CHAPTER 8
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LOW-COST ARTIFICIAL HAND

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Client Coordinator: Mike Shipp, Center for Rehabilitation Engineering, Science & Technology
Supervising Professor: Dr. Alan Chiu, Dr. Patrick O'Neal,
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INTRODUCTION

This project addresses the problem of limb absence. The absence of a hand is a major obstacle that has to be overcome in order for people to easily accomplish activities for daily living (ADLs). Sometimes in the past, hooks and cable system prostheses have acted as substitutes for the hand. These devices are poor substitutes for the human hand because the hand is incredibly complex, with 21 degrees of freedom, and has the ability to manipulate delicate items and lift heavy objects. There are current solutions to the problem of limb absence, but many commercially available prosthetic hands are expensive or utilize cable systems that lack automated points of motion. This is not the first attempt at this type of prosthetic; this project improves upon a previous generation from a senior design last year. Using this knowledge, we have worked to design an artificial hand which utilizes: 1) smaller, stronger motors to increase the gripping strength, 2) stronger structural materials to increase the durability, 3) a new cover design to reduce the slippage of objects during usage, and 4) a lower cost. The final product, beyond the scope of our mechanical prototype, will be an inexpensive myoelectric artificial hand capable of completing ADLs.

Fig. 8.1. The Aluminum Chassis Palm.

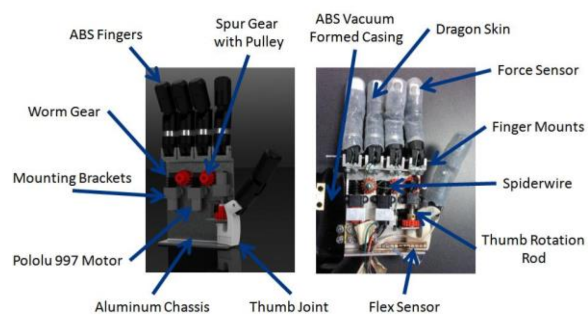

Fig. 8.2. Artificial Hand Components.

SUMMARY OF IMPACT

Target consumers are persons who have amputations of the hand. The main problem that these clients face is that they are restricted or limited to almost no hand functionality. The whole goal of this project is to give our clients more independence in their lives. This device creates less frustration for a potential customer who wants to simply lead a normal life. Once the device is on the market, we believe it has the potential to be the new type of hand used by amputees.

TECHNICAL DESCRIPTION

The primary goal stated the desire to create a prosthetic hand that is better in all mechanical areas than the previous generation. Our design increased the curling force, decreased the closing time, decreased the weight, decreased the volume, decreased the cost, decreased the slippage, increased the structural strength, maintained the current gripping patterns, and was easier to repair than the previous generation. Along with these criteria a prosthetic hand should be easy to clean, difficult to unintentionally open, and have a maximum gripping force that resembles a human hand.

The first major modification implemented was the addition of the aluminum chassis in the palm, in order to use it as a mount for all components. The chassis is easier to manufacture, and constructed more quickly than a palm constructed using a rapid prototyping printer.

An aluminum chassis also provided more rigidity at a smaller volume and lower weight. The thumb joint was modified from a SolidWorks file provided by the creators of the previous generation. It is the only remaining piece of rapid prototyped ABS plastic. To protect the interior components, we created an outer shell also made of ABS plastic. This was done using the vacuum forming technique. Creating a single mold for each half of the shell resulted in a 30 minute production time for new coverings. This was much faster compared to the hours it would take to 3D print something similar in size. Vacuum formed pieces were also much more resistant to impact damage, withstanding even the force from repeated hits with a claw hammer. The outer shell pieces were hinged to the aluminum chassis to allow for easy access to internal components. The fingers were also attached directly to the chassis, using aluminum u-brackets.

The basic design of our drive system did not change; we still used a pulley system in the same fashion seen in the previous generation. However, we were able to improve upon the system by using smaller, more powerful motors. We also changed to a smaller gear with a larger radius pulley to increase the closing speed from the previous generation. There were no changes to the type of wire used in the drive system. The wire was attached to the fingertip in the same manner as the previous generation.

The four fingers had the same number of joints as the previous generation. The thumb, however, was given an extra joint to increase dexterity. This slowed the closing speed of the thumb, but allowed it to form more complex gripping positions. The manufacturing and material components of the fingers are completely new in our design. We routed a solid block of acrylonitrile butadiene styrene (ABS) plastic, in comparison to rapid prototyping in which the ABS is layered. This greatly increased the breaking point of the fingers. By routing the ABS, we attempted to replicate the results of injection molding, but at a price that was in our budget. Each piece of routed plastic is connected by an aluminum tube to create the full finger. Routing a solid block of ABS also reduces the cost of manufacture.

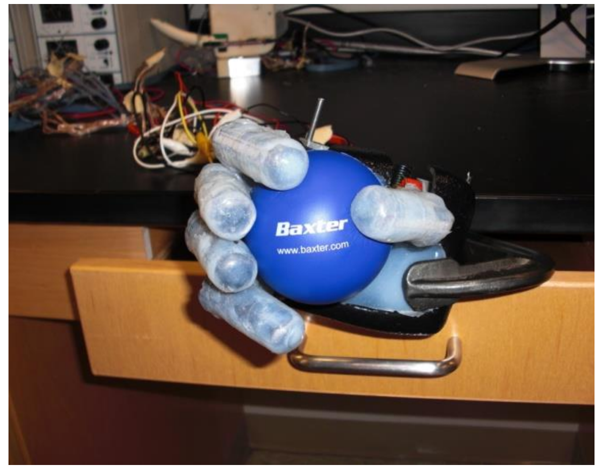

Fig. 8.3. The Vacuum Molded Fingers.

The glove design was implemented using Dragon SkinTM, a form of silicon rubber. However, instead of creating a complete glove, we coated only specific areas of the palm covering and the fingers. This allowed much easier access to the interior components than the glove used in the previous generation, while maintaining the friction necessary for gripping.

Testing was segmented in several processes to determine the performance of the new hand. As expected, the design proved to be better than the previous design in multiple areas. The tests that were completed by the hand are as follows: finger strength, closing time, curl force, maximum grip force, slippage, weight, volume, cost, and grip position. Improvements in performance relative to the previous generation of hand in were not observed in the maximum grip force test and the volume test. The overall cost of the parts for this project was approximately $195, which was $70 dollars cheaper than the previous generation.

AT DEER STAND

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Client Coordinator: Mike Shipp, Center for Rehabilitation Engineering, Science & Technology
Supervising Professor: Dr. Mel Corley
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INTRODUCTION

The AT (assistive technology) deer stand was developed to help enable a deer hunter without leg mobility to more fully enjoy the outdoors. This stand is fully capable of being used by any hunter that uses a wheelchair for mobility. Existing stands for these hunters are either too expensive or not mobile enough to meet the needs of clients. This stand is a box stand that is mounted onto a general flatbed trailer. It lays flat on the trailer until it is hoisted into the operational position. The deer stand is operated by a manual winch, which is used to hoist the stand into the upright position. A custom safety harness system was also designed to hold a person in a wheelchair safely in the deer stand. Also, custom stops were implemented as a way of transporting the hunter's firearm in a quiet and safe manner.

SUMMARY OF IMPACT

The overall goal of this project was to produce a deer stand capable of being an independently operated device for someone who uses a wheelchair. This deer stand could be put on the market fairly quickly and be somewhat competitive in the outdoor industry. It gives mobility and independence to a deer hunter who uses a wheelchair. This deer stand also causes no negative environmental impact from operation as well, which may be a problem with some current solutions.

TECHNICAL DESCRIPTION

The deer stand we designed had several specifications that we inferred from conversations with the client.

These specifications required that the stand had to be big and strong enough to hold someone in a wheelchair, the stand had to have a safety harness system, it had to have a way to safely transport a firearm, and it had to be independently operational. The safety of the consumer was stated to be the first priority of the team when we were designing this

Fig. 8.4. Safety Harness System.

deer stand. This can easily be seen by the custom safety harness system that they incorporated into the design, which is shown in Figure 8.4. The safety harness is simply made of towing straps that are mounted to the walls of the deer stand by eye bolts. They also included a system to securely and safely transport the hunter's firearm while the deer stand is being hoisted into the hunting position. This design consisted of two pieces of wood using a simple hook and eye type lock to fully secure the firearm. The final design the team decided upon was a box stand that worked on a standard manual winch system which would be mounted onto a stand and then mounted to the base of a trailer (not included). The box stand was a standard 5′x 5′ x 5′. A shooters window with a height of 12″ is incorporated into the design of this deer stand.

The operational procedure started by lowering of the trailer ramp and then lowering the deer stand ramp. Once this was complete the hunter placed the firearm between the stops and secured the latch. The hunter then entered the stand and raised the deer stand ramp and put on the safety harness system. Lastly the hunter needed to winch himself into position until the stand is in the upright position. The winching system could be raised and lowered easily while remaining fully seated in the wheelchair.

A 2200 lb. winch was selected by the designers. The winch cable is drawn through a sheave located at the bottom center of the stand where it is then routed to a lifting lug with a shackle at the vertical support arm. This type of lifting was chosen because it will lift the box stand evenly and easily. The designers decided to use a basic four-bar mechanism which can be mounted to any flatbed trailer. Using a steel frame floor that was welded together was claimed to be the only feasible option. The designers used 2″x 2″x ¼″ square tubing, 1 ½″x1 ½″x3/16″ angle iron, ½″ steel plate, and ½″ flat bar. The system was fastened with ¾″ tractor bolts and secured to the trailer with ½″ bolts. In the fabrication of this deer stand, the group used several different saws, a mig welding machine, a grinder, a power drill and a drill press with standard drill bits. A custom component for this deer stand that was used in the fabrication process is a simple bracket made out of a ½″ steel plate. These brackets were used to mount the sheave to the frame of the stand and also to connect the frame of the stand to the base of the trailer via the arms and pins of the trailer.

The group was able to safely raise the deer stand with the winch in an average time of 134.7 seconds to get it in an upright position with this design. Once the deer stand was erect it stood approximately 9.6ft from the hunter's sightline to the ground. This height of the deer stand should present no problems in the field as far as sight capabilities are concerned. However, if the customer would like a shorter or taller deer stand, a trailer compensating such height should be provided.

The total cost to build this deer stand was $1,154.96 which included the labor of the welder that the team hired.

Fig. 8.5 Deer Stand halfway up.

THE ELECTRIC SLIDE

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Client Coordinator: Mike Shipp
Supervising Professor: Dr. Patrick O'Neal
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INTRODUCTION

The independent use of electrical outlet connections is a problem for people with Multiple Sclerosis, Osteoarthritis /Arthritis and Parkinson's disease. The Electric Slide is designed to help ease the use of electrical outlets for these types of clients. Some devices that are currently available for this problem are known as Electronic Aids to Daily Living (EADL). However, EADLs have a significant disadvantage in that they must remain connected into a wall outlet at all times. This suggests an inherent lack of independence for the client. Every time that an electrical device needs to be moved, the client must have someone else remove the electrical cord from the outlet and then reinstall it. The Electric Slide addresses this issue with its magnetic outlet design. The Electric Slide gives anyone the ability to remove and reinstall an electrical appliance anywhere in their home.

SUMMARY OF IMPACT

The target consumer is any individual with Multiple Sclerosis, Osteoarthritis/Arthritis and Parkinson's disease. One main problem that these clients face in common is that they have limited upper-body mobility. The whole goal of this project is to give our clients more independence in their lives. This device creates less frustration for a potential customer who wants to simply lead a normal life. Once the device is on the market, we believe it has the potential to be the new type of electrical outlet used in households everywhere.

TECHNICAL DESCRIPTION

A magnetic connector system is what we selected for the final design of The Electric Slide. The design of The Electric Slide featured a faceplate for the outlet and an electrical cord attachment which created an easily established magnetic connection. The final design accounted for both the faceplate and cord to have user-installable adapters. The design of these adapters called for both a independent top and bottom half. This design allowed for components such as a male "bridge" and a female "bridge" to be installed in the adapters. This modular design stabilized the inner components and alleviated some issues with US standards and electrical codes by using standardized methods and parts. The two blocks combine to secure all of the electrical components in The Electric Slide. The components inside the wall adapter/faceplate were the male "bridge" (Figure 8.6) and the contacts.

Fig. 8.6. Male Bridge (top) and Female Bridge (bottom)

The contacts were crimped onto the male "bridge". The female "bridge" (Figure 8.6) and the pins were placed inside the device for the cord adapter. As the contacts were crimped into the male "bridge", the pins were also crimped into the female "bridge". Three pins and three contacts are required for this design. This ensured that a grounding component is associated with the standard three-prong American outlet. In summary, the male "bridge" and contacts were placed between the top and bottom halves of the faceplate adapter. The female "bridge" and pins were installed in between the top and bottom halves of the cord adapter. This design of The Electric Slide accounted for several key design specifications of the device such as size, weight, safety, and the force of loading a cord into the adapter all meeting the criteria of the client. Also, real world design specifications, such as the issues of arcing and shock, were accounted for. Arcing and grounding requirements were the main safety concerns with this device. If the pins should somehow not fully connect with the contacts, the electrical current jumps resulting in sparks. The ABS plastic that is used for the faceplate adapter has a high rating for arcing potential, therefore creating a less hazardous situation. This means that if arcing does occur, it will take several seconds before any electrical current can affect the device. To assess the potential of arcing, a testing strategy was devised by the group which created a loop-through the device. The circuit is only then complete if every pin connection is made.

The testing of this device was done by connecting a 9V battery to the faceplate adapter. A computer was then used to monitor the amount of voltage that was received in the electrical cord. The current that flowed through the device at that time was recorded with a Data Acquisition Device (DAQ) system using the computer program LabView. If a connection was made, the voltage recorder output was equivalent to the original amount of voltage placed in the circuit. We ran the testing process 314 times and a full connection was made on 291 of those times.

This device was tested to find out exactly how much magnetic strength was needed to completely remove the electrical cord from the outlet adapter. This process was completed with a tensile testing machine to determine the exact amount of force required to remove the cord. The device was sheared from top to bottom, bottom to top, left to right, and right to left. After the test was completed, statistics confirmed that the force needed to remove the device was below 20 Newtons.

A $500 dollar budget was given for this group to complete the project. The group produced the prototype within this constraint, and since most of the parts could be bought in bulk, the device would be relatively cheap to manufacture.

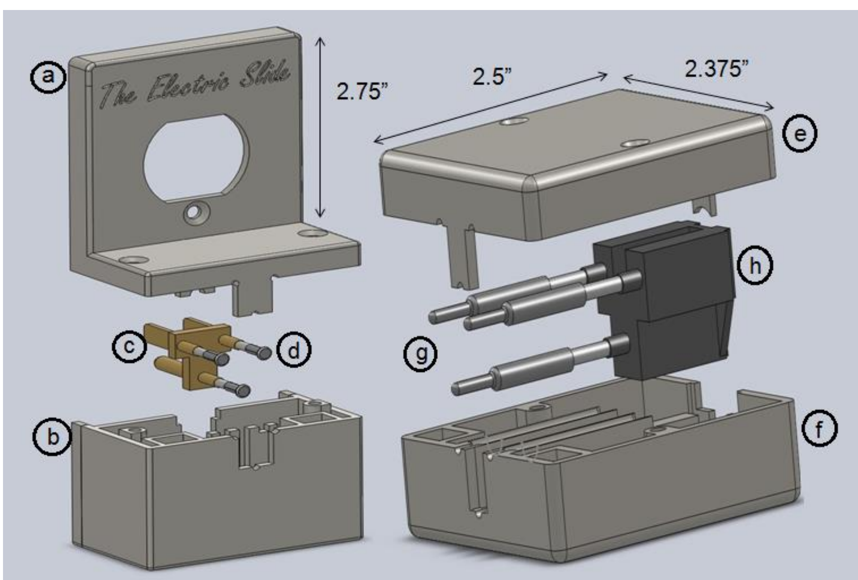

Fig. 8.7. Prototype overview. (a) Top half of faceplate adapter. (b) Bottom half of faceplate adapter. (c) Male Bridge Heyco component. (d) Contacts Etco component. (e) Top half of cord adapter. (f) Bottom half of cord adapter. (g) Contact pins Etco component. (h) Female Bridge Heyco component.

MOBILE INDEPENDENCE AUTOMATION

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Supervising Professor: Dr. Melvin Corley
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INTRODUCTION

Scoota-Trailer Mobility Products makes a trailer to load and transport scooters and power wheelchairs designed for individuals with limited mobility. The commercially available Scoota-Trailer can be hitched to the back of a vehicle and towed around with minimal effort. Such designs accommodate individuals who feel discomfort when walking more than short distances and allow individuals with limited upper body mobility to operate a vehicle. However, this product requires some strength to load and unload scooters and power-chairs. We postulated and prototyped an adaptive design to automate the loading and unloading of scooters and power chairs onto a standard Scoota-Trailer frame. The adaptation uses a system of linear actuators which reduce the effort required to load a wheelchair to the turn of a key. In addition, this adaptive design is cost effective and will cause a relatively small increase in current market prices for the standard Scoota-Trailer.

SUMMARY OF IMPACT

This modification of a standard Scoota-Trailer makes the loading, unloading and transportation of a powered wheelchair more convenient with less discomfort for individuals who find it difficult to walk for any more than short periods and have limited upper limb mobility. This design is intended to be an affordable, add-on package that can be marketed alongside the Scoota-Trailer for customers who feel that an automated system will be beneficial. The implementation of an automated process of opening the trailer compartment and loading/unloading a scooter or chair allows clients to enjoy a greater sense of independence and convenience without unnecessary discomfort.

TECHNICAL DESCRIPTION

The design is constrained by a combination of the Scoota-Trailer's inside dimensions (66 inches x 37.5 inches) in the opened and closed state as well as the

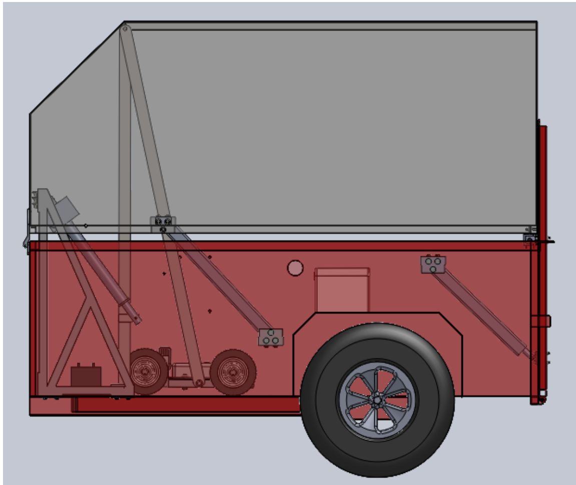

Fig. 8.8. Scooter-trailer adaptive design (transparent view of the driver side).

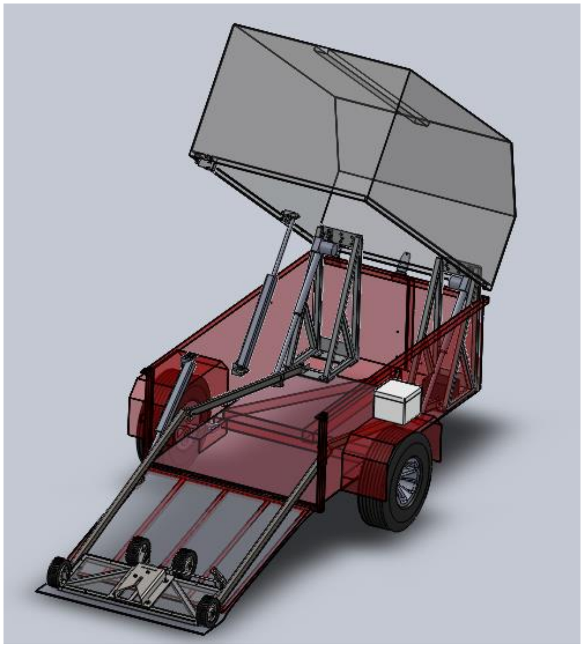

Fig. 8.9. Scooter-trailer adaptive design (Open rear aerial view)

dimensions of the power wheelchair or scooter that will be housed inside. The power wheelchair/scooter dimensions include height, width, length, and a maximum weight of 350 lb. Also, the maximum trailer weight is limited to 2000 lb and the tongue weight is limited to 200 lb. As it stands, the standard Scoota-Trailer alone can house scooters up to 37.4 inches wide and 65.8 inches long.

Improvements to the Scoota-trailer consisted of a system for the automated opening of the lid and ramp as well as the automated loading and retrieval of the wheelchair or scooter from a position that is as close to the ground as possible. An added feature is a battery charge system that would support multiple applications per complete charge.

The design implements linear actuators to automate the ramp and lid. For the lid, a 150lbf actuator with a 12 inch stroke and manufactured by Firgelli Automations (FA-05-12-12”) is used. The lid actuator is attached to the left inner wall of the lid 1.29 inches from the bottom surface of the lid and 17.31 inches from the front (driver’s end) wall of the lid. The fixed end of the actuator is fastened to the inner wall of the trailer, 7.45 inches from the trailer floor and 31.30 inches from the front wall. Fully extended, the actuator allows a 42.95° displacement of the Scoota-Trailer lid. The ramp also employs a 150lbf actuator from Firgelli Automations (FA-05-12-9”) but with a 9 inch stroke. The fixed end is attached on the left wall of the trailer 17.30 inches from the floor and 53.33 inches from the front inside wall of the trailer. The ramp opens 104.80° to the ground. In Figures 8.8 and 8.9, the attachments of the linear actuators for the ramp and lid are shown.

This adaptive design prototype uses an A-frame design to carry out the loading and retrieval of the transported power chair or scooter. A pair of 400lbf linear actuators (FA-400-L-12-12”, Firgelli Automations) each with a stroke length of 12 inches is used to drive the A-frame arms constructed from ASTM 500 rectangular tubing which is 1.5”x1”x0.12”. A cart with an integrated EZ-Lock system (used to attach the power chair or scooter) and four wheels are attached to the extending end of the driving arm. The other end of the driving arm is fixed to the actuator mount 10 inches from the front inner wall of the trailer. When fully extended, the driving arm spans 92 inches with the front wheel of the cart 2 inches off of the ramp. Figure 8.9 shows the entire system with the ramp and lid open and the driving arm of the retrieval system fully extended. All of the actuators used require a 12V voltage supply, while the 400lbf actuators require 10 amps each and the 150lbf actuators need 4 amps each.

This modification of the Scoota-trailer implements a control system powered by a 12 volt battery. Mounted within the trailer is a 12 volt trickle charger with an associated 12 volt plug outlet so that the design can be plugged into an AC outlet and charged. The average time required to fully charge the battery is 90 minutes from the 1.5 amp charge of the trickle charger.

The system is engaged by turning the key switch in the control box on top of the right wheel well on the outside of the trailer. This unlocks the trailer and allows the use of a two-position sustaining rocker switch, also located within the control box. The polarity of the rocker switch can be reversed to allow the opening and closing of the ramp and lid. On the inside of the trailer there is a second rocker switch mounted onto a handheld electronic enclosure. The switch controls the extension and retraction of the driving arm and EZ-Lock cart.

The location of this second switch ensures that the driving arm is not powered while the trailer is closed. A tilt switch mounted onto the driving arm breaks the circuit to the lid and ramp actuators disallowing the closing of the lid and ramp while the driving arm is extended. The control box and handheld are in easily accessible locations. The modified design loads in an average of 95 seconds.

The entire cost of the automation modification of the Scoota-Trailer was $2453.65.

ADAPTIVE USB DATA TRANSFER TECHNOLOGY

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Client Coordinator: Mike Shipp, Center for Rehabilitation Engineering, Science & Technology
Supervising Professor: Dr. Patrick O'Neal
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INTRODUCTION

There has been a global standardizing of basic methods in data communication in a time where technological advances are rapid and widespread. One such method, USB data transmission, has become more prevalent as computers and several independent electronic devices are being fitted with USB technology. Consistent with the trends of modern technology, USB communication devices are becoming smaller presenting possible difficulties for individuals with disabilities. Persons with rheumatoid arthritis, for instance, as well as individuals with limited upper limb mobility and fine motor function find it a tedious or even painful to use a small USB memory stick. A device has been conceptualized and prototyped to provide a method of plugging a standard USB flash drive into a USB hub for data transfer. The device requires minimal finger dexterity and upper limb motor function.

SUMMARY OF IMPACT

This adaptive USB data transfer device has a tray to house the USB flash drive and through purely mechanical means allows the insertion of the drive into an onboard USB port for data transfer. As the primary action of plugging the drive requires less than 3lbs of force in a singular horizontal direction, the device reduces the discomfort normally associated with such an action. It provides a convenience as well as a greater sense of independence for individuals with limited upper limb mobility.

TECHNICAL DESCRIPTION

The device is constructed of four main components. The base, female port hub, back plate and cover plate make up the functional components of the USB adaptor displayed in Figure 8.13. The USB memory stick is placed into the tray of the base plate with the male end of the USB plug toward the female port hub. A horizontal force can then be applied to the back plate, compressing the two springs of the base

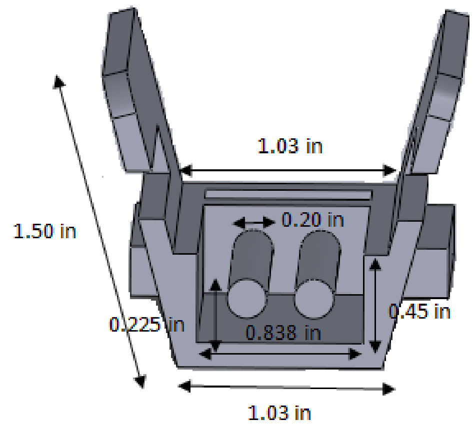

Fig. 8.10. SolidWorks representation of the Base component (without springs loaded).

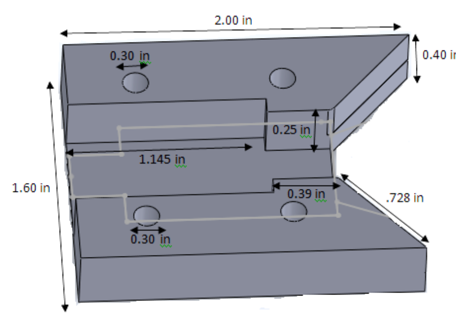

Fig. 8.11. SolidWorks Representation of the Female Port component (without screws and metal plate).

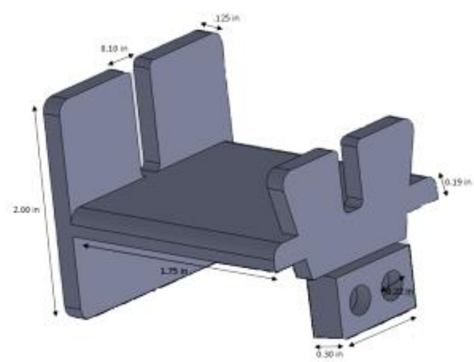

Fig. 8.12. Back plate component of the device.

Fig. 8.13. Complete assembly of adaptive USB device.

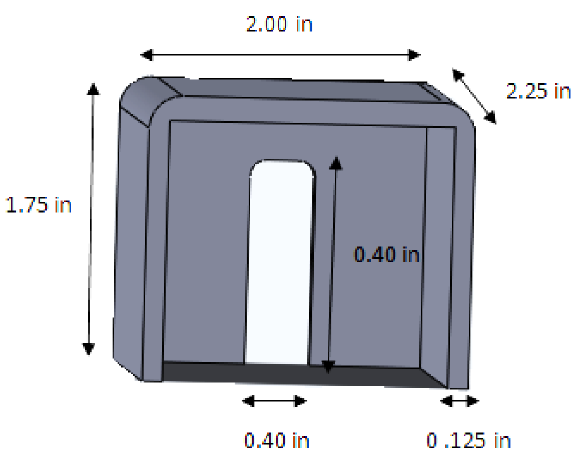

Fig. 8.14. SolidWorks representation of Cover component

component and pushing the USB drive toward the USB port until snugly inserted. The compression springs then retract the back plate for subsequent loading. A lanyard connected to the USB memory stick can be pulled horizontally away from the device to unplug and retrieve the USB memory stick.

The base component, shown in Figure 8.10, contains the tray that supports the USB flash drive and a platform for the female USB port component. Beneath the tray are two horizontal cylinders which suspend the compression springs that support the mechanical retraction of the back plate component. The base is composed entirely of ABS plastic with the exception of the tray which is a sheet of 0.021″ steel.

The female port hub, shown in Figure 8.11, houses the actual USB port of the USB cord which the drive is plugged into. It is constructed with a widened mouth to allow the USB flash drive to be guided into the port. Four screws run through a plate of 0.021″ steel, the ABS plastic molding which houses the USB port and into the base support to keep the structure sturdy. Compression springs placed around each of the four screws connecting each component, allow for the adjusting of the USB port to the dimensions of the USB flash drive being used.

The back plate, shown in Figure 8.12, is a component that fits into grooves carved into the base component, beginning at the ends of the horizontal cylinders and compression springs. It is also constructed entirely of ABS plastic. When a maximum force of 2.31lbf is applied to the back plate it compresses the springs and moves the USB flash drive toward the female port. Magnetic tape serves to attract the drive into the slot (not shown). The horizontal compression springs cause the retraction of the back plate for subsequent loading and trials.

The final component (dimensions shown in Figure 8.14) is the cover plate for the female USB port hub. It is constructed purely of ABS plastic and acts as a water resistant covering for the USB female port.

This USB adaptive device project explores a mechanical solution to the problem of handling small devices. A purely mechanical solution such as this, while reducing the dexterity and strength required to insert a USB drive, may not be adequate in satisfying convenience and comfort for individuals with limited upper limb mobility and finger dexterity.

The total cost to prototype this adaptive USB technology project was $136.88.

VISUAL ALERT SYSTEM

Designers: Zach Crooks, Joel Fitch, Doug Gates and David Holland
Client Coordinator: Christy Garrett, Center for Rehabilitation Engineering, Science & Technology
Supervising Professors: Dr. Paul Hummel, Dr. Davis Harbour,
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INTRODUCTION

The inspiration for this project is a client who owns a business and has a hearing disability.

The client's business has multiple entrances and having a hearing disability makes it difficult to keep track of persons entering and exiting the building. An alert system was designed to make it easier to keep track of the opening and closing of building entrances/exits. It is primarily a visual alert system which implements radio frequency technology to communicate the opening and closing of doors.

SUMMARY OF IMPACT

This radio frequency oriented visual alert system can be used for individuals who work indoors and may have limited hearing. When an entrance to the work building is opened a radio frequency signal is transmitted. The signal is received by a wall mounted display that subsequently indicates which door is ajar. The same transmission is also received by a personal alert system (PAS), worn by the client, that triggers an LED output indicating which door is ajar. The PAS also has a vibrating output to alert the wearer of the opening and closing of secured doors within the building. This visual alert system will improve the awareness of owners and personnel with limited hearing, thereby increasing their sense of security and management.

TECHNICAL DESCRIPTION

The visual alert system designed has three primary components. The first is a door sensor and transmitter that detects an electrical stimulus from the opening and closing of a secured door and transmits the signal using radio frequency technology. The second component is the PAS unit which is a receiver that detects radio frequency signals and alerts the user with a page and with the lighting of the corresponding LED. The third component is another receiver, the Wall – mounted unit, which uses an LED matrix as a visual output to the user(s). The system interface is controlled by Cerebot Nano microcontrollers developed by Digilent, Inc. The Cerebot Nano microcontroller was implemented in this system for three primary reasons; its relatively low cost, its small size, and its power conservation abilities. Each component utilizes one Cerebot Nano microcontroller to operate transmitting and receiving. The Nano runs on a reference voltage of 1.1V and as such, every component is wired to preserve the integrity of the microcontroller. The PmodFR1 from Digilent Inc. is the transceiver used to facilitate wireless radio frequency communication between each component of the visual alert system.

The door sensor system, shown in Figure 8.15, has one input and two outputs. The input is derived from a magnetic reed switch package (also from Digilent Inc.) mounted on the door and door frame to determine whether the door is opened or closed.

When the magnetic switch is open, an electrical signal is sent to the microcontroller as an input. The microcontroller records the state of the switch and outputs data to an onboard bi-indicator status LED. The Cerebot Nano toggles the status of the LED between green and red signal to denote the door closed and door ajar signals respectively. The microcontroller then sends the data to the PmodFR1 which subsequently transmits the signal in the form of a radio frequency signal. In Figure 8.16 the circuit diagram of the door sensor system is displayed.

The personal alert system, shown in Figure 8.17, was designed to alert a mobile user. Since the wall mount would be stationary, an owner whose work demands that he/she moves around the business would require a portable alert system to keep track of traffic through the business. When turned on, the PAS runs a peripheral check to ensure that the LEDs onboard and in-the-door sensors are functioning appropriately. The status of every LED is recorded and saved for later use. If a door is opened, the RF signal received from the door sensor is detected by

Fig. 8.15. Door sensor system showing magnetic switch on door and sensor with RF antenna.

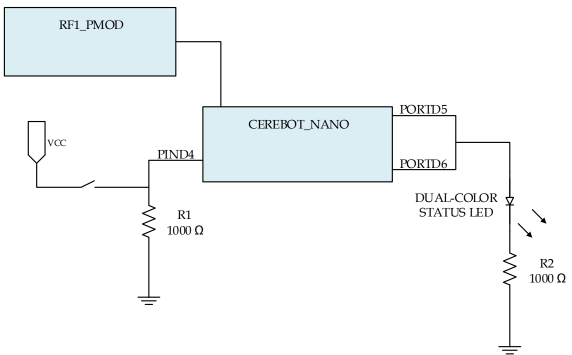

Fig. 8.16. Circuit diagram for door sensor system.

Fig. 8.17. Back – side view of the PAS showing indicator LEDs and battery pack.

the onboard Pmod1 transceiver and processed by the Cerebot Nano microcontroller. The microcontroller differentiates between the three door sensors in the system and enables the corresponding LED to signal an opened door. The microcontroller also activates two onboard vibrating motors to alert the user. In the event of a closed door, the microcontroller checks

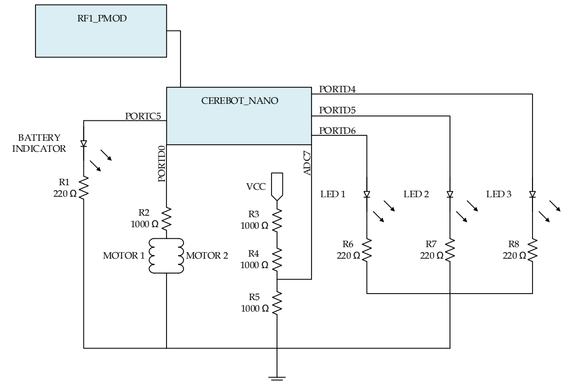

Fig. 8.18. Complete circuit diagram of the PAS Unit.

Fig. 8.19. Wall mounted unit showing LED matrices with corresponding door numbers

whether any other doors are open. If not, the motors are disabled as with the LEDs. The PAS is powered by an attached 3.3V battery pack using two standard AA batteries. An onboard battery power indicator LED turns red when the battery power runs below a voltage that significantly affects the performance of the PAS (about 2V). Figure 8.18 shows the entire wire diagram for the PAS including the component, LED door status circuit and the motor circuit.

The final major component of this visual alert system is the wall mounted display shown in Figure 8.19. This system design is similar to that of the PAS but without motors and LED matrices as the signal outputs for each corresponding door. When powered up the system runs peripheral checks to ensure the integrity of each respective LED matrix. RF signals are received from the onboard PmodFR1 transceiver and the Cerebot Nano microcontroller determines whether a door has been opened or closed.

The signal is then transmitted to the LED matrix for the corresponding door. When a door is opened, the corresponding LED matrix is enabled. There are three 8x8 LED matrices; one for each corresponding door sensor system. A 5V power supply is used to power the wall mounted display. The circuit for the unit, shown in Figure 8.20, uses three 5V relays and transistors to regulate the power going to the LED matrices when an "enable" signal is transmitted from the Cerebot Nano microcontroller.

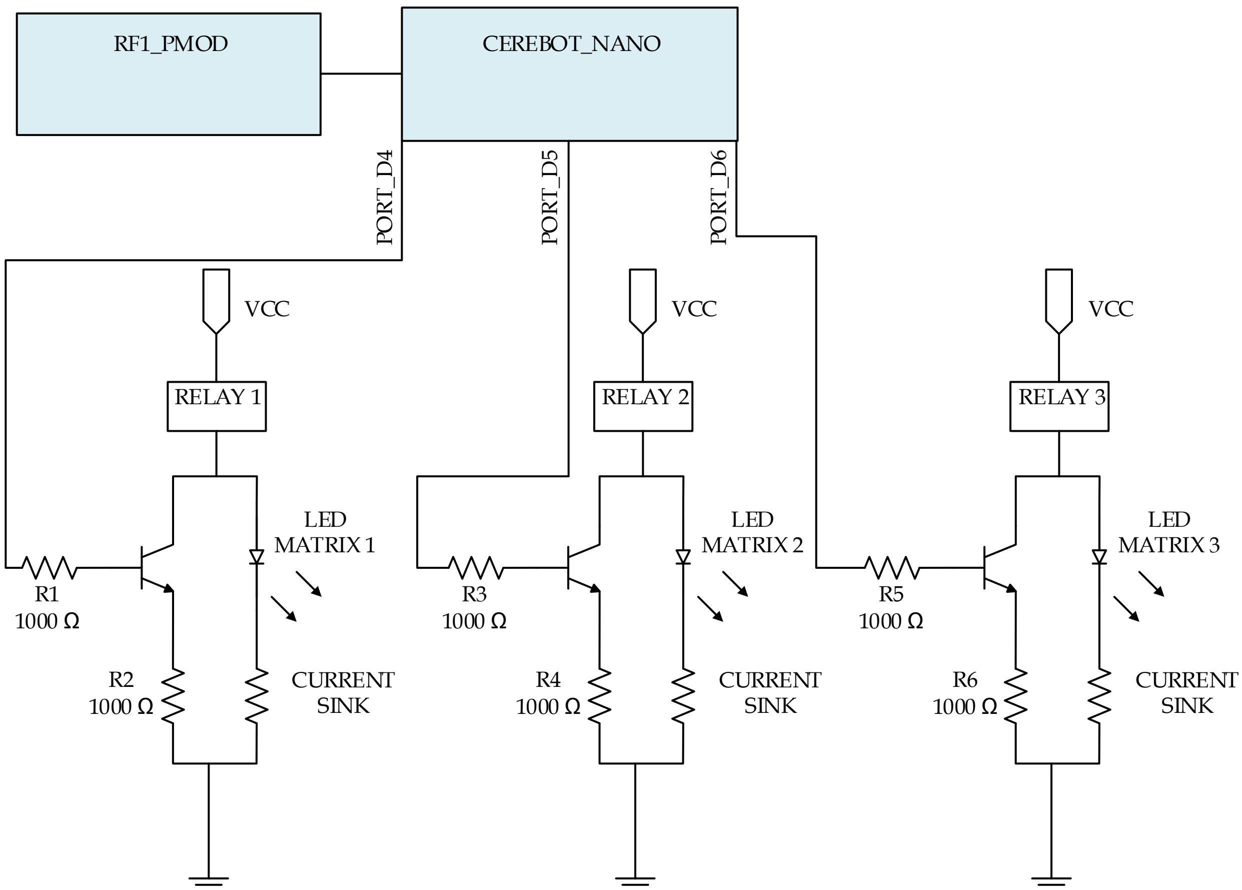

Fig. 8.20. Circuit diagram of complete wall mounted display system.