CHAPTER 16
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SINGLE HAND BRAKING FOR MOUNTAIN BIKES

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INTRODUCTION

Current bicycle brakes are not designed with a one handed rider in mind. The bicycle braking system typically consists of two levers, one attached on each side of the handle bar. The left-hand lever is attached to the front brake by a cable. Similarly, the right hand operates the rear brake.

Considering the needs of a one handed rider, a braking system was designed to allow the rider to use both the brakes independently with one hand (Fig. 16.1 and Fig. 16.2). The CES software was used to select the material and determine the manufacturing process for the brake. This design implements an innovative idea to integrate both the front and rear levers in a single housing, thereby allowing independent actuation of both the brakes with one hand.

SUMMARY OF IMPACT

If a person lacks the use of one arm, to apply brake he or she will either have to choose between the front or rear brake. As in an automobile, the front brake provides the most stopping power. On a bicycle however, the rider can potentially be thrown over the handlebars if too much front brake is used. This is especially true when mountain biking down a steep hill. By using a single hand brake lever that can independently control front and rear brake distribution, the hazards of using a single brake are eliminated.

TECHNICAL DESCRIPTION

In addition to simultaneous brake control, the brake is compatible with current mountain bike components such as shifter pods. The mounting clamp is able to accommodate the standard handlebar diameter. Additionally, the price, performance, and weight are similar to the currently available, mid-range brake levers. The lever is aesthetically appealing, as well as ergonomically correct.

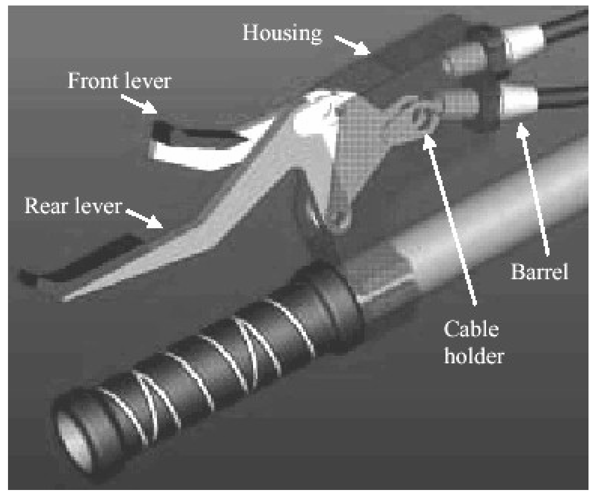

Figure 16.1. Pro-Engineer™ Rendering of Brake Prototype.

When the rear lever is applied, only the rear brake becomes active. When the front lever is applied, both front and rear brakes will be active, and the user can independently control the distribution to each. Typically, a combination of front and rear, or only rear brake application is used, so this design should not restrict the rider in his ability to maximize stopping power. The front lever allows for use of one finger, either the index or middle finger. The rear lever can accommodate one or two fingers, the middle and ring finger or ring finger and the little finger (Fig. 16.3).

The hinge pin serves as a pivot point, allowing the levers to rotate freely. A torsion spring attached to the levers ensures that they will return to the rest positions after being released (Fig. 16.4). To accommodate for varying finger length, reach adjustments are provided for each lever. These allow the rest position to be moved closer or farther away from the handle bar. The brake cables are connected to the levers by means of cable attachments (Fig. 16.5). The barrel adjustment allows the user to individually control the initial brake pad positions by tightening or loosening the brake cable (Fig. 16.6).

The single hand brake lever satisfies all the design requirements including the cost and weight of the component. The material used for the brake is Al 6061-T6. The weight of the prototype was 187 grams as opposed to 190 grams for a pair of standard levers. The production weight of the brake was estimated as 130 g.

Approximate production cost is $6 plus hardware. The prototype cost was $27.

Figure 16.2. Mounted Prototype.

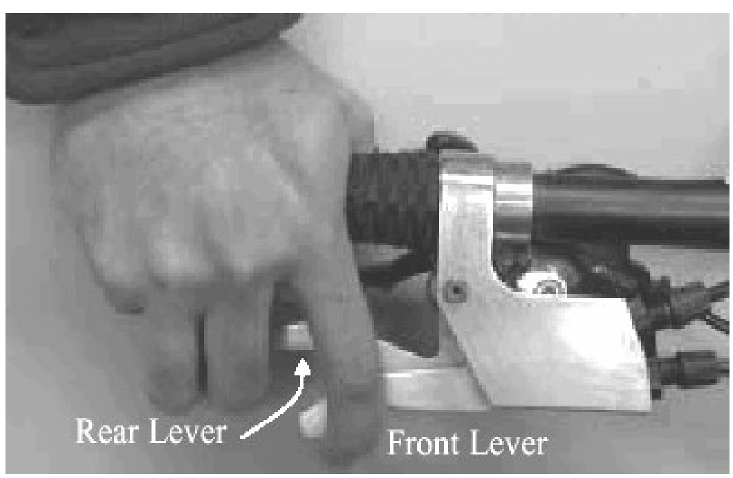

Figure 16.3. Finger Placement.

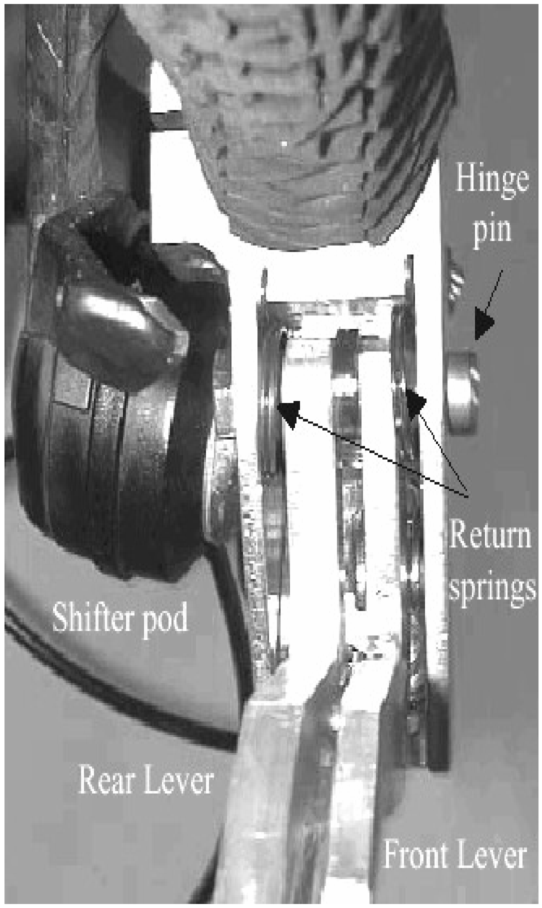

Figure 16.4. Placement of Return Springs.

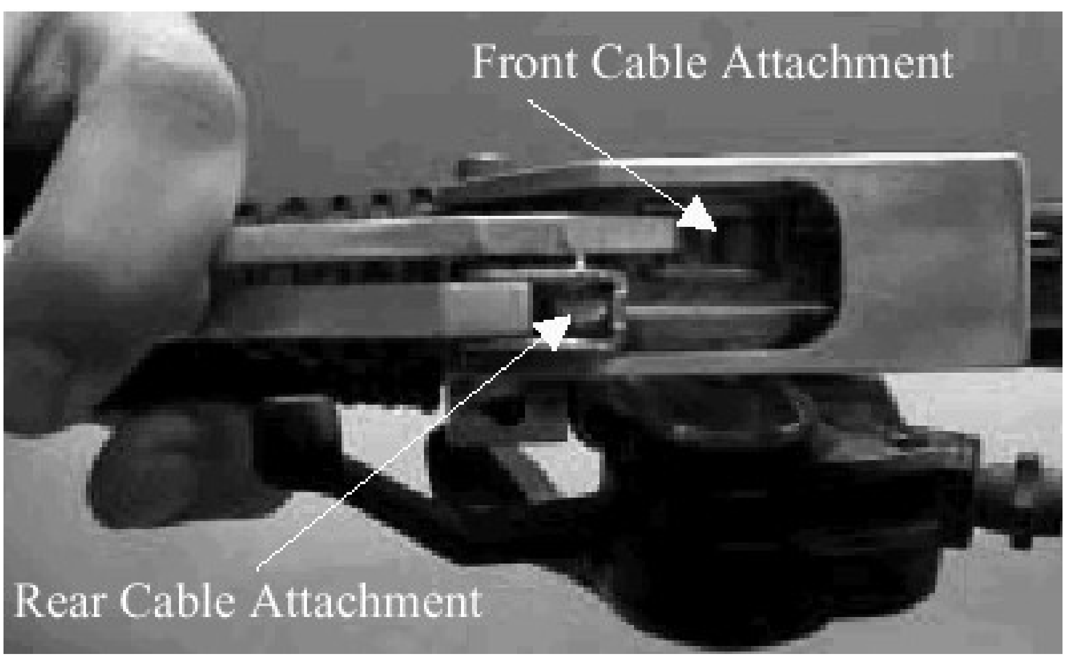

Figure 16.5. Cable Attachments.

Figure 16.6. Barrel and Reach Adjustments.

SIGNAL PROCESSING IN A CANE FOR THE BLIND

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INTRODUCTION

It is estimated that there are over six million blind people in this nation's population, and many more who have severely impaired vision. For people with such disabilities, activities such as walking down the street can be dangerous because of overhanging objects. The ultrasonic cane for the blind helps reduce these hazards.

The goal of this project is to detect overhanging objects that cannot be detected by the traditional long cane (which is tapped against the ground immediately in front of the user). The ultrasonic cane sends out an ultrasonic signal and records the time it takes this signal to deflect off the surroundings and return. This information enables the cane to take a virtual picture of its surroundings. It alerts the user of any target within a range of three meters.

SUMMARY OF IMPACT

A comprehensive survey indicates that there are currently a few "smart" long canes on the market. These canes use everything from lasers to ultrasonic signals to detect objects. However, all of these canes are very expensive and do not "feel" like a traditional long cane. This aspect of the cane is incredibly important to the user, and is a major flaw in the design of these canes. The ultrasonic cane around which this data processing was done, aims to solve these problems and not alienate the clientele that the cane is designed to assist.

TECHNICAL DESCRIPTION

The work presented here includes the analysis of the data collected from the ultrasonic transducers. The data were collected using an experimental setup that consisted of a PC with a National Instruments DAQ card using LabView Software. The signal was sent from one transducer and received by two ultrasonic receivers.

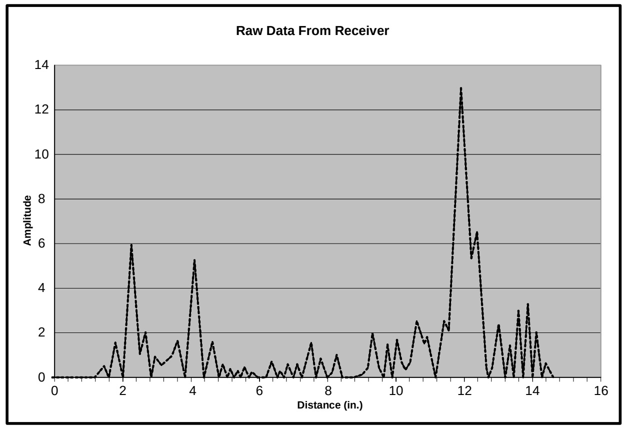

Figure 16.7. Raw Data from Receiver.

The data from both receivers was analyzed in order to discern the peaks from the other noise that is collected during data acquisition (see Fig. 16.7 and Fig. 16.8). These peaks were found through a number of steps used in detection. The first step was finding the local peaks in the data. It was seen from certain "ideal" echoes that there are certain side lobe characteristics that were found empirically and used for final differentiation of the peaks. An example of this data filtering is seen below.

As seen, this data analysis filters out the peaks efficiently. This \ analysis was then carried out using two receivers. This enabled new data processing techniques. There is an acceptable detection range above the cane of one meter. Objects higher than one meter above the transducers are to be rejected because the user will not run into objects that are this tall. In addition, the user tapping his cane on the ground can feel objects one meter in front of the cane. This one by one meter distance in front of the cane sets up a 45° angle at which the closest possible object can be detected as seen in Fig. 16.9.

A relation can be found between the distance to the object and the angle to the transducer plane. As the distance in the X direction is increased, this angle, α, decreases, as is logically deduced. The maximum detection distance of the cane has been determined to be three meters, so it is seen that this acceptable angle (given the one meter height requirement) can be found to be a function of distance, and therefore the sample number. This function is found to be:

$$\theta = \frac{(18.44-45)}{(3-1)} \cdot X = -13.28 \cdot X \text{ in degrees}$$

where, X =(sample #) * (sample rate) * (speed of sound)

Therefore, θ= -(π/180°)*(13.28)*(sample#)*(sample rate)* (speed of sound), in radians

With this knowledge of the acceptable angle, as well as having data from the two transducers, a synthetic aperture could be established. This synthetic aperture limits what the cane sees in the vertical direction based on this θ. The way that this was carried out was through converting this angle to the time difference that it would take an echo to hit the respective transducers. It was found that the time difference between the two transducers would be:

$$\Delta t = \frac{d}{c}\sin\theta$$

where, d is distance between transducers (0.1 m), c is speed of sound in air (343.2m/s), t is the time difference between sensors (sec), and θ is the angle as found above (converted to radians).

This time difference can be converted to number of samples using the sample rate, and this can be used to compare the two transducers' signals. Because transducer one is above transducer two, a sample "window" *n* samples wide can be inspected in front of transducer one's echo peaks in order to see if there was an echo peak from the transducer two data. If there is not a peak within this sample "window" (alarm zone), then this indicates that the object is either outside of the synthetic aperture described earlier, or that the object is below the plane of the transducers and is to be rejected since this can be detected by tapping the long cane.

This "Alarm Zone" technique as shown in Fig. 16.10, can be used to effectively detect overhanging objects within the synthetic aperture. The implementation of this data processing will be done in the smart cane prototype.

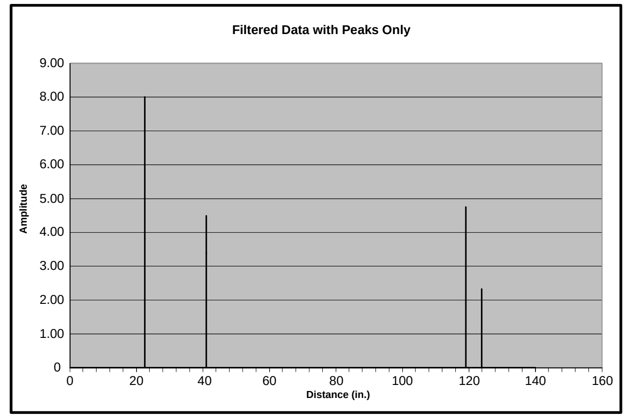

Figure 16.8. Filtered Data with Peaks Only.

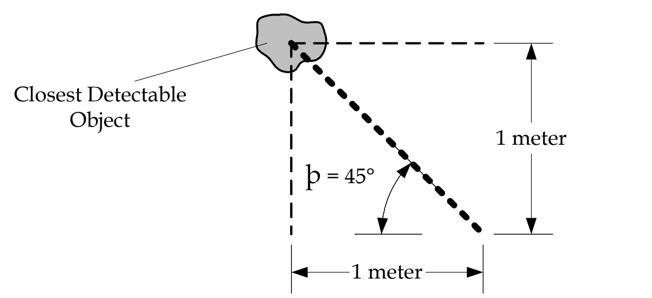

Figure 16.9. Obstacle Detection Geometry.

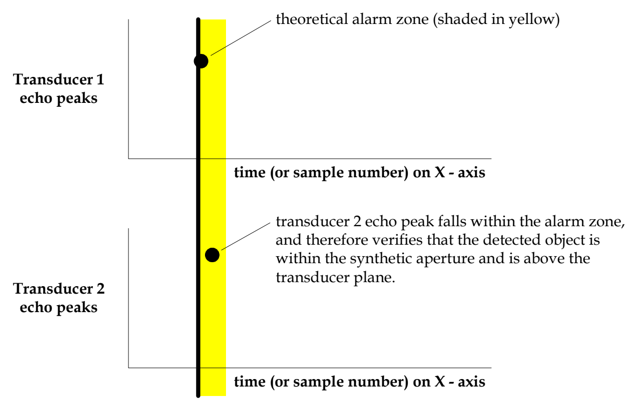

Figure 16.10. "Alarm Zone" Technique for Obstacle Reporting.

THE TROUSER ASSISTANT

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INTRODUCTION

The Trouser Assistant is an adaptive-technology dressing tool that will allow individuals with limited reach and mobility to pull up their pants successfully without assistance. Based on interviews with individuals who have a lack of mobility, it was determined that there is a need for such a device, and a variety of members of the community would benefit from owning the Trouser Assistant.

A design was conceived and developed that would successfully lift an individual's pants from his ankles to approximately waist height. A material and manufacturing process analysis was then conducted to create a product that was not only lightweight but also inexpensive.

SUMMARY OF IMPACT

Currently, there is no product on the market similar to the Trouser Assistant despite a large market base. There are approximately half a million Americans who are affected by cerebral palsy alone. Cerebral palsy is one of many conditions that would limit a person's mobility. The Trouser Assistant would give individuals with limited mobility more freedom to function independently. The Trouser Assistant is small and compact. It will therefore draw little attention to the owner or the owner's disability.

TECHNICAL DESCRIPTION

The design of the Trouser Assistant was dictated by the design objectives and constraints that were established based on the needs of the client. The device must hoist a pair of pants from an individual's ankle to his waist without requiring the operator to reach to the floor or supply a significant amount of force. The objective was to create a device that would successfully meet the needs of the user. To do so, the device must be lightweight, inexpensive and resist failure under standard operating conditions.

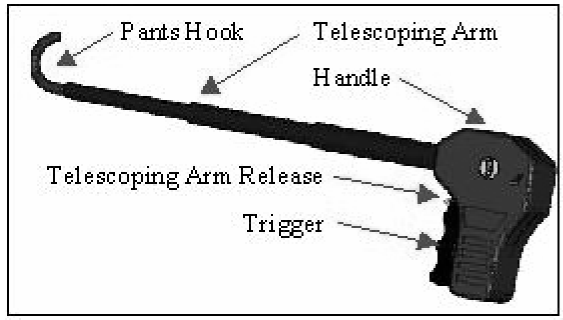

Figure 16.11. The Trouser Assistant.

The final design of the Trouser Assistant can be seen in Fig. 16.11. As can be seen, the final design is compact and discrete.

The operation of the Trouser Assistant is simple. First, the user applies pressure to the telescoping arm release lever and extends the telescoping arm with the opposite hand. The operator then uses the pants hook on the end of the arm to snare the belt line of his pants. The operator must then repeatedly pump the trigger, which in turn retracts the telescoping arm. Once the pants have been hoisted to within reaching distance, the operator can grab the pants with his opposite hand and secure them around his waist.

A cable powers the retraction of the Telescoping

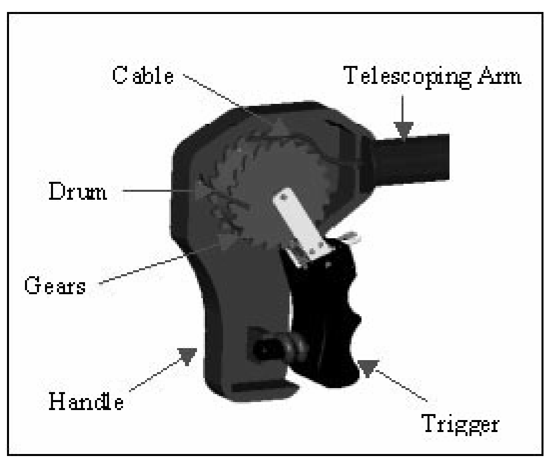

Figure 16.12. Handle Cut Away of the Trouser Assistant.

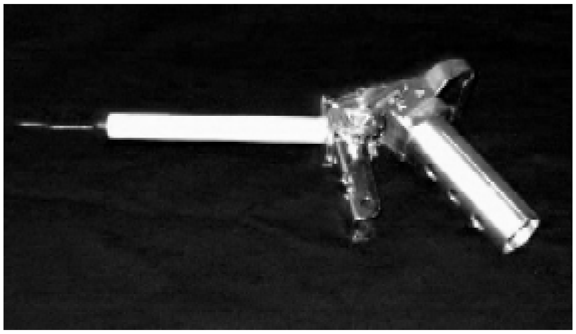

Figure 16.13. The Trouser Assistant Prototype.

Arm. When the trigger is pulled, it acts against a gearing mechanism. As the gears turn, so does a cable drum, which coils the cable retracts the arm. A cross section of the handle, which makes the various mechanical components of the trouser assistant visible, can be seen in Fig. 16.12.

A full-scale prototype of the Trouser Assistant was used to test operation (Fig. 16.13). The prototype demonstrated that such a clothing assistant would be beneficial to individuals who need assistance pulling up their pants. It was easy to use and greatly reduced the distance that the person dressing needed to reach. The Trouser Assistant in use can be seen in Fig. 16.14.

Performing a thorough material and manufacturing method selection procedure completed the design of the Trouser Assistant. The Cambridge Engineering Selector software was used to select the appropriate material to construct each component and process by which each component could be manufactured. The results of the search determined the best material for the handle, plastic trigger and drum was polypropylene. The gear is nylon, and the telescoping arm is high density polyethylene. The spring and cable can be commercially bought and are made of steel.

Figure 16.14. The Trouser Assistant Prototype in Use.

It was also determined that all of the components would be formed by injection molding. After the selection of the ideal materials to construct the Trouser Assistant, the device was sized to resist failure.

The resultant product will cost approximately $8.81 and will weigh approximately 0.28 pounds.

THE AUTO BRAKE FOR A BABY CARRIAGE

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INTRODUCTION

An automatic braking system for a baby carriage was designed. This system was designed to retrofit a Cosco® Scamper™ baby carriage and engages brakes as soon as the user releases the carriage handle. The design was targeted at people who experience sudden loss of grip or weak grip. It was found, using the Cambridge Engineering Selector software, the material of choice for the brakes was Glass/Fiber Composite and the material for the braking handle (hoop) was low alloy steel. Using the same software, it was found that the best processes for manufacturing the brake and the hoop were BMC molding and bending of standard bar stock respectively.

SUMMARY OF IMPACT

Baby carriages available in the market today have brakes that can be set so that the carriage will not move. Unfortunately, these brakes cannot be set during motion of the carriage and are only set when the user is aware that the brake is necessary. There are many cases where a brake would be more effective if it was automatically activated when the user is not at the carriage. This prompted the design of the auto brake for the baby carriage in order to increase the safety of baby carriage use and make the user more confident that the baby is safe.

TECHNICAL DESCRIPTION

The automatic brake for the baby carriage was designed to have a braking handle (hoop) that will be pressed against the existing handle when in use. When the handle and hoop are released, springs will engage the brake onto the wheel. Fig. 16.15 shows the solid model of the design as it is on the Scamper™ carriage. This assembly must be very resistant to the environment, since it will get most use while outdoors. Thus, the carriage must be resistant to wear, water and ultra violet light. The components must also pass all mechanical criteria. All stresses and forces were calculated for the case of a carriage loaded with 50 pounds that must be stopped in two meters with an initial speed of one meter per second. It was found that the torque required to stop the carriage with the requirement was 2.41 N-m.

Figure 16.15. Solid Model of Auto Brake.

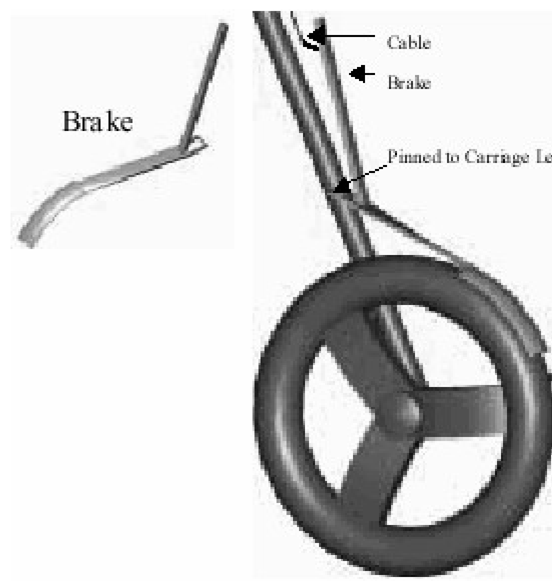

Figure 16.16. Solid Model of Brake.

The brake was analyzed and optimized with regards to size, material and manufacturing process, using stiffness as the failure criteria and 100,000 units. With the CES software, the material and process chosen for the brake shown in Fig. 16.16 was found to be a glass/fiber composite manufactured by BMC molding. The other component, the hoop, shown in Fig. 16.17, was made of low alloy steel that could easily bend into shape.

Fig. 16.18 shows the prototype of the carriage with the braking system in its intended use. It shows the user with the hoop depressed into the handle as seen in Fig. 16.17.

Shown in Fig. 16.19 and Fig. 16.20 are close up views of the hoop and the brake, respectively. As shown in Fig. 16.19, the hoop was bent to the shape of the existing handle so that it would fit, and it shows the brake used in the prototype. The mass of the brake was found to be 21 grams with a total production cost per brake of $2.52.

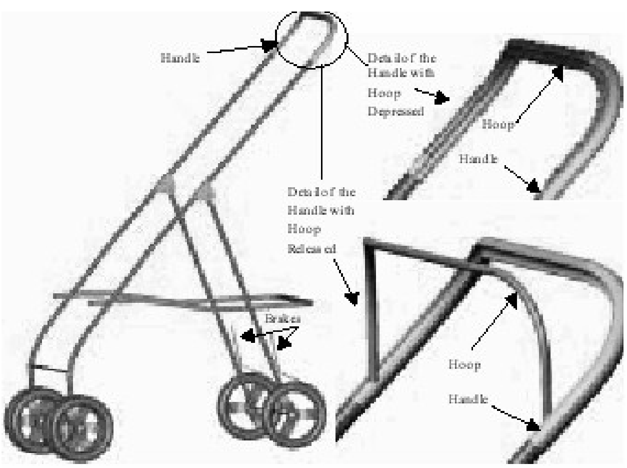

Figure 16.17. Hoop Component.

Figure 16.18. The Auto Brake in Use.

Figure 16.19. Hoop Component Close-up.

Figure 16.20. Brake.

PRESSURIZED SLEEPING BAG (PSB)

Designers: Rajesh Luharuka
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Supervising Professor(s): Robert Gao, Ph.D. & Sundar Krishnamurty, Ph.D.
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INTRODUCTION

Autism is a developmental disability that occurs in approximately one in 500 children and is four times more prevalent in boys than in girls. Pathological anxiety related sleep disorder is commonly reported in people with autism. Though there is no cure for autism, treatment may reduce symptoms increase function levels. Pressure stimulation, a sensory integration therapy, has often been found helpful in reducing anxiety in a variety of clinical settings. On the basis of this hypothesis, focus of this project is the design and development of a Pressurized Sleeping Bag (PSB) that provides pressure stimulation to people with autism. The pneumatic pressure inside the sleeping bag is controlled manually using a handheld module. The Galvanic skin response (physiological feedback) of the user and the pressure inside the sleeping bag are sensed, and the data are stored in memory for further analysis.

SUMMARY OF IMPACT

Sensory integration is a much-practiced therapy in children with autism. Some of the popular products available on the market are the “Squeeze machine” (see Fig. 16.21) and weighted vests/blankets. These devices, though inexpensive, are difficult to use and cause fatigue because of heavy weight. One of the major concerns in using such products is the high risk of desensitization to pressure. The PSB addresses these issues and aims to design, develop, and test a pressure stimulation device that is ergonomically pleasing and functionally advanced.

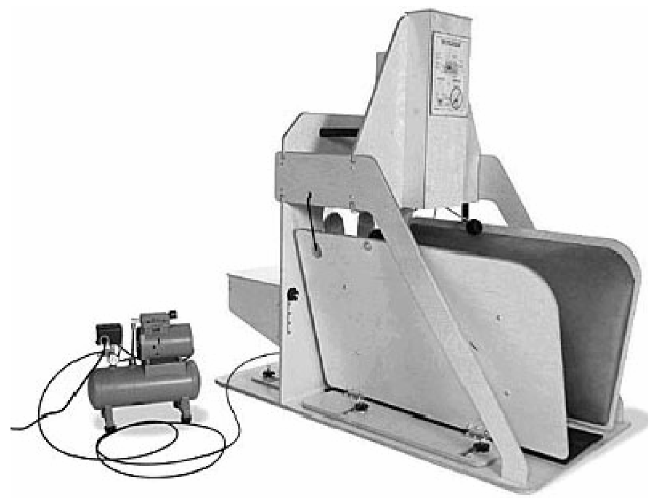

Figure 16.21. Squeeze Machine.

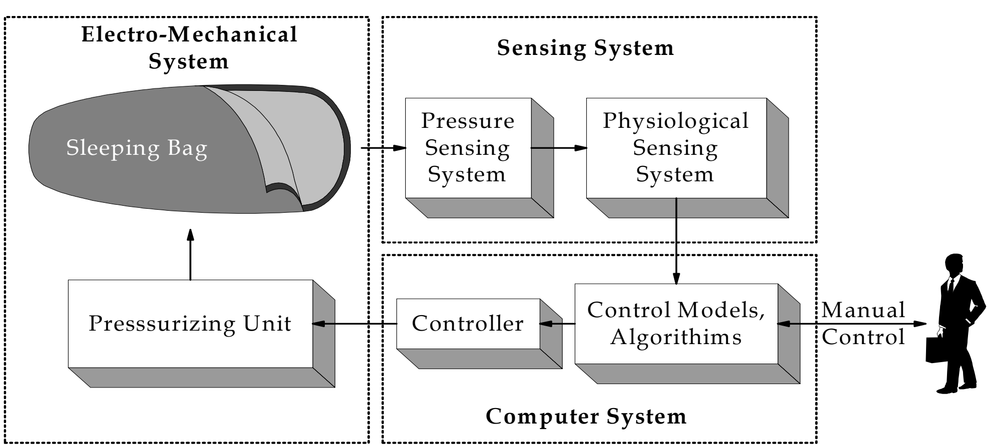

Figure 16.22. Schematic Diagram of the Proposed SPSB.

TECHNICAL DESCRIPTION

The criteria for the design of the device are safety, low noise level, uniform pressure distribution, and high controllability. The device should be able to apply pressure in the range of 0.50 psi and the physiological sensing system should be least intrusive and robust. Based on the functionality, the device is divided into different modules as shown in Fig. 16.22.

A mummy shaped sleeping bag is considered to be best suited for the proposed development. An inflatable cover is used inside the sleeping bag to apply pneumatic pressure. Galvanic Skin Response (GSR) sensor is used to monitor the physiological state of the user in the sleeping bag. GSR is the result of changes in electric conductivity of the skin caused by an increase in activity of sweat glands when the sympathetic nervous system is active, in particular when the subject is anxious. It is considered to be the most robust measure of a person's physiological state. The control system receives air pressure and physiological feedback from the sensing module, which is then stored in the non-volatile memory for future analysis. The stored data can be uploaded to the computer to further study the effects of pressure stimulation. The prototype of the device is shown in Fig. 16.23. Sample data, showing the GSR and pressure readings, are presented in Fig. 16.24.

The prototyping cost is $2000.

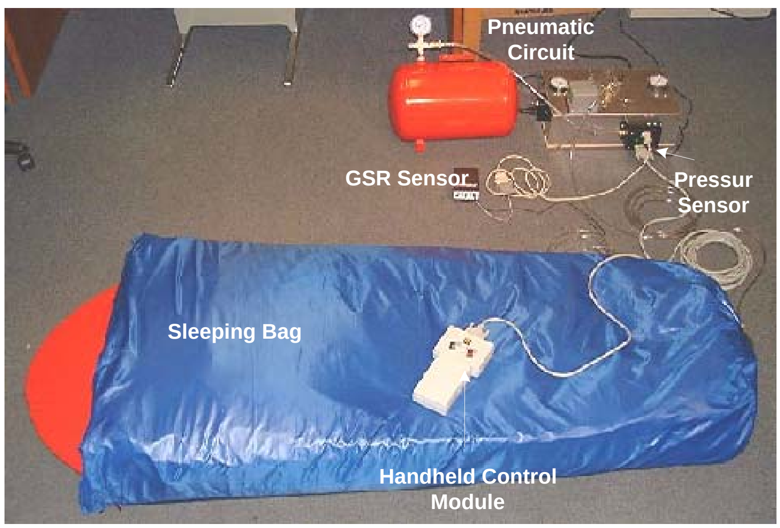

Figure 16.23. System Prototype of the Pressurized Sleeping Bag (PSB).

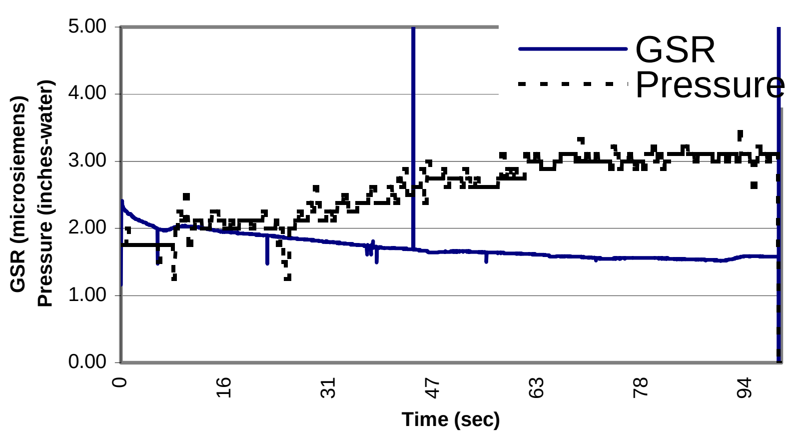

Figure 16.24. Sample Data Collected Using the PSB.

TABLE TOP ACTIVITY CENTER

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INTRODUCTION

A tabletop activity center was designed in response to a kindergarten teacher's demands. The activity center was targeted at children between the ages of five and six who have poor motor skills. Using the Cambridge Engineering Selector software for material and processing analysis, the final design specifies Acrylic as the material of choice and compression molding with additional drilling as the manufacturing processes. This design meets all mechanical constraints and child safety requirements while still sustaining a low cost of about $28.58.

SUMMARY OF IMPACT

Currently, tabletop activity centers on the market only attempt to enhance coarse motor skills while ignoring the fine motor skills. The goal of this project was to create an activity center that could be used by kindergarten-level children with and without disabilities, while providing a fun, game-like experience that enhances fine motor skills. The ability to put the thumb, middle, and index fingers together was the fine motor skill with the main focus. This is an important skill because it is the first step in holding a pencil. With this activity center, the children will learn to hold a pencil sooner, which could aid in their future writing skills.

TECHNICAL DESCRIPTION

Design criteria for the tabletop activity center included containing activities that will strengthen the motor skills of young children, such as hand strength and coordination. The center was to be used by any student and needed to be easily portable, ergonomic, aesthetically pleasing and child safe. It was extremely important to choosing the appropriate material and manufacturing process that met all requirements for the design. The Cambridge Engineering Selector (CES) software allowed for a thorough review of many types of materials and their properties in order to obtain the final choice.

Figure 16.25. Solid Model of Tabletop Activity Center.

In Fig. 16.25 (above), the final design for the tabletop activity center is shown. The center is easily placed on any tabletop and includes several activities that will teach as well as entertain. There are several switches, lights, and noises, as well as a steering wheel that will provide the child with many stimulating activities requiring the use of many motor skills and senses.

The lights and noises are connected to several colorful buttons and switches. However, not every switch has a light or sound connected to it. The simple movement of a switch is adequate to improving a motor skill. The eight lights that are located on the top are connected to a 9.6 V rechargeable nickel-cadmium battery. The sounds that the activity center makes are connected to three AA batteries. The nickel-cadmium battery needs to be recharged daily if used for extended periods of time, but the other batteries will last for weeks.

The activity center housing is made from acrylic polymer, which is a tough, strong material with very good wear characteristics, and can be easily formed to have smooth surfaces and round edges. The acrylic is formed into the shape of the housing through compression molding, and the required holes for the switches and lights are machined after the molding process.

The activity center is 0.4517 meters (18 inches) wide by 0.341 meters (15 inches) deep by 0.2032 meters (eight inches) high, and has a uniform wall thickness of 19.9 millimeters (0.7835 inches). These dimensions allow the activity center to fit on a table comfortably, and at the same time allow the child to reach all the activities. It has an ergonomic curved front edge, which enables the child to get closer to the activity center.

This activity center will be used in a kindergarten classroom to enhance the children's fine motor skills. A picture of the prototype activity center is shown in Fig. 16.26.

Figure 16.26. Prototype of Tabletop Activity Center

WHEELCHAIR LIGHTING SYSTEM

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INTRODUCTION

Performing errands or miscellaneous tasks at night could pose a problem to a person in wheelchair. It is difficult to hold a flashlight while propelling the wheelchair forward. The often-used solution is to use bike lights, although mounting is difficult due to differences in bar sizes. Additionally, the bike light does not have the option of aiming the light to a chosen position without moving the entire wheelchair. Since bike lights are not the ideal solution, it was decided to design an inexpensive wheelchair lighting system that can simply be attached to the wheelchair.

SUMMARY OF IMPACT

Current wheelchair lighting systems are only available on the top-end, expensive wheelchairs. Most people in wheelchairs use existing bicycle lighting systems, which are also expensive and designed to fit only bicycle tubing with specific mounting requirements. Currently available bicycle lighting systems are also large and impede the wheelchair operators' range of motion. The new wheelchair light design incorporates a low profile design and adjustable positioning, which allows the light to be mounted almost anywhere on the wheelchair.

TECHNICAL DESCRIPTION

Several attributes for the wheelchair lighting system were considered important. Included were a low profile battery case that would not interfere with the operation of the wheelchair, an adjustable positioning system so the beam of light may be aimed, and a remote switch for ease of use. The final design consists of four main components: battery case, light housing, flexible coupling and remote switch (see Fig. 16.27). The design incorporates a split clamp held together by two screws, which mounts the main battery case to the tubing of the wheelchair. The lighting system is capable of being mounted to virtually any part of the wheelchair with this clamping system. In addition, it is compact enough so it does not interfere with the operation of the wheelchair. Located within the battery case are two C size batteries. It was decided that this power source would provide adequate run time while maintaining the compact design. The lamp housing is similar to that of the common flashlight but utilizes a krypton bulb for superior light output. The lamp housing, mounted to the battery case through the use of a dual ball joint coupling, allows the light to be aimed up to 90 degrees in any direction. The final feature of the lighting system is the remote switch. Attached to the main body by a thin wire, the remote switch can be mounted anywhere on the wheelchair using the provided Velcro strap. This remote switch provides easy on/off control of the light while remaining within reach of anyone with limited mobility.

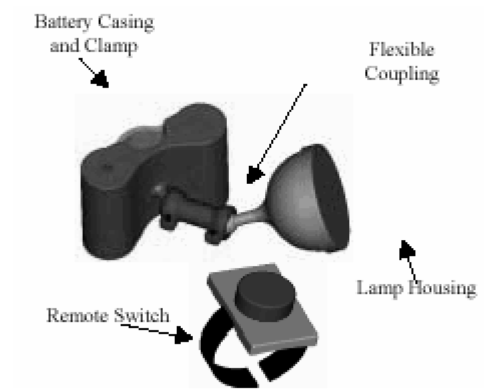

Figure 16.27: Lighting System Components.

The main parts of the lighting system, the battery case, light housing, flexible coupling and remote switch, are made of injection-molded polypropylene. The Velcro strap, bulb, hardware, wiring, and electronic components are all common parts that can be purchased from a supplier. Thorough analysis and elimination proved polypropylene to be the best material for this design. Injection molding of all parts would be a cost-effective manufacturing method.

Fig. 16.28 shows a prototype of the wheelchair lighting system, and Fig. 16.29 shows the lighting system mounted on the wheelchair.

The capital costs of purchasing a molding machine could be divided between all required parts. The estimated cost of the entire system is approximately $6.

Figure 16.28. Lighting System Prototype.

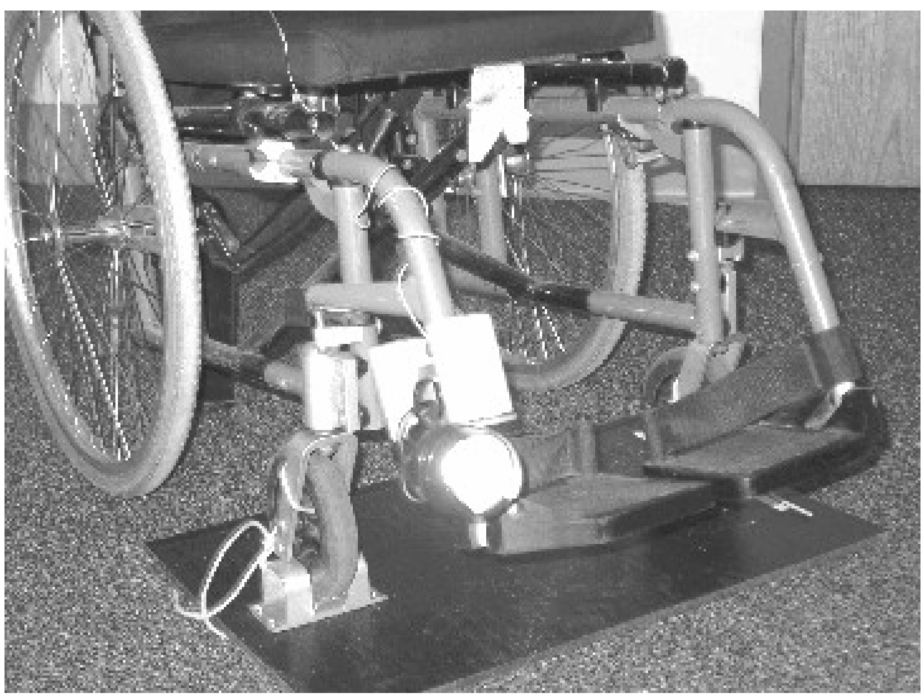

Figure 16.29. Mounted Prototype.

ASSISTIVE WALKER

Designers: Jeremy Paskind, Richard Kowalski, Michael Doe
Supervising Professor: John E. Ritter, Ph. D.
Department of Mechanical and Industrial Engineering
University of Massachusetts
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INTRODUCTION

The design of this Assistive Walker is different than current walker models on the market today. Built for people with limited upper body usage and strength, this walker aids a person by increasing his mobility without requiring use of his hands. This walker allows the user to rest his weight onto his underarms, similar to the way a crutch is used. The wheels on the bottom allow the frame to be pushed along as it supports the person. A small hand brake can be placed anywhere on the unit's frame for versatility and safety.

With the aid of the Cambridge Engineering Selector Software, the optimal materials and manufacturing processes were chosen to best suit this type of device. By analyzing the anticipated loads the walker would have to withstand, it was built to be as light as possible without sacrificing any strength. After these two criteria were accounted for, materials and processing costs were minimized to yield the most economical design possible.

SUMMARY OF IMPACT

The basic design of current walkers and similar aids has remained somewhat unchanged for a number of years. While adequate for most people, these devices require the user to lift the walker and edge it along as they walk or, if it has caster, to roll it along. For people who have little or no usage of their upper arms, however, these walkers simply cannot be used effectively. The design of the new Assistive Walker overcomes this limitation by supporting the user's weight by his underarms. The walker can then be slid with them without having to be lifted or maneuvered by hand.

TECHNICAL DESCRIPTION

A design was created to accomplish the need of the Assistive Walker to support the user under his arms. Because this design concept had to incorporate support under the armpits, adjustability and sizing issues had to be addressed. In particular, the upper

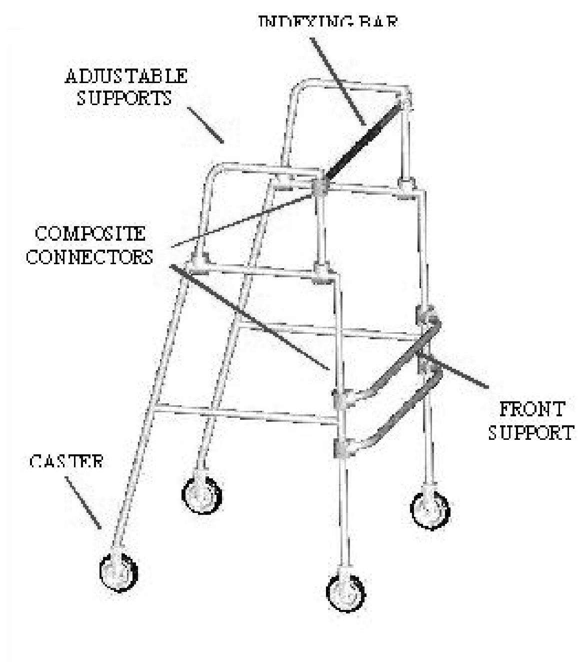

Figure 16.30: Assistive Walker Model.

frame had to adjust inward to accommodate the varying width of different users. A CAD model of this concept can be seen in the Fig. 16.30. The new design, not seen in existing walkers, is used in a different manner that brings about new adjustability and sizing issues.

By analyzing the design to find the most critical loading scenarios most likely to be encountered, the precise modes of failure for different components were found. With this data, material and shape requirements were derived and CES plots were generated to guide the selection of the optimal material for each major component. From the original design specifications, each part was to be both failure resistant and lightweight. Only after these two criteria were met was the cost to be minimized. Functionality, not cost, took priority in the construction to result in a safe and highly useful product.

Figure 16.31: View of Prototype.

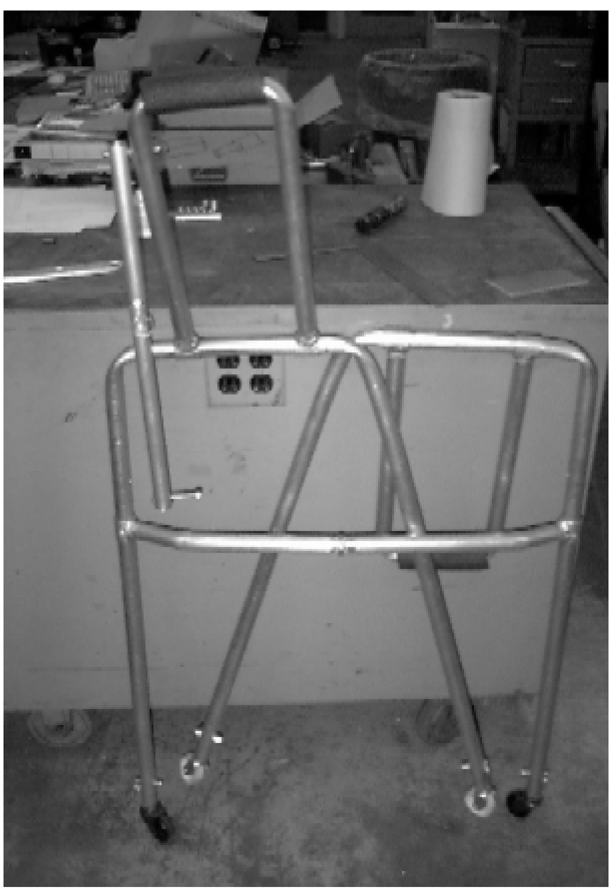

Figure 16.32: Folded View of Prototype.

conducted on the frame of the walker, wrought Aluminum Alloy tubing with a one-inch outer diameter was chosen. Used in most current models on the market, alloy tubing provides a lightweight, strong, and aesthetically pleasing alternative to other possibilities. Due to its availability, standard alloy tubing could be purchased for the construction of the frame to save money on manufacturing and overhead costs.

To allow for rotational movement of certain parts of the frame and facilitate folding and size adjustment, some of the joints were not welded. Instead, small connecter pieces were designed. By analyzing the parts at the most critically stressed location, the probability of failure was reduced almost completely. Designed to be lightweight and strong, the CES software led to a material selection of an injection molded, Phenolic Matrix Composite connector hinge. The wheel housings were also analyzed for failure criteria and found that stiffness was the dominant factor.

Using the derived material index for the part, it was decided that the part be injection molded out of Glass fiber reinforced ABS plastic. Once sized, the part was then checked for other modes of failure to insure that the original assumptions were correct. Many other parts in the design of the walker were found to be standard, commercially available products. All of the hardware, the caster wheels, and the caliper brake mechanisms were purchased to reduce the overall cost of the product.

The final design weighs less than nine pounds. The walker's maximum rated user weight was 250 pounds with some additional safety factors built in. Materials were chosen to not only support the applied loads, but also to withstand most typical environmental factors. Overall, this design addressed all of the specifications, while remaining within a close weight and cost range of the existing walkers.

The cost was about $59 dollars.

THE BAR ON THE T

Designers: Tricia Deleporte, Matthew Fuccillo, and Sarah Stilgoe
Supervising Professor: Dr. John Ritter
College of Engineering
University of Massachusetts
Amherst, MA 01003

INTRODUCTION

This design addresses the issue of the safety and security of people in wheelchairs riding city trains. This device is self-contained, can be easily added to the trains already in existence and requires no assistance from anyone other than the user.

SUMMARY OF IMPACT

This design provides security to an individual in a wheelchair riding on the train. Once the passenger has boarded the train, he situates himself behind the lap bar. The bar and the existing brakes on the wheelchair work together in resisting motion parallel to the motion of the train.

TECHNICAL DESCRIPTION

This design has three major components that can be installed on any of the MBTA's one hundred Green Line trains: the lap bar, hinge and track. The bar is constructed from long hollow wrought aluminum alloy tubing and is covered with foam. Both are stock parts that can be purchased from most material supply companies. The foam padding is used for ergonomics and is aesthetically pleasing in its environment. The bar rests on either the lap of the user or the armrest of the user's wheelchair.

The hinge is constructed using cast wrought aluminum alloy. This plate slides vertically in the track allowing various positions for the various size users. The plate also contains two holes where the clevis pin is positioned. The clevis pin attaches the forged steel yoke assembly welded into the bar, and allows the bar to move from a horizontal position to a vertical position when not in use. The yoke and clevis pins used are locally purchased parts.

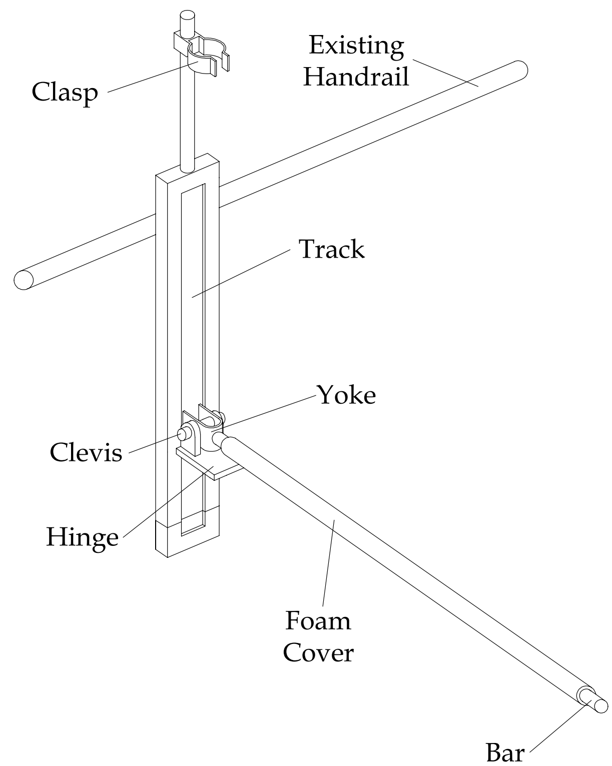

Figure 16.33. Pro-E Drawing of Design.

The track is the component that allows the hinge to slide vertically, allowing it to adjust to the height of the user. It is easily attached to the already existing handrail on the trains. The track is a medium carbon steel manufactured part that requires a small amount of machining for proper sliding. A PRO-E drawing of the design is given in Fig. 16.33. The prototype constructed can be seen in Fig. 16.34 and Fig. 16.35.

The cost of the Bar on the T is $295.96.

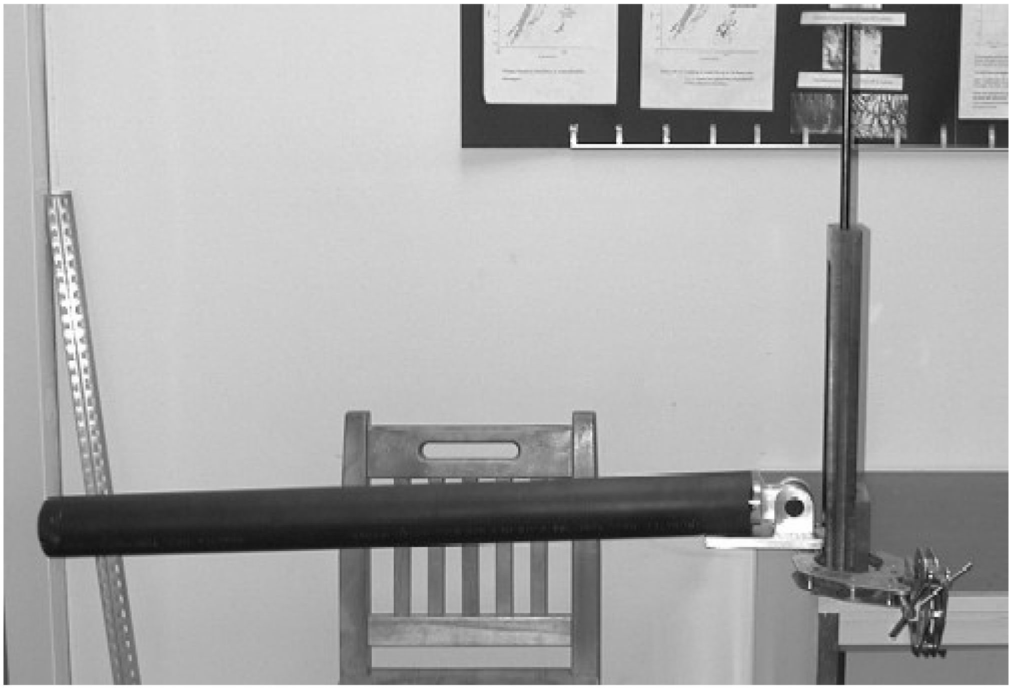

Figure 16.34. Side View of Lap Bar in "Down Position".

Figure 16.35. Side View of Lap Bar in "Up Position".

THE FISHER ASSISTER

Designers: J. Foulis, R. Gallagher, B. Ewing
Supervising Professor: John E. Ritter, Ph.D.
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Amherst, MA 0.003-3662

INTRODUCTION

A person who has only one arm or hand may have difficulty performing everyday tasks taken for granted. Some sports or hobbies may be difficult or even impossible to perform with the use of only one arm or hand. People with disabilities still have a desire to participate in sports such as fishing. However, for a person with only one usable hand, it is difficult to fish since two hands are required to operate the fishing pole. One hand is needed to hold the pole, while the other is needed to work the reel. A design has been devised to eliminate the need to hold the rod while fishing (see Fig. 16.36).

CES software was used to find out what material should be used in the design. It had to be lightweight, inexpensive and strong enough to hold a fish while reeling it in. GFRP was selected for the attachment, and polypropylene 40 percent glass fiber was selected for the harness.

SUMMARY OF IMPACT

There are few products currently available for fishing with the use of only one hand. These products were found to be unstable and awkward to wear. The Fisher Assister was designed to allow a person with one hand to successfully fish with ease. The Fisher Assister holds and stabilizes the fishing rod while reeling, and it allows for easy and quick release of the fishing rod for re-casting. The clamp located on the upper portion of the harness provides the user with another "hand" in order to perform tasks such as tying a hook or removing a fish.

TECHNICAL DESCRIPTION

The essential characteristics of our product are that it will be lightweight, easy to wear and easy to use with one hand. The device will hold the fishing rod secure and stable during reeling, while allowing the rod to be removed from the holder quickly and easily with one hand.

The design consists of two main components: the harness and cylinder attachment (as shown in Fig. 16.36). The harness portion of our design is similar to the harness a drummer in a marching band would use to support drums. The harness is one solid piece that slides over the head and rests on the shoulders. The cylinder attachment of our prototype (Fig. 16.37) is secured to the front of the harness with 4-1/2 inch

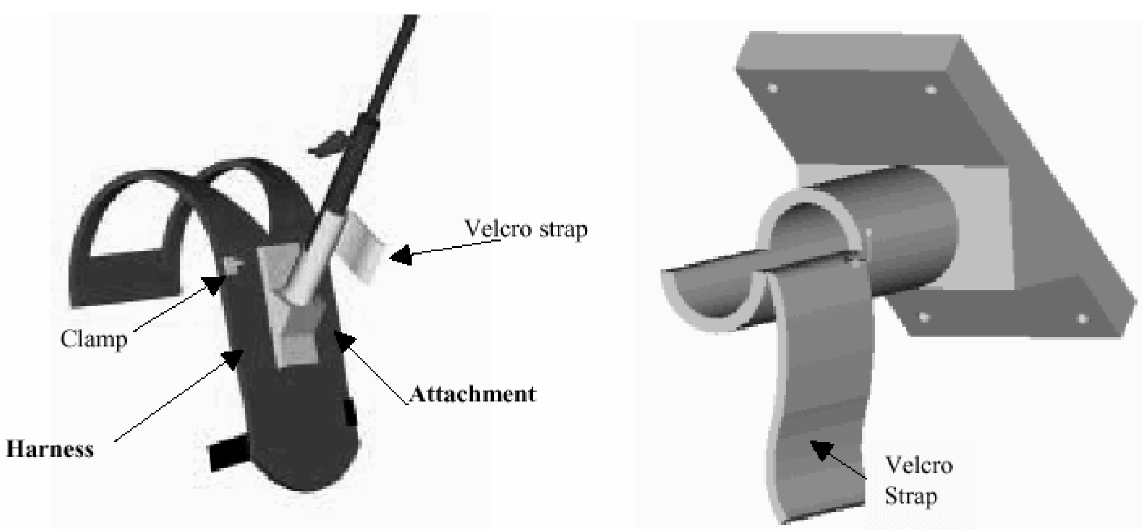

Figure 16.36. The Fisher Assister Components (left) and Close up of Cylinder Attachment (right).

bolts. It is 12 inches long, and has an inner and outer diameter of 1.25 and 1.38 inches, respectively. A quarter of it is cut out and has a loose strip of Velcro to wrap around it, keeping the pole secure when it is being reeled in. The cylinder is positioned at a 45 - degree angle from the user's chest. The harness also has other features added to assist a person while fishing. Shown in Fig. 16.37, a clamp on the side of the chest will assist a person in tying a hook onto a line, baiting the hook and removing a caught fish. A beverage holder attached to the harness completes the Fisher Assister.

CES was used to find the best material for a lightweight, inexpensive and strong cylinder attachment and harness. Glass fiber/polymer (GFRP) laminate is the material chosen for attachment. The harness is made out of polypropylene. The process used to make these parts was also determined from CES and was narrowed down to compression molding.

It is a simple device to operate with only one hand. The user casts the pole with his operable arm, and then places the rod in the cylinder of the Fisher Assister. The pole is then secured in place by means of a Velcro strap (Velcro is also on the pole). The user can then reel in the rod with his operable hand. Fig. 16.38 shows how the design is worn by a person.

The price of the two main components had a total cost of $12.76 per unit. Adding the cost of the other items, such as the Velcro strap on the attachment, Velcro strap and clip on the harness, the total cost of the unit is about $13.

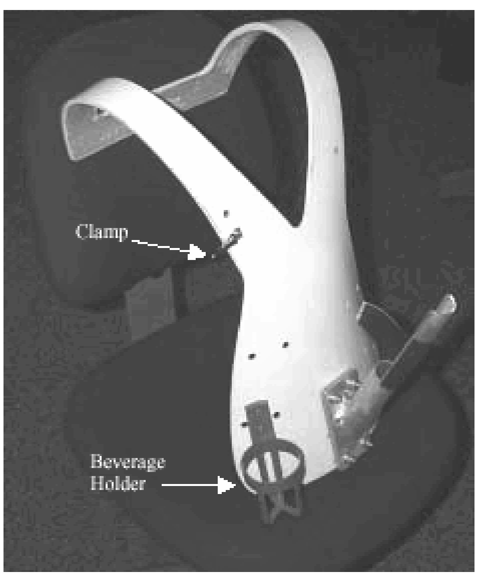

Figure 16.37. The Fisher Assister.

Figure 16.38. Testing Prototype.

SANDY WHEELS CONVERSION SYSTEM

Designers: M .S. Ingalls, J. Labrie, and J. Piccirillo
Supervising Professor: John E. Ritter, Ph. D.
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INTRODUCTION

A conversion system was designed to modify standard wheelchairs to provide the ability to travel over soft terrain. The system was designed to be compatible with most modern wheelchairs, and through a ratcheting device, the users can propel themselves either forward or backward. The design had enlarged rear wheels and a sled that was placed under the front caster wheels, all of which were made from injection molded high density polyethylene. A ratcheting system attached to the rear wheels, and a ratcheting arm made from wrought aluminum provided users with a means of propelling themselves (see Fig. 16.39).

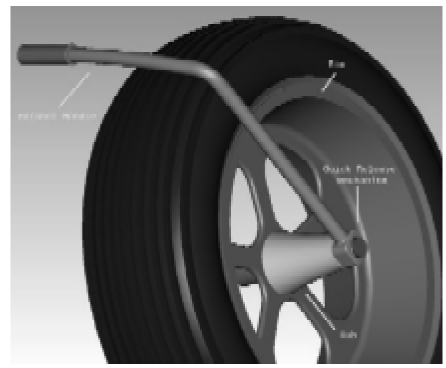

Figure 16.39: Rear Wheel and Ratchet Arm.

SUMMARY OF IMPACT

Standard wheelchairs are designed to be used in buildings and on sidewalks but are not meant to be used on soft terrain such as the beach. Specialized wheelchairs exist specifically for beach use, but these items are expensive and most often require a second person to push the chair. The Sandy Wheels Conversion System allows people to quickly modify their every-day wheelchair for beach use for only a fraction of the cost of a specialized wheelchair. Even with a 100 percent markup in price, this system will cost approximately one fourth of what an entire beach wheelchair costs.

TECHNICAL DESCRIPTION

The design centers around two very important necessities. First, the design had to be consistent with many of the universal and interchangeable parts employed in newer wheelchairs. Second, the user had to be able to operate the chair independently. These design features were obtained by optimizing stiffness when selecting materials and by minimizing cost and weight, so the system would be easy to install and affordable.

Using the quick release system that is incorporated into most modern wheelchairs, the standard rear wheels are removed and replaced with eight-inch wide wheels that distribute the weight over a larger surface area and keep the chair from sinking into the ground. The pin on the outside of the ratchet arm is part of this quick release system (see Fig. 16.40).

The caster wheels are placed into the sliding base, which is located on the sled. This sled distributes the load on the caster wheels over a larger surface area to keep the chair from sinking into soft terrain, much like the wheels above. In a one-time setup, a sliding dovetail permits proper location of the two caster-to-sled connections. The connections are to be located so the casters will roll into the wheel grooves shown below (see Fig. 16.41). Moreover, they can then be permanently affixed with easy-to-install set screws. Then each time the user wishes to use the Sandy Wheels system, the casters are then strapped

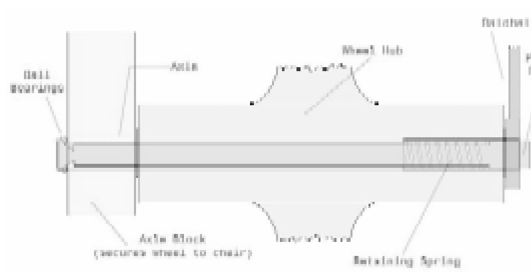

Figure 16.40: Quick Release System.

firmly to the caster-to-sled connections with a quick tie system or strap.

Strapping the wheelchair casters onto the caster-to-sled connections is done with an adjustable hook and chain. Tension on the chain is facilitated by the use of a comealong. A very general diagram of a comealong is shown in Fig. 16.42. Once the device is in its closed position, it becomes locked in place and cannot be unlocked without pulling the two handles apart.

Finally, the user of the chair is ready for travel over soft terrain. By pushing the ratchet arms forward, the chair moves forward. By pushing only one arm at a time, the chair is able to turn. Finally, there is a switch on the ratchet that will allow the chair to move in reverse.

The wheel hub, sled, and sliding base will be made out of injection molded high-density polyethylene. This material was chosen based on maximizing stiffness and minimizing cost and weight. It was also important that the material had good environmental properties against fresh water, seawater, and UV radiation. The rubber tires, aluminum ratchet arms, and other standard parts such as the ratchet, comealong, and screws will be purchased from vendors. The Pro-E drawing of wheelchair is given in Fig. 16.43 and Fig. 16.44 shows the prototype that was built.

The Sandy Wheels System can be manufactured for about $125.00

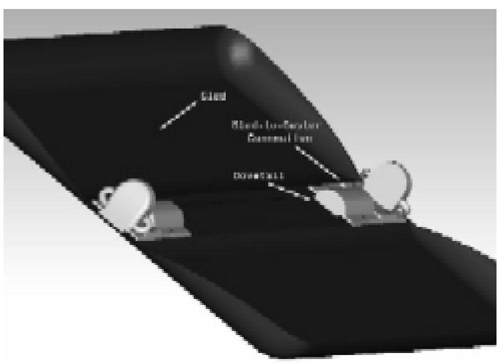

Figure 16.41: Sled that Supports Caster Wheels.

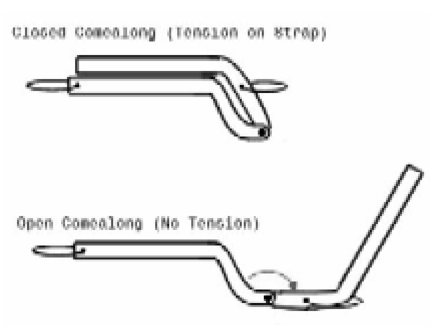

Figure 16.42: Operation of Comealong.

Figure 16.43: Wheelchair with Sandy Wheels System.

Figure 16.44: Sandy Wheels System Prototype.

HELPING HAND CAR DOOR CLOSING ASSISTANT

Designers: Matthew Atwood, Christopher Beebe, Fyodor Grechka
Supervising Professor: John E. Ritter, Ph.D.
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INTRODUCTION

A mechanical system was designed to aid in closing a car door. An ergonomically driven material design process was employed for the handle of the system using Cambridge Engineering Selector software. The optimal material for the handle was discovered to be Polyvinylchloride (UPVS) a rigid material produced by injection molding.

SUMMARY OF IMPACT

Current car door designs require a large amount of applied force at the handle to close a fully opened door. This novel design would create an ergonomic product that would reduce the force needed to close a car door while at the same time not interfering with unassisted closing of the door. Market research indicates that there is currently no similar product available.

Being able to comfortably close a heavy car door would allow elderly individuals and those with physical disabilities to be more self-sufficient and would prevent discomfort and possible injury.

TECHNICAL DESCRIPTION

The primary components of the car door assistant are the handle and its retaining clip, as well as the chain retraction mechanism and its holding bracket. Metal cable secures the handle to the cable retraction mechanism that houses the excess cable, as seen in Fig. 16.45. The primary design criteria for the handle involved ergonomics and cost. In addition, the handle had to be able to withstand the largely varying temperatures of a car interior (0° F to 120 °F). Cambridge Engineering Software (CES) enabled an optimal material to be selected based on these criteria. This material was found to be rigid Polyvinylchloride (UPVS). The cable retraction mechanism is commercially available, retailing at $8 at a local hardware store. The brackets can be made of polypropylene and the chain and its retracting spring can be bought commercially.

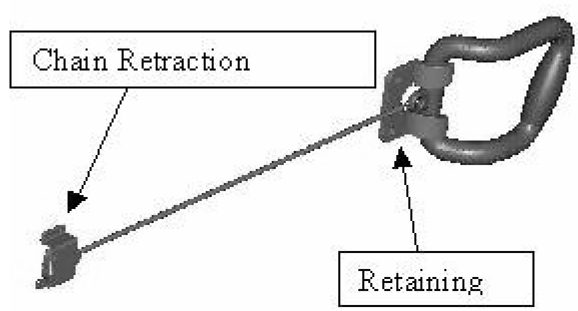

Figure 16.45. Solid Model of Door Closing Assistant

To use this design, the user gets into the car normally, but instead of pulling the conventional handle to close the door, he or she instead grabs the helping hand handle secured to the door via the retaining clip. The user then removes the handle and pulls the handle (see Fig. 16.46). When initially pulled, the chain retractor lets the cable spool out to approximately four inches in addition to the 10 inches let out in the storage position, before the spool reaches its end stop. The user can then pull on the handle to close the door as a result of the force caused by the cable in tension. After the door is closed, the user returns the handle to its storage position on the retaining clip (Fig. 16.47).

Special attention was paid to the ergonomics of the handle. The grip bulges in the center, conforming to the natural contours of the palm. In addition, the grip is angled at 35°, the neutral angle of the human hand. In addition, the material of which the polymer hand grip is made has a low thermal conductivity, leading to an acceptable grip temperature. The ergonomics of this handle leads to comfortable use by the operator (see Fig. 16.48).

Static analysis shows that to reduce shoulder stress in car door closing, either the application force's line of action has to be changed (thus creating a longer moment arm), or the force has to be supplied from somewhere other than the person's shoulder. After construction of the prototype (Fig. 16.49) it is seen that this design successfully accomplishes both of these goals by reducing the necessary force by 41 percent and involving the use of the biceps instead of the shoulder in applying this force.

The assistive car door closing system can be produced for about $17.00.

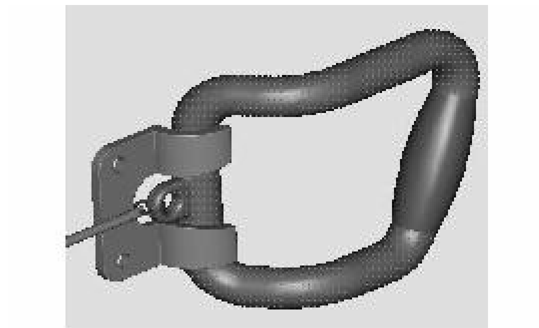

Figure 16.47. The Handle in Storage Position.

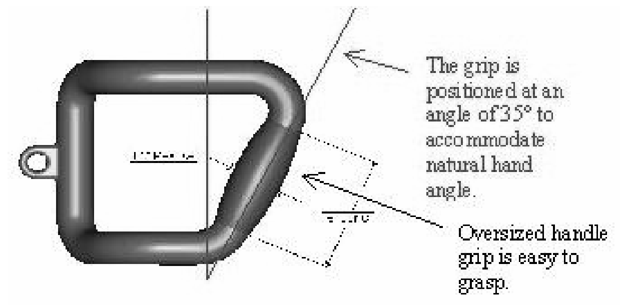

Figure 16.48. Ergonomic Design of the Handle.

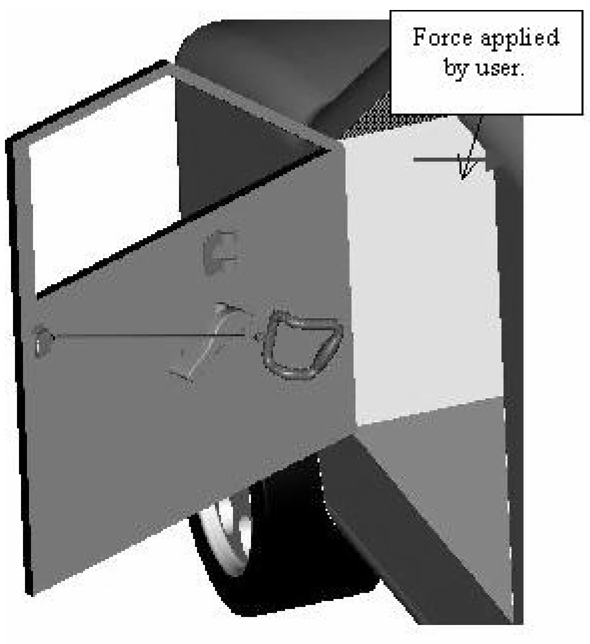

Figure 16.46. The Car Door Assistant in Use.

Figure 16.49. Prototype Model of Helping Hand.

GAS-SPRING ASSISTIVE CANE

Designers: W.Abad, J.Lapointe, and S.Nualpring
Supervising Professor: John E. Ritter, Ph.D.
Department of Mechanical and Industrial Engineering
University of Massachusetts
Amherst, MA 01003-3662

INTRODUCTION

An assistive walking cane was designed to aid a person to lower and raise himself in a controlled manner. The design will allow the client to lower himself to a kneeling or seated position and vice versa. The gas-spring provides the mechanism by which the cane can be lowered or raised in a controlled manner. The materials and processing analysis was completed with the assistance of the Cambridge Engineering Selector software, the design uses Cast Aluminum Alloy and Low Carbon Steel as the material and gravity die casting as a suitable manufacturing process.

SUMMARY OF IMPACT

Over five million Americans need the assistance of a cane or crutch. In certain situations, the user needs to sit down or reach to the ground. The current canes do not allow the user to safely accomplish these tasks.

TECHNICAL DESCRIPTION

The primary design criterion is minimizing the load applied on the user as he lowers himself. The use of a padded handle and assistive brace will produce a comfortable feeling for the user. The design must provide a sense of balance and sturdiness. A secondary design parameter is maximizing the number of cycles the gas-spring and cane can endure. It is specifically designed to hold a maximum load of 250 pounds. Another secondary parameter is minimizing weight since users want the lightest possible canes. A third parameter is minimizing cost to keep the system affordable. An optimal material was chosen using the Cambridge Engineering Selector (CES) software, which lets the designer explore what materials meet or exceed these requirements.

Fig. 16.50 shows the solid model of the gas-spring assistive cane. The lever that controls the release of the gas spring is right below the handle.

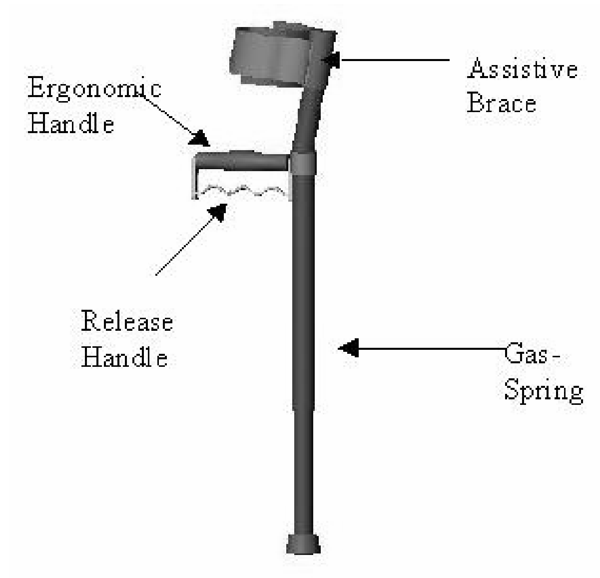

Figure 16.50. Solid model of Gas-spring Assistive Cane.

The proof-of-concept of the cane is shown in Fig. 16.51. The proper use of the cane is shown in Fig. 16.52. The fingers are applied to squeeze the release handle. The lever is then retracted and the cane with the assistance of the gas spring lowers it self at fixed rate till it locks into the next lower level of teeth.

The use of the CES materials analysis features yielded two materials, cast aluminum alloy, and low carbon steel for the stopping teeth and pull lever. Assuming a production volume of 100,000 units, the CES manufacturing process analysis yielded one process for the stopping teeth and pull lever: gravity die-casting. After analyzing business factors such as power and space usage, tooling, labor and capital costs, as well as purchasing of the aluminum alloy gas-spring, brace, and handle from outside contractors, the total manufacturing cost of the assistive cane came to $16.69.

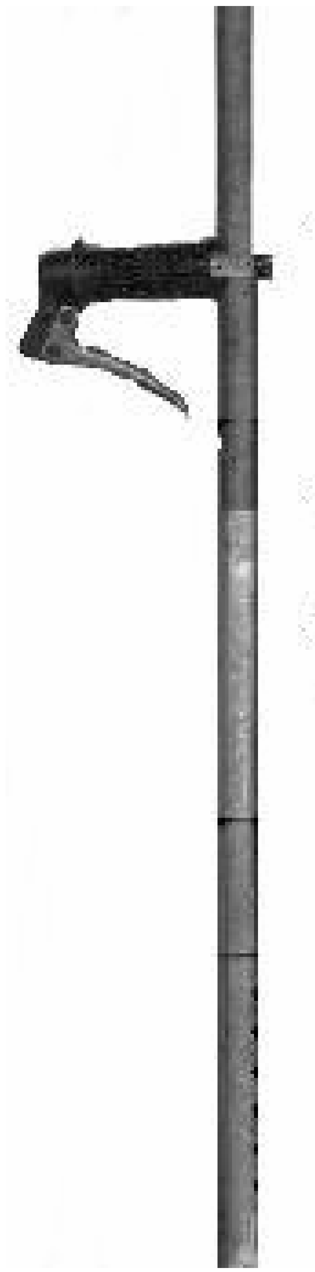

Figure 16.51. Proof-of-Concept of Assistive Cane.

Figure 16.52. Proof-of-Concept of Assistive Cane Collapsed.

ONE-HANDED MOUNTAIN BICYCLE BRAKE

Designers: A. Bail, D. Quimby, and C. Taylor
Supervising Professor: John E. Ritter, Ph.D.
Department of Mechanical and Industrial Engineering
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INTRODUCTION

A one-handed mountain bicycle brake was developed in response to bicycle safety issues. The only one-handed brake system on the market is unsafe because it forces the user to apply both front and rear brakes simultaneously, which can cause accidents. This improved design employs two brake levers that allow the user to apply both brakes safely and independently from each other. All other standard brake materials such as cables and brake pads are adaptable to the design. From a materials and processing analysis utilizing the Cambridge Engineering Selector software, the design uses Cast Aluminum Alloy as the material and die casting as a suitable manufacturing process.

SUMMARY OF IMPACT

There is a demand for braking systems for persons without the use of one hand. In some situations, the user needs to slightly apply the front brake, for example, during turns. The current one-handed brakes are unsafe because both brakes are applied instantly. The goal of this improved design is to allow the user the freedom to apply the brakes independently from each other.

TECHNICAL DESCRIPTION

The primary design criterion is minimizing brake lever deflection to provide a sense of sturdiness. One secondary design parameter is maximizing corrosion resistance, especially counteracting the effects of sweat. Another secondary parameter is minimizing weight since users want the lightest possible brakes. A third parameter is minimizing cost to keep the system affordable. An optimal material was chosen using the Cambridge Engineering Selector (CES) software, which lets the designer explore what materials meet or exceed these requirements.

Fig. 16.53 shows the solid model of the one-handed mountain bicycle brake design. The lever that controls the front brake is a short channel beam, which surrounds the rear brake lever. The rear lever is a solid member with an elliptical cross-section. Both of these members pivot about an axis, which is a pin. This system is secured to the handlebar by a bar mount. The brake cables and casings are attached to the brake assembly by standard barrel adjusters.

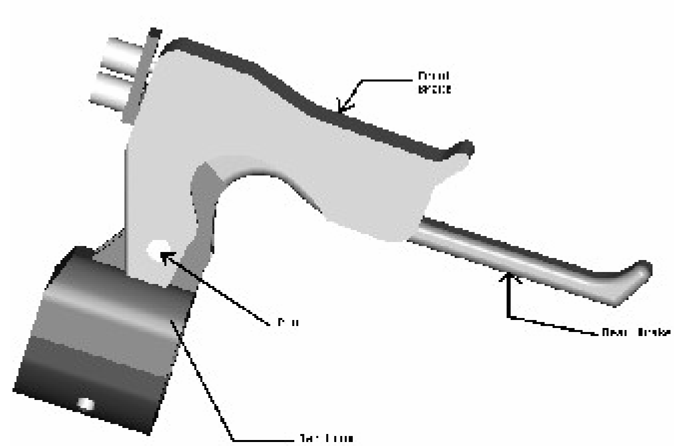

Figure 16.53. Solid-Model of One-Handed Bicycle Brake.

The proof-of-concept of the brake levers is pictured in Fig. 16.54. The proper use of the levers is shown in Fig. 16.55. The index and middle fingers are applied to the front brake and the ring and pinky fingers are applied to the rear brake. This is an ambidextrous design; it can be used on the left or right side of the bicycle handlebars.

The use of the CES materials analysis features yielded one material, cast aluminum alloy, which meets the primary and secondary design criteria. Assuming a production volume of 100,000 units, the CES manufacturing process analysis yielded one process, die casting, that meet all volume, shape and tolerance criteria. After analyzing business factors such as power and space usage, tooling, labor and capital costs, as well as purchasing pins from outside contractors, the total manufacturing cost of the braking system is $8.61.

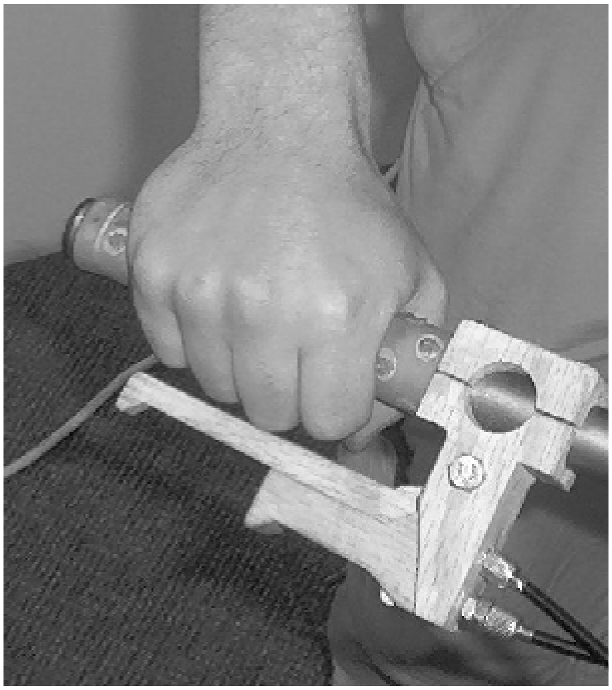

Figure 16.54. Proof-of-Concept of One-Handed Bicycle Brake.

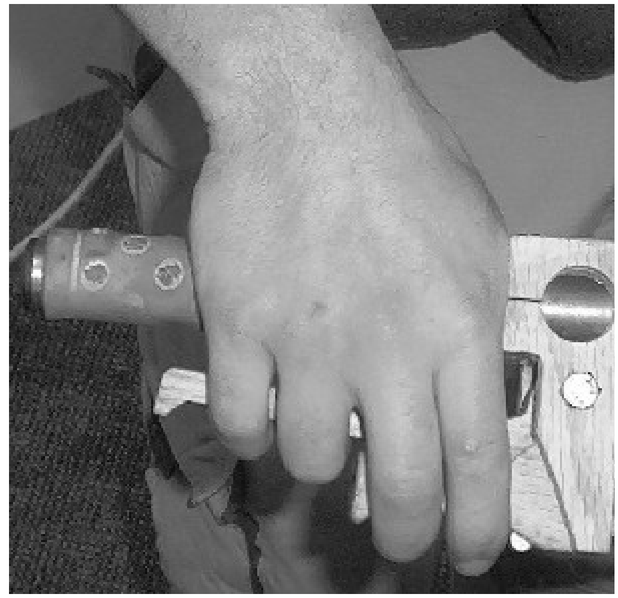

Figure 16.55. Proper Use of One-Handed Bicycle Brake.

HANDY GARDENING TOOL FOR DISABLED GARDENERS

Designer: Sheng Chou, Manza Masamuna, and Patrick Cushna
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INTRODUCTION

A handle was ergonomically designed to permit people with disabilities in their arms and hands to use a variety of garden tools. The design is focused on allowing these individuals to enjoy gardening without discomfort or unnecessary difficulty. The design consists of a pair of Velcro straps that allow the user to exert a large force without placing too much stress on the hands and fingers. A rigid frame disburses the forces through the arm instead of the wrist and fingers. The handle is universal, so multiple gardening tools can be fitted into its head.

Materials were compared and evaluated using the Cambridge Engineering Selector (CES). Polyvinylchloride (UPVC) was selected as the material to be used for the handle. Also using the CES software, injection molding was selected as the primary manufacturing process. For the shovel, high carbon steel was chosen as the material, and stamping as the forming process. A series of secondary processes were also selected to complete the design. These include drilling holes, cutting of the UPVC tubes, and assembling of parts.

SUMMARY OF IMPACT

Unfortunately, when people lose strength in their hands, it becomes difficult to hold the handle of the typical small gardening tools. Thus, a need exists for a set of gardening tools that have a handle to assist people with limited hand strength. This handle must be lightweight, inexpensive, ergonomically designed and aesthetically pleasing.

Our design handle allows for an interchangeable tool head so that users can change from shovel to rake and other existing gardening tools. Also, people with a wide range of disabilities including weak hand strength, weak wrist, and arthritis, can use this handle.

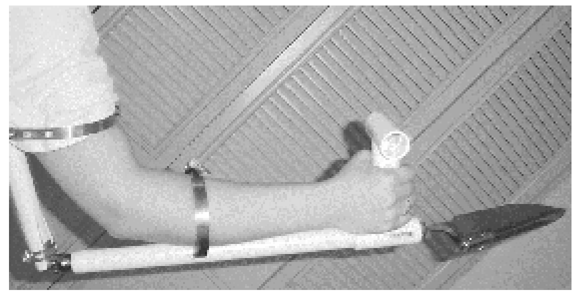

Figure 16.56. Assistive Gardening Tool.

TECHNICAL DESCRIPTION

The gardening tool had to be lightweight, ergonomic, and inexpensive. A concept has been designed that will not only target people with limited strength, but also people with disabilities who might only have one hand, no fingers, or very weak hand strength. A prototype of the assisting gardening tool is shown in Fig. 16.56.

The main body of the gardening tool is PVC tubing. Velcro is used to strap around the bicep muscle and the forearm. This configuration allows the transfer of the arm's motion and strength directly to the shovel. An ergonomic handle is used to assist the user who is not able to grip firmly. It will also add security and comfort in the maneuvering of the tool. A foam grip will be placed on the handle. The added diameter and softer material will make gripping easier for people with hand and wrist disabilities. Fig. 16.57 is a PRO-E drawing of the handle.

The joint of the assistive gardening tool must be as flexible as an actual elbow. This required the joint to be able to rotate on two axes. It was determined that an off the shelf, double-jointed hinge could be used as the joint. This joint allows the user to rotate in two planes similar to an elbow, while also transferring the force from upper to lower. The joint is fastened to the tubing by way of a pin. The pin will be placed through holes drilled across the diameter of the PVC tubing. Once in place the pin aligns the two holes and secures the body and joint in place.

Aside from the versatile usage among the different disabilities, our design has included a changeable tool head (see Fig. 16.58) that will allow the user to easily change from spade to rake or any tool head available. The advantage of having a universal tool head is that once a person has the handle mounted on the arm, he or she may change between tools without having to take off the handle. A pin securing system, similar to the pin used to secure the handle and joint, is implemented to allow for easy interchangeability between tools. The pin is slid through aligned holes in the handle and tool, and can be removed when the tool is no longer desired. This allows for a quick exchange between various tools. This pin, unlike the pin used for the joint, has a spring-loaded ball that expands when the pin is in the correct position. The expansion prevents the pin from sliding out unexpectedly. The force needed to remove the pin is relatively small, allowing someone with limited strength to use the pin without difficulty.

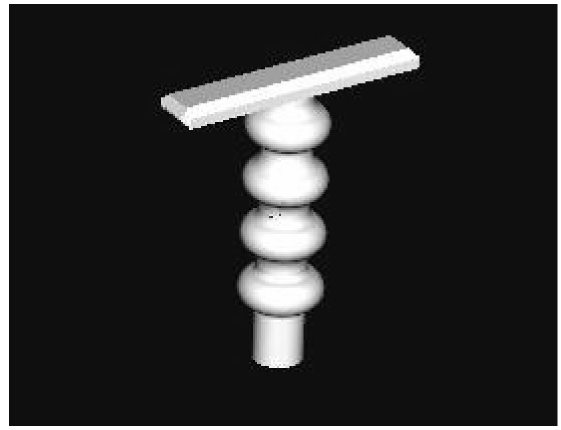

Figure 16.57. Ergonomic Handle.

A cost analysis determined that it would cost $6.40 for each handle.

Figure 16.58. Interchangeable Tool Head.

DESIGN OF A ONE-HAND KAYAK PADDLE

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INTRODUCTION

A paddle attachment was designed to allow a person with the use of only one arm to paddle a whitewater or flat-water kayak. The product was designed under the input of a kayaker with one arm and other experienced kayakers. Pro-Engineer solid modeling software and Mechanica finite element analysis software are used to optimize the design. Material and manufacturing selection was analyzed with the Cambridge Engineering Selector software. Injection molded epoxy glass fiber composite was chosen for the forearm attachment and injection molded polypropylene for the handle.

SUMMARY OF IMPACT

Currently, it is not possible to use a kayak paddle with only one arm. The only device available today is a hand paddle, which does not allow the kayaker to gain enough speed or maneuver easily. The client is a kayaker with one arm, who is having difficulty advancing to more challenging rivers because of his hand paddle's limitations. The goal of this project was to design an attachment for a kayak paddle that would allow the client and other people with disabilities to paddle a kayak without difficulty.

TECHNICAL DESCRIPTION

The primary focus of the design is functionality. The performance of the paddle using one arm must be comparable to a regular paddle using two arms. The paddle cannot be much heavier than a regular paddle. It also has to be a simple device, easy to install and use. It has to be durable and withstand any force applied in normal use. Safety is also very important in this design. Kayaking can be lethal if a person cannot roll or exit the kayak after he or she flips upside-down. Kayakers often have to swim after they escape from their kayak. For these reasons, the paddle must be removable. Also, the attachment must be affordable. Finally, it has to be easy to make using inexpensive material and manufacturing processes.

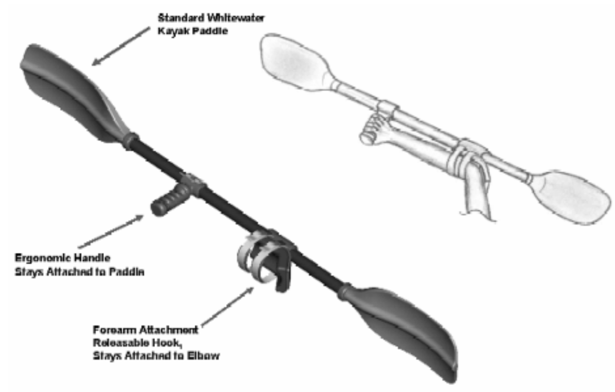

Figure 16.59. Solid Model and Hand Drawing of Paddle and Attachments.

It was determined that a two-component attachment (see Fig. 16.59) could perform the function of the proposed design. The handle is strapped to the paddle and remains on the paddle during use. The forearm attachment is strapped to the user's forearm. It hooks onto the paddle when the user is paddling and can be easily detached when the user wants to release the paddle.

The handle has several unique features (see Fig. 16.60). The grip has a large diameter and there are finger and thumb slots to fit the natural position of a person's gripping hand. The finger and thumb slots have a rubber-like material molded into them using a mold-over injection molding technique. There are enlarged areas behind the user's hand and between the user's thumb and forefinger. This will prevent

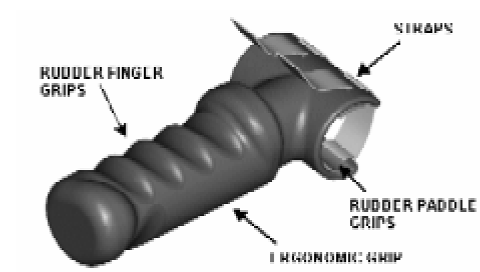

Figure 16.60. Handle Component.

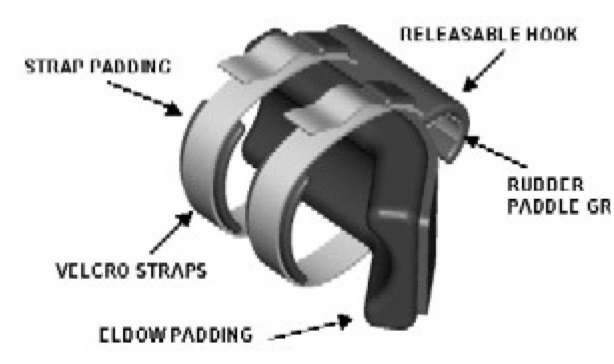

Figure 16.61. Forearm Component.

the hand from sliding forward or backward when the paddle is pushed in a right-hand stroke and pulled in a left-hand stroke. The handle has a C-shaped end, which allows the paddle to be pushed easily. The straps are tightened after the handle is in place.

As mentioned above, the forearm attachment (see Fig. 16.61) is strapped to the user's forearm near the elbow. It consists of elbow padding glued to a plastic "hook" component, which has two paddled Velcro straps and rubber paddle grips. The straps comfortably secure the arm to the attachment. The rubber paddle grips keep the paddle from twisting or sliding. The hook is allowed to deflect when the user twists the arm out of the paddle (see Fig. 16.62). The hook is designed to remain stiff under a normal paddle stroke, but allow the paddle to escape when the user wants to remove it or if it gets caught on something in the river.

The Cambridge Engineering Selector is used to determine the best material for each part. The handle is a stiffness-limited design and the forearm attachment is a strength-limited design. The indices are then used to determine a material with the lightest weight, lowest cost, and precise mechanical properties. For the forearm attachment, epoxy/glass fiber was chosen because of its excellent strength properties, since this part will carry much of the load from paddling. Polypropylene was chosen for the handle because of its low cost and ease of manufacturing. Data from the Human Strength handbook by Dreyfus was used to determine the correct forces that one could implement on this device. Sizing of each component was done based on the required strength. Once the parts were sized, a process selection was done to determine the best form of manufacturing. Injection molding was determined to be the most suitable process for making the handle and forearm attachment. A prototype was constructed and successfully tested (see Fig. 16.63).

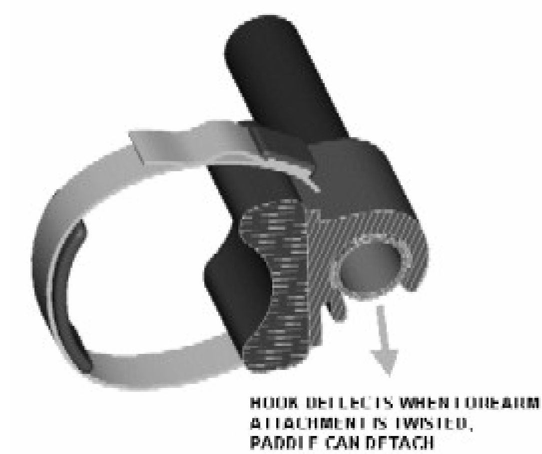

Figure 16.62. Forearm Component X-Section.

The materials cost $10 and about four hours of machining and assembly time were required. The part production cost was determined to be $11.48 for 100,000 units.

Figure 16.63. Prototype Images.

THE ONE HAND WASHER

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University of Massachusetts
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INTRODUCTION

The one hand washer provides a means of hand washing for someone who has only one hand. The design concept was created, and then the material choice was optimized using the Cambridge Engineering Selector (CES) software in conjunction with a merit index. The processing was also selected using the CES software. Finally a cost analysis was conducted based on the optimal material and corresponding process. The result is an ergonomic, attractive, and inexpensive design (see Fig. 16.64) that will assist people with disabilities who have the use of only one hand.

SUMMARY OF IMPACT

Hands are generally washed together, but for a one handed person, this task is challenging. The one hand washer provides a solution to this problem. It can be easily affixed to the counter or sink, and offers an array of cleaning modes (soft sponges, abrasive sponges, and scrub bristles) that can be used with only one hand.

TECHNICAL DESCRIPTION

The hand washer needs to be stiff, lightweight, and low cost. These three criteria were combined together to give a merit index. The hand washer was designed so it can be cleaned in a household dishwasher. Further material selection criteria were determined to be: corrosion in fresh water and maximum service temperature (165°C). The CES software was used to maximize this merit index and the other considered criteria, and find the optimal material for the one hand washer. The resulting optimal material was high-density polyethylene. The processing was also selected using the CES software. A proof of concept model was constructed (see Fig. 16.65).

Figure 16.64. One Hand Washer Design.

By considering the mass range, the shape, the allowable surface roughness, and the required tolerances, the process of injection molding was determined to be the best. In conclusion, the one hand washer is ergonomic, attractive, inexpensive, and useful.

A cost analysis was conducted based on economic data from the CES software. The number of units produced was considered to be 100,000. The final cost of the one hand washer was $5.09.

Figure 16.65. Proof-of-Concept Picture.

LIGHTWEIGHT KNEE BRACE

Designers: P. Veiga, M. Mudawar, and B. Cerone
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INTRODUCTION

Knee related injuries are one of the most common injuries that occur in sports. This causes a demand on the market for a knee brace that will protect people who are either recovering from an injury or wishing to prevent an injury. Products on the market now are either too expensive or bulky and are not aesthetically pleasing. The objectives were to design a product that would be lightweight, very protective, aesthetically pleasing, and reasonably priced.

SUMMARY OF IMPACT

Knee braces available on the market today range from $85 to $600. The most inexpensive products are bulky, not aesthetically pleasing, and do not function well. This design is rigid, compact, simple, and inexpensive. It will prevent knee injury by restricting unnatural movement, such as hyperextension, hyperflexion, and buckling. This product is geared to for athletes who are looking for an inexpensive but effective brace.

TECHNICAL DESCRIPTION

Design criteria for a preventive knee brace include following:

- The brace must withstand 300 pounds of force on the hinges due to hyperextension, hyperflexion or side impact with little to no deflection;
- The brace should be comfortable and easy to use;
- Materials must have good corrosive resistance; and
- Materials must have good wear resistance.

The brace consists of four major parts: the frame, the two hinges, the Velcro straps, and the foam padding (Fig. 16.66, foam padding not shown). Fig. 16.67 displays the design of the hinge. The hinge is designed to restrict the knee past 180 degrees and restrict flexion of no less than 15 degrees. These critical angles were determined to be the angles at which, when surpassed, injury may result.

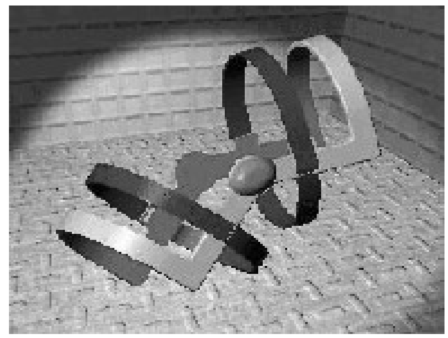

Figure 16.66. Solid Model of Preventive Knee Brace.

Merit indices were derived to maximize strength while minimizing mass and deflection for the hinges. Using these indices, the Cambridge Engineering Selector (CES) software produced unidirectional Carbon Fiber Reinforced Polymer as the optimal material and that the process of injection molding of themosets would be used to create the desired shapes. After analyzing the stresses that could be applied to the pins, it was found, by CES,

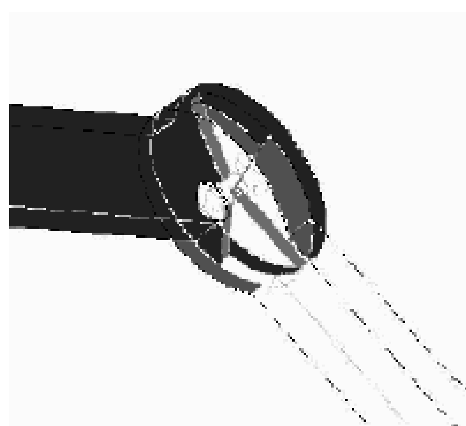

Figure 16.67. Hinge Design.

that the same material could be used. By limiting wear and corrosive resistance and accounting for comfort, closed cell polyurethane would be the optimal material used for the padding. The prototype is shown in Fig. 16.68 and Fig. 16.69.

A detailed cost analysis was done yielding a total cost per unit of $21.80 at production volume 100000 units.

Figure 16.68. Prototype in Full Flexion.

Figure 16.69: Prototype in Full Extension.

UNIVERSAL WHEELCHAIR SPLASHGUARD

Designers: Kevin Beaulieu, Tony Cheung, and Mike Ross
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INTRODUCTION

Wheelchairs are a mode of transportation exposed to a wide variety of weather conditions and road surfaces. Beaches, salty streets and walkways produce a corrosive environment. When traveling over wet surfaces, water, snow, or mud, etc., debris can be thrown up from the wheel's rotational movement. This often soaks users. Although some wheelchair models come with splashguards incorporated into their design, most do not.

SUMMARY OF IMPACT

There are currently several different wheelchair designs on the market. Lack of standardization makes it difficult for most wheelchair users to find a product that can be used with any particular wheelchair design. An adaptable, symmetric design that incorporates corrosion resistant materials would be highly beneficial. The adaptable splashguard will be universal for most wheelchairs. Aluminum and low-density polyethylene parts allow the system to be manufactured and installed inexpensively.

TECHNICAL DESCRIPTION

The splashguard system was broken up into two main sub-assemblies for material selection (Fig. 16.70). The first assembly was the actual splashguard itself. It was determined that a material needed for its purpose would have to be light, tough against fast fracture, corrosion resistant, and cost effective. Strength was included so that a 75N pulling force could be withstood. This force was determined from the Human Factors catalog by Human Scale. Using the Cambridge Engineering Selector software, the material chosen was low-density polyethylene.

The second assembly included the bracketing clamp and swivel joint. The criteria for this included the same parameters as the splashguard, however stiffness was used to replace strength. Stiffness was included to assure that the system would maintain a

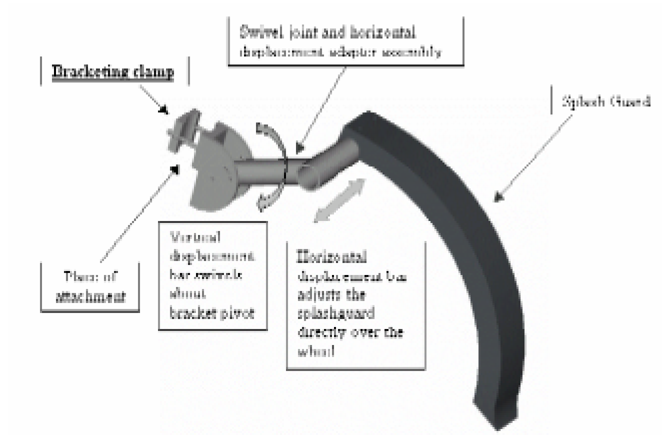

Figure 16.70. Universal Splashguard Design.

stable position under any loading. The required load considered was the weight of a 250 pound person standing on the swivel joints. The material selected was aluminum. The two material selections were inexpensive, corrosion resistant and lightweight. The aluminum allowed standard parts to be included (aluminum tubing, and plate aluminum).

With known material properties and specified loading, sizing was done to ensure that the parts would not yield. Some dimensions were fixed due to geometry constraints. The swivel joints had specified lengths of 0.15m and 0.169m and this required that applied moments of 188 Nm and 167 Nm had to be supported respectively.

Manufacturing processes were considered for 100,000 units. The process selected for the splashguard was injection molding. The only aluminum part that needed to be manufactured was the bracketing clamp. It was determined that sheet form aluminum could be stamped to produce the bracket.

The system works by attaching the bracketing clamp to a vertical bar in the back of the wheelchair. The swivel joint can then be fixed into place with a series of pins. One pin allows the joint to pivot while the other allows the angle of the swivel to be secured at 15-degree increments. The bracket clamp and swivel angle should be set to give the proper clearance above the wheel. The horizontal adjustment bar allows the user to adapt to the necessary wheelbase, and is secured with a set-screw. Fig. 16.71 and Fig. 16.72 show the prototype of the splashguard.

Figure 16.71. Assembled View of Prototype.

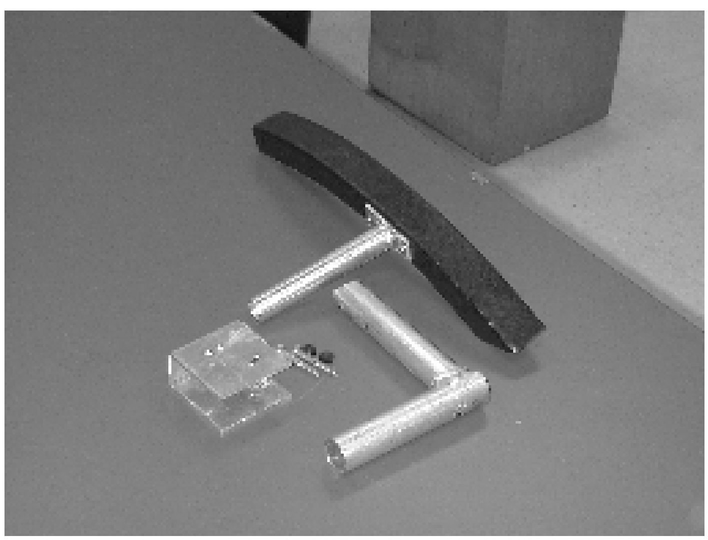

Figure 16.72. Unassembled View of Prototype.

PORTABLE INTELLIGENT DEEP PRESSURE VEST FOR AUTISTIC CHILDREN

Designer: Jeremy K. Paskind
Supervising Professor: Sundar Krishnamurty, Ph.D.
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INTRODUCTION

Clinical studies have shown that the application of deep pressure around the upper body and shoulders of autistic children has a calming effect on them. These children in particular have difficulties adapting to their environment and remaining composed in normal every day settings. Little changes often set off elevated excitement states or in severe cases, seizures. Thus, a pressure vest was designed to provide autistic children with deep pressure stimulation around the upper body and shoulders.

SUMMARY OF IMPACT

Current products on the market that address this disability include weighted vests, used to simulate pressure on the upper body. These apply static pressure onto the shoulders of the user at all times while worn. Other large pressure devices also exist in limited quantity, convenience, and economical cost. Each current design has major limitations to their effectiveness or availability of use at all times when pressure is needed.

The Intelligent Vest will to some degree combine the two existing technologies. It will have the portability of the weighted vests, with the selective pressure application of the pressure machines. It will apply deep pressure instead of static pressure, similar to the "squeeze" machines, only when needed by the user.

TECHNICAL DESCRIPTION

Since the vest is to be worn on a regular basis, primarily by young children, one of the most important design considerations is its level of comfort. Since children vary drastically in size, the design of the vest must be able to be replicated for each individual user, regardless of the user's physical dimensions. The vest should also be aesthetically pleasing, which is an important feature

Figure 16.73. Air Containment Tubes on Deep Pressure Vest.

of any clothing article designed for children. Both of these, along with comfortable, lightweight, and non-intrusive mechanics have to be taking into consideration for the creation of the device.

The design uses air to fill up the space inside the vest, causing pressure to be applied to the abdomen and shoulders of the child. The core of the vest design focused on the creation of the inflation bladders that contain the air inside the device. Along with the specifications derived from the recommendations of various parents of children with autism, the final design utilized two "L" shaped tubes fabricated from polymeric sheeting. The "L" configuration was found to reduce the total size of the inflatable while remaining highly effective. Inside each vest, two bladders link together with an adjustable elastic to form a "U" shape that wraps around the upper torso and over the shoulders. An elastic fabric connects the bottom half of each "L" tube to each other and is positioned at the back of the child. Base of the "U" wrap around the torso of the child, just beneath the armpits, while the upper portions extend over the shoulders. The elastic will not only leave room for error in the fit of the vest, but also alleviate unwanted pressure changes caused by normal breathing of the user. The air containment tube design is shown in Fig. 16.73.

The two optimal material films for the fabrication of the vest bladders were low density Polyethylene and vinyl, each with a standard material thickness range from four to eight mil for strength and weight considerations. The four-mil thickness provided more than adequate endurance to the pressure changes during use, while the eight-mil film was found to be necessary only if the user desired extra levels of durability. While the current prototypes were constructed out of the LDPE film, vinyl offered a slightly more durable and more flexible alternative. With UTS of 5800 psi, (about double that for LDPE) and a much more rubbery nature, the use of vinyl will ultimately insure both a longer lasting and more comfortable product.

The inflating and deflating processes of the vest is accomplished using a standard medical DC diaphragm pump. Two of the AA series miniature diagram pumps made by Sensidyne Co. were chosen for inflation and deflation. Both processes are controlled using two, three-way solenoid pneumatic valves. Following extensive research and testing, the series 34 MAC valves were chosen. This model was the thinnest and most economical of all standard OEM solenoids. When no current is applied to the device, the inlet port is connected to the exhaust port on the opposite side. When energized, the outlet ports are switched while at the same time plugging up the exhaust port. A picture of the inflation device is shown in Fig. 16.74.

The final component selection for the vest was the battery packs. Considering the many rechargeable cell types available today, Nickel Metal-Hydride "AA" size cells were chosen. These cells do not have any charge memory (as do NiCd cells) and are chemically more inert than other alternatives such as Lithium Ion or Nickel Cadmium. While Lithium Ion cells are much lighter, for the current vest design, they were not used for safety issues. More research needs to be done in this area to produce a lighter, safer battery pack. In an effort to distribute the battery weight, the pack was custom constructed in two, five-cell clusters, each to be worn around the hips of the child. The cells were connected with wire instead of normal battery tabs to insure that it was flexible and could follow the contour of the curves of the body. All the devices were then mounted to a belt that was incorporated into the vest, so as to make the power system removable from the rest of the unit.

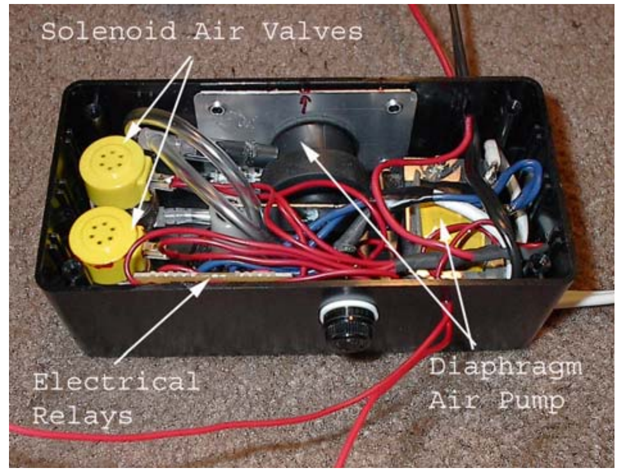

Figure 16.74. Vest Inflation Module.

The excitement levels of autistic children are known to be correlated with the output readings of a Galvanic Skin Response (GSR) monitor. GSR measures the conductance of one's skin. As the excitement level of a person increases, there is an increase in sweat production, thus causing increases in electrical conductance. Two small electrodes are placed on the fingers or soles of the feet to take the best measurements. A small computer analyzes the sensor outputs and returns a voltage that can be used to control the vest. The output of the GSR can be fed into a small computer chip, programmable to control the pressure in the vest.