for much mechanical use of his arms or strength in his fingers. This limits his abilities to perform many everyday activities such as using the restroom, getting dressed, playing, and performing classroom activities. He currently uses a reaching stick to help him with certain tasks, but it is largely ineffective for most activities. Due to the rarity of ulnar and radial hypoplasia, which affects fewer than 200,000 people in the US population, there are currently no devices commercially available to assist individuals with this condition with everyday tasks. However, there are many devices that are designed to help those with similar disabilities. Numerous upper arm prostheses have been designed for amputees and others with congenital conditions. Simple shoulder shrug arm prostheses are among the most common. None of these devices are specifically designed for someone lacking forearms. The goal for this design project is to design, develop, and deliver a device that will promote independence for the client in performing day to day activities.

SUMMARY OF IMPACT

The final prototype device is functional; however, our client's fingers and not yet strong enough to manipulate the elbow joint and completely close the hand. At the completion of the prototype there are

Fig. 10.14. Dynamic Transhumeral Prosthesis.

several recommendations for further investigation and development of the dynamic transhumeral prosthetic. The elbow joint as currently designed and built requires too much force to manipulate its position. It is recommended a different elbow joint be investigated to obtain the necessary force to effectively manipulate the joint to within the range of the client's finger strength. It is further recommended that different foams be researched in order to provide the client with the most comfortable fit possible. The current prototype uses polyurethane foam on the inside of the socket that may be replaced with softer memory foam. It is also recommended that expert sources are contacted for their advice on developing the most effective socket for the client.

Although the prototype device is not currently in use by the client, it would be a viable solution if increased finger strength is gained.

TECHNICAL DESCRIPTION

The transhumeral prosthesis that is designed to establish lower arm utility for the client is comprised of three subsystem including the hand, user input, and socket. The hand subsystem is designed around the concept of a linked-lever mechanical system that preserves adaptive adjustment as the fingers are flexed around an object. Therefore, the hand would passively adjust to objects being grasped by the client. The hand subsystem may also provide mechanical advantage through a system of cable and pulleys, and allows the client to grasp and hold objects using the strength of only one finger. The hand subsystem connects directly to the forearm of the prosthesis, which is designed under the user input subsystem. The user input subsystem provides a means for the client to manipulate the prosthesis in order to better interact with his environment. The subsystem is comprised of a Polyvinyl Chloride (PVC) pipe, cables, and a network of pulleys and springs that give greater mechanical advantages in both strength and functional range. One finger allows the client to control the hand and the other to bend the elbow. The user input subsystem is securely connected to the two ABS plastic braces at the end of the socket subsystem. The plastic braces are then attached to the ABS plastic sleeve via numerous ratcheting snaps that firmly attach the device to the client's arm. It incorporates two different designs in order to provide the client with the most security and stability when interacting with his environment. Velcro® straps and a back strap securely attach the ABS plastic sleeve to the arm and allow the prosthesis to withstand typical and falling forces it may be exposed to in all three dimensions.

The cost of parts and materials for the project is about $350.

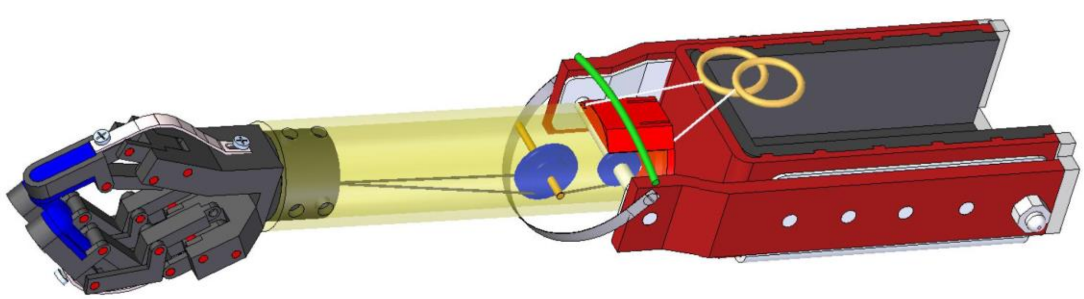

Fig. 10.15. Detailed assembly diagram of the final transhumeral device.