# CHAPTER 13
# ROSE-HULMAN INSTITUTE OF TECHNOLOGY


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# ASSISTIVE DRUMMING DEVICE FOR MUSIC THERAPY

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## INTRODUCTION

Currently, over 10,000 infants are diagnosed with cerebral palsy in the United States each year. This condition affects the motor control region of the brain which can impair a person's fine and gross motor abilities. Musical therapy has been shown to improve motor skills and even alleviate some of the pain associated with cerebral palsy. An assistive device was developed to help individuals with compromised motor abilities play the drums independently using a simple hand-driven interface which causes a motor-driven mallet to strike a drum (see Figure 13.1). This assistive drumming device will enable users to play the drums in a safe and independent manner without restricting them to certain skill-dependent instruments. Some existing commercial solutions use mechanical switches to trigger drums sticks to tap a percussion instrument. The problem with the commercial solutions is that they are not easy for users with limited strength since they require a high level of force to activate the switches.

## SUMMARY OF IMPACT

The Assistive Drumming Device allows students with physical disabilities to participate fully in music therapy sessions. Students who previously found it difficult to play the drums can now use the device to effectively play and accompany the therapist during music therapy. Previously, the students performed a vertical striking motion with their hands to play the drums which was uncomfortable and resulted in fatigue early in the therapy session. Implementation of the new technology allows the students to use horizontal hand motions, which are easier and less tiring. As a result, students receive the maximum therapeutic benefits from these sessions.

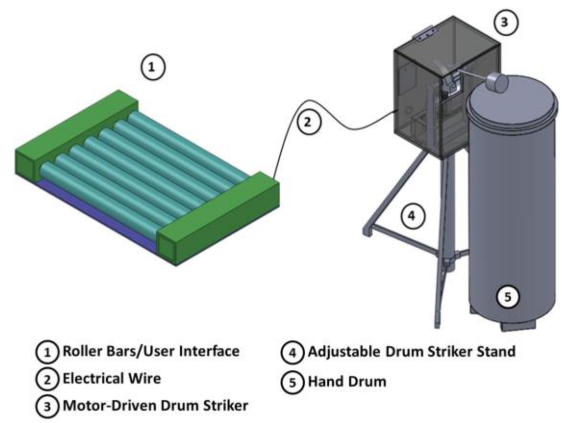


Fig. 13.1. Overview of Assistive Drumming Device: The user interfaces with the roller bars (1) using their hands which send a signal to the drum striker (3) to hit the drum (5) and create a sound.

## TECHNICAL DESCRIPTION

The design encompasses two primary systems that function together to meet the needs of the client. A trigger and a striker component interface with one another to meet the needs of the client as a final design solution. In essence, the trigger device will provide a means for the user to control the striking of the drum which is carried out by the striker device. In order for the trigger device to communicate with the striker device, instrumentation was implemented to electrically connect both devices. This naturally divides the final design into three components which will be referred to as subsystems: the trigger subsystem, the striker subsystem, and the electrical subsystem.

The trigger subsystem features plastic roller bars which can be easily rotated by a gentle waving motion of the users' hands or arms over the top of the bars. Rotary encoders from the electrical subsystem transduce this rotational motion into a digital signal.

This signal then travels to the striker subsystem which houses the electrical subsystem components. The digital signal is interpreted by a microcontroller which drives the motor to rotate the drum mallet of the striker subsystem. The striker subsystem contains an adjustable housing box which encases a rotatable drum mallet. This mallet is motor-driven and when engaged, it swings down to strike a drum placed adjacent to the striker subsystem. Once a complete striking cycle occurs, the electrical subsystem restores the original position of the mallet in order to strike again (see Figure 13.2). The approximate cost of the assistive device is $500.

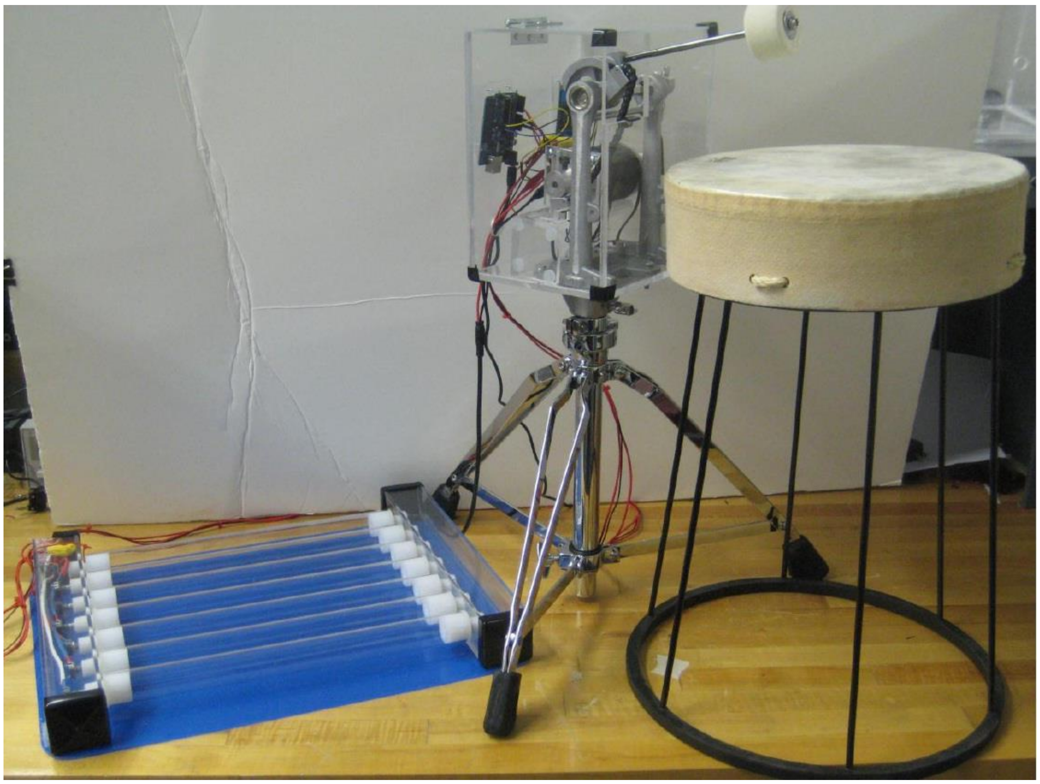

Fig. 13.2. Assistive drumming device as constructed.

# MULTI-SENSORY STIMULATION DEVICE

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## INTRODUCTION

The multi-sensory stimulation device (see Figure 13.3) was designed for a facility that provides a variety of services including vocational training, assessment, employment assistance, and individual therapy that allow their clients with physical and cognitive disabilities to become more independent in their daily lives. The goal of the device is to provide multi-sensory stimulation therapy to both over- and under- stimulated adults with cognitive disabilities. This device is able to provide stimulation to the user's sense of smell, sight, hearing, and touch. Aroma beads are used to produce different scents and to stimulate the user's sense of smell; touch rollers with different interesting textures are used to stimulate the user's sense of touch; picture rollers along with different colored LEDs that emit light in soothing patterns are used to stimulate the user's sense of sight; and a relaxing song accompanies these interactions in order to stimulate the user's sense of hearing. This device runs on the concept of themes; therefore, each type of stimulation has a portion that coincides with each theme. There are four themes contained within the device: a beach theme, a winter theme, a farm theme, and a meadow theme. Two textures also accompany each theme (one from each touch roller), as do one scent and two pictures. For LEDs, colors that are related to each theme are used in a pattern, such as blue and green LEDs for the beach theme. There is also an LCD display which communicates to the user which theme they are experiencing. The control panel, located on the back of the device, allows the user's therapist to personalize the user's experience by indicating whether the user is over- or under- stimulated, which theme they would like to experience, and the amount of time they would like to use the device (five minutes or fifteen minutes).

## SUMMARY OF IMPACT

The goal of the device is to provide multi-sensory therapy to the user. Caregivers have reported improvements as a result of multi-sensory therapy, such as an improvement in concentration, a better relationship between caregiver and patient, behavioral improvements, improvements in self-awareness, and increased social and environmental interactions. Since the Hamilton Center has a variety of patients, each with a different level of ability, it was believed that, if the concepts of multi-sensory therapy could be harnessed and tailored to a more specific range of cognition, it would be noted by an improvement in patient well-being. This design could be easily modified to provide sensory stimulation therapy to adults or children of any cognition range. Improvements have been seen in patients with disabilities ranging from learning disabilities to dementia to chronic pain using these methods. This device is very portable, easy to maintain, and would be ideal in instances where more than one person would be using the device, such as a day-care center, a school, or a doctor's office.

## TECHNICAL DESCRIPTION

This project utilizes several subsystems: an auditory subsystem, a visual subsystem, a structure subsystem, an interactive subsystem, an electronics subsystem, a tactile subsystem, and an olfactory subsystem. All subsystems are controlled and powered by the electronics subsystem: upon start-up of the device, an LCD/keypad module relays user choices to a PIC18F4520 microcontroller. This microcontroller communicates with a second PIC18F4520 in order to evoke a particular response from the subsystems. With different scenes chosen by the user, different songs are played by a speaker in the auditory subsystem, using a playlist built into the program. For the duration of sound emission, two servos move the tactile subsystem rollers to a pre-determined location, while the PIC emits a constant signal to the second microcontroller. The second signal drives the visual roller. A second PIC controls the olfactory and interactive subsystems. As the PIC receives the signal from the first microcontroller, a constant signal is send to the fan, driving it continuously. Another servo moves the olfactory bowls to their appropriate positions, based on the port through which the signal is received. Twenty LEDs are controlled by the signal, which varies the colors that are observed. By the implementation of several loops in the program to ascertain the operating parameters requested by the client, the device can accept and execute several settings for different scenes and different stimulation levels of the user. Two time increments are available for each setting, five minutes and fifteen minutes (instead of a timer, the program monitors the length of the songs that are playing, terminating a positive signal when a song ends). The entire unit is powered by eight AA rechargeable batteries, which reduces the operating costs. The final price for the unit was $400.

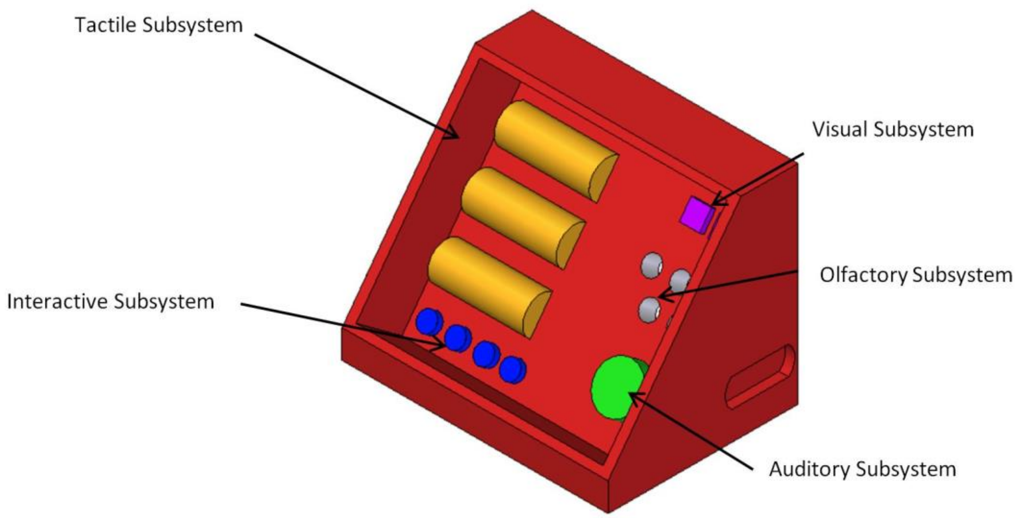


Fig. 13.3. Schematic drawing indicating the different tools used for sensory stimulation.

# ASSISTIVE DEVICE FOR OPENING POP CANS AND REMOVING THE TABS

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## INTRODUCTION

For persons with limited fine motor control, opening an aluminum pop can with the attached tab can be a difficult task. Additionally, it can be challenging to remove the pop tab from the aluminum can once it has been opened. No prior devices or processes were available in the market to assist persons facing this problem. The motivation behind the device was to provide consumers who have limited fine motor control with a durable and safe device for opening pop cans and removing the pop tabs, allowing them to perform the task independently while remaining active in the process.

In order to design this particular device (see Figure 13.4), specific criteria were identified which were of vital importance for the functionality of the device, as well as criteria that would enhance the device. In order to make this device feasible for use by consumers, the device had to accommodate the physical limitations of potential users by incorporating one of the following activation methods: one hand requiring no pincher-grasp motion, activation via foot pedal requiring less than 15 pounds of force, or activation with an applied elbow or hip force. Also, in order to make the device feasible, it had to be free of all sharp edges that could cause injury and the device had to dispense the removed tab to the user or to a collection bin. Desired attributes that would increase satisfaction with the device included increasing the number of users the device could assist, improving the robustness of the design over its lifetime, minimizing the potential for users to harm themselves while using the device, and decreasing the time it takes to open the pop can and remove the tab.

## SUMMARY OF IMPACT

The device improves the ability of a person with limited fine motor control to independently access the contents of a pop can. With the help of this device, the clients will be able to operate the device on their own to open their beverage. Since the device also removes the pop tab, the users can collect the pop tabs and donate them to charities such as the Ronald McDonald Foundation.

Fig. 13.4. The Can Opener device.

The assistive device is durable. The materials used in the construction of the device were chosen to increase the lifetime of the device as well as to provide robustness to the design. Additionally, the design keeps the user separated from the internal mechanisms of the device during operation in order to prevent any harm to the user and produces an opened pop can that does not pose any threat to the user from sharp edges on the can.

## TECHNICAL DESCRIPTION

The full design (see Figure 13.4) rests on a custom-made table set at 31 inches high. The device housing, which is composed of ABS plastic, has an effective internal compartment of 24 inches by 12 inches by 11 inches and contains the components which will act on the aluminum can. The right and top walls as well as the front door are clear plastic to provide the user with a direct view of the internal operation as it occurs. Each housing wall is fastened to the adjacent walls via aluminum trim and screws. The housing is recessed 0.5 inches into a 17 inch by 27 inch by 2 inch wood base.

Once the front door is opened, the user is able to pull the tracked cup holder out and insert an unopened aluminum pop can. The holder is pushed back into place which positions the can in the exact location for the can opener to appropriately contact the can top's rim. After the front door closed, the spring-stop is pulled on the right side of the housing and the can opener falls onto the can, with its tip piercing the can top just inside of the rim. By pulling the handle of the can opener downward from its vertical position to 90 degrees, the tip is pulled into the can opener body and associated turning gear. The user activates the can opener by rotating the handle clockwise, which turns the can inside the housing, cutting the lid as it rotates. Located on the can opener is a tab wedge which falls inside the rim and slides under the tab as the can rotates. Once the can opener has fully cut around the can rim, the handle is returned to the vertical position and the aluminum can is released from the can opener while the tab and lid remain attached to the tab wedge. A handle on the right side of the housing is then raised up which drives a pulley system under the table to raise the can opener up until it is caught once again by the spring-stop.

As the can opener returns to its initial position, the tab wedge is turned clockwise until the lid strikes a point on the can opener and is forced off of the tab wedge and onto a ramp. The high density polyethylene (HDPE) ramp allows the lid to slide away from the can opener location and onto a platform, centered under an arbor press tip. The handle, which is still raised up by the user, can then be driven down to the table, activating the arbor press and punching through the rivet in the center of the lid. The tab and lid are effectively separated and the handle is raised up to retract the press tip. A resistance gate then allows the handle to come to rest such that the punch tip is inactive but can be overcome by the user during the punching action.

With the tab and lid separated, the user moves to the left side of the housing and pulls on the handle extending from the wall. This handle activates a spring-loaded slider, which previously situated the lid as it fell to the press platform, and pulls the lid and tab onto another HDPE ramp which facilitates their separation and exit from the housing into their respective collection bins. The user may then return to the front of the device and retrieve the opened pop can.

The approximate cost of this design is $700.

# ASSISTIVE DEVICE FOR MUSIC THERAPY SESSIONS

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## INTRODUCTION

A design was required to aid the client, a music therapist, in administering music therapy to two of her patients with cerebral palsy. The design was required to be melodic while also taking all of the patients' physical constraints into account. This will provide the client the ability to provide a better therapy session for these two patients, both physically and cognitively.

The client is a music therapist who specializes in therapy with patients with neuromuscular disorders. She focused the scope of this project to help two of her patients, both with severe cases of cerebral palsy. Currently, the majority of their time in therapy sessions is spent playing the keyboard. Because the patients cannot control individual finger movements they have difficulty playing a single note at a time. Typically the patients fatigue quickly during their sessions, and are not able to hold their arms out in front of them.

## SUMMARY OF IMPACT

The prototyped design is a novel musical instrument (see Figure 13.5) which meets all of the needs of the client. The treadmill belt allows for alternative playing modes which the client can customize to the patient based on his or her motor skills. The user interfaces with the Tread-Tempo by lightly touching plastic note markers. In contrast to traditional keyboards, these note markers are much larger than keyboard keys. This allows the client's patients to play a single note with a fist or palm. As a result, the instrument is still melodic but much easier to play for patients with limited finger dexterity or muscle control.

## TECHNICAL DESCRIPTION

The user console is a 0.25" thick Plexiglas box to help ensure robustness during use. The console is mobile and can be placed on a desktop or on a wheelchair. Internally, the console incorporates a miniature treadmill belt system (Tread belt), touch screens, stepper motor, microcontroller, and keyboard components. The Tread belt system is composed of nylon roller chains, sprockets, gears and bearings. Strips of polyethylene are woven onto the roller chains using a monofilament nylon thread to represent markers that correspond to a note. The sprockets are fixed to the side of the front and back walls of the device by inserting a drive shaft through them. The drive shafts are inserted, on either side of the wall, into a bearing that is fastened with screws to the Plexiglas panels. The gear on the drive shaft is linked to a gear on the stepper motor which relays information from the microcontroller. Under the belt, are stationary touch screens which lie on a Plexiglas platform, giving the sensitivity necessary for a microcontroller system to sense the physical input of the user/patient. The system recognizes which marker/note is being contacted and plays the corresponding note based on the position of the belt. The microcontroller also controls the client interface. The client interface has additional switches installed to let the client control the power to the motor, the speed of revolution, and the mode of play (stationary, manual, rotation).

Also located on the front panel of the console, is the original Casio SA76 44-key keyboard front panel, with all the switches and dials. This interface allows the user to control the power, volume, instrument tone, and background beats just as a standard keyboard. The Tread-Tempo has a foot remote. The remote is used for Mode 2 (manual) whereby the therapist can select notes for the patient to play on cue. The remote has buttons protruding from an angled face which allows the therapist to select a desired note. The last feature of the design is an ergonomic laptop stand to provide for optimal positioning for each individual user.

The cost of parts/materials was approximately $650.

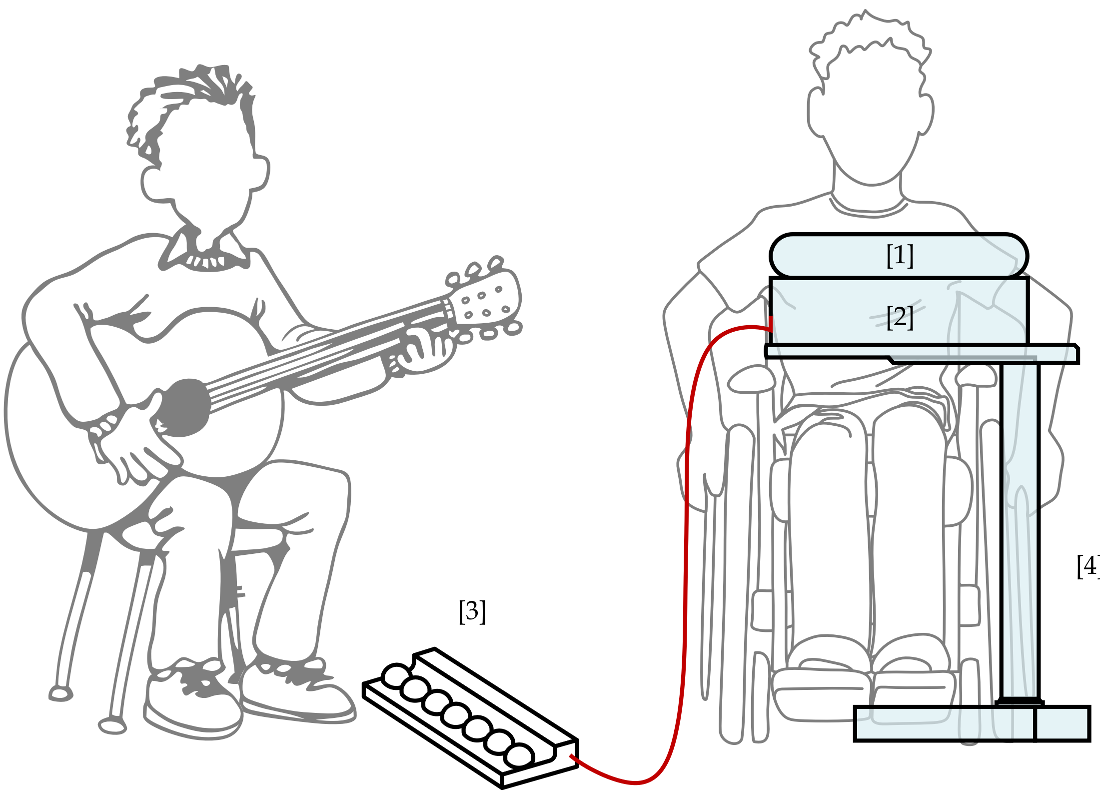


Fig. 13.5. Four subsystems in setup with client and patient—the tread belt [1], the console [2], the remote [3], and the stand [4].

# HANDS-FREE SECURITY SYSTEM

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## INTRODUCTION

The client for this design project has Spinal Muscle Atrophy, a disease that impacts the nerves of the body and often results in reduced muscle function. She currently uses a wheelchair as her primary mode of transport, but has reported difficulty in gripping an object that is smaller in diameter than a standard colored marker. Her husband works outside of the home, leaving her alone in the home in a city with an above average crime rate for a large part of the day. As it is the desire of the client to feel secure in the home while maintaining her independence, it became the desire of the team to design a hands-free system that allows the client to independently lock and unlock her door from the interior of the home.

Prior to the project, there existed very limited solutions that were applicable to the client's situation, the best of which was a remote-controlled system. However the client's condition prevented implementation of any of the existing commercial solutions for a variety of factors unique to her situation and/or condition. The client specified that she preferred the ability to both lock and unlock the door from within the home to maintain her freedom and her sense of normalcy. The client also stated that she desired an inconspicuous system for the home.

## SUMMARY OF IMPACT

The system designed provides a level of freedom and independence to the client that was previously unavailable to her. Using the system, she can secure her home from the inside with limited physical effort; the only step in triggering the system is to move her wheelchair within the range-of-view of the modified motion sensor. Should she have a visitor to the home, it will now be much easier for her to open the door to welcome them in, and then to secure the home upon their departure. As the client previously depended on others to lock and unlock her door, she often felt trapped within the home and depended on her husband and friends to keep her safe. With this device, she is able to implement her own safety precautions.

## TECHNICAL DESCRIPTION:

The design (see Figure 13.6) includes three separate subsystems with modifications incorporated for greater functionality and better manufacturing practices. The first of these subsystems is the user interface of the system. The main component of this subsystem is the motion sensor which is located within an exterior plastic housing. This housing was designed to be mounted on the wall next to the door in order to obtain the signal from the client whenever she or her husband wished to lock or unlock the door.

In order to reduce a potential misfiring of the system from unintentional movement close to the front door (i.e. retrieving an object from the closet located directly to the right of the door) the range of view of the motion sensor was limited. The range of the motion sensor has been focused using the exterior housing so that, rather than detecting a cone-shaped range, it sends an infrared beam that reaches 2 meters from the housing through a 0.3″ diameter hole in the front face of the part. The housing was designed to encase not only the motion sensor, but also the printed circuit board, microcontroller, and h-bridge parts from the electrical components subsystem.

The electrical components subsystem was built by using a computer program to code a microcontroller chip to translate the input from the motion sensor into an output for the motor. A few changes to the initial schematic were made to ensure that the motor would have enough torque and that the battery would power the system without applying too much voltage to the chips. The electrical components subsystem was designed to be triggered by input from the motion sensor. When the sensor detects movement, the microcontroller sends an electrical signal to the h-bridge which then turns the motor clockwise or counterclockwise, depending on the current state of the lock.

The locking mechanism subsystem was constructed to maneuver the thumb turn from locked to unlocked position (and vice versa). This motion was determined and controlled by input from the stepper motor. In order to translate the rotation of the motor to the rotation of the thumb turn, a system of gears was designed and integrated into the internal workings of the deadbolt.

Following the manufacture of the gears, each gear was mounted upon the hub to which it turns. For the motor gear, the part was mounted upon the rotating shaft and the lock gear was mounted onto the slotted shaft of the front plate of the deadbolt lock. The motor was mounted to a metal plate that was manufactured to fit within the plastic housing. The plate was attached to the housing using two small screws, and the plate also had holes to allow for the shaft of the lock and the motor gear to pass through. This mounting plate functioned in the alignment of the two gears to ensure that they interlocked in order for the system to work effectively.

The total cost for developing the prototype was $350.

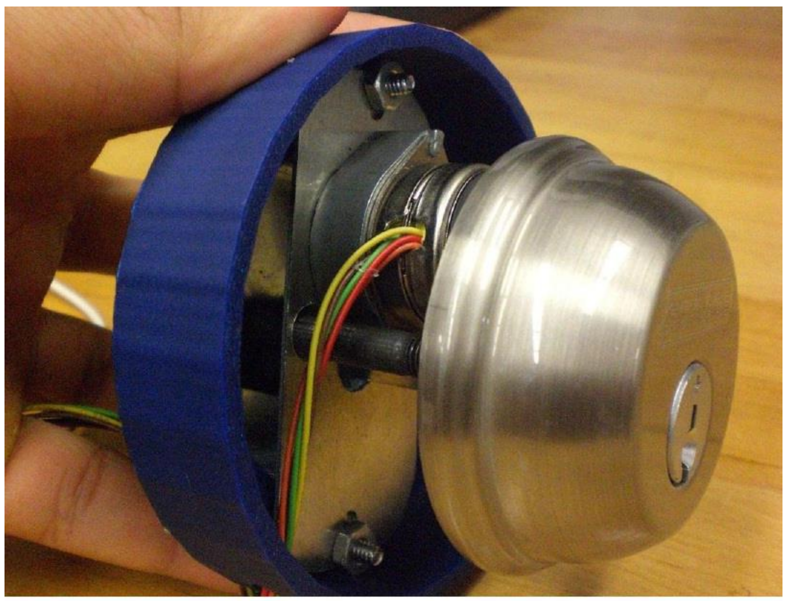

Fig. 13.6. View of the assembled deadbolt system. The motor receives a signal from the motion sensor via a microcontroller and operates a pair of gears to turn the deadbolt to the locked or unlocked position.

# LOCKER INDEPENDENCE

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## INTRODUCTION

A system was developed to assist a student with Spina Bifida with the task of opening her locker. The final design (see Figure 13.7) utilizes RFID technology and requires the user to push a button to unlock and open the locker door. This approach was useful for the student because she has difficulty remembering passwords, lifting the latch on the locker, and opening the door. There was no commercially available solution that addressed all of the needs of the client.

## SUMMARY OF IMPACT

The implemented design has the potential to improve the student's quality of life at school because it enables her to independently access her belongings with ease and in a timely manner. Previously, the client required extra time to put away or retrieve her belongings from a locker, which required her to leave early from class or arrive late. This design unlocks the locker door and opens it with the touch of a button. In addition, it keeps the student's locker secure from other students.

This design allows students with disabilities to focus on what is important to them – studies, friends, enjoying life – instead of being reminded of what they are not able to do. It will therefore boost the student's self-esteem and confidence. The user will be able to spend more time in class learning, too.

## TECHNICAL DESCRIPTION

The automated locker door opener uses a push-button activated radio frequency identification (RFID) system to signal a microchip-controlled pair of actuators to lift the latch and push open the door on a basic side-hinge locker. The automated locker door opener can be described using three subsystems: the security subsystem, the actuator subsystem, and the connections subsystem. The security subsystem is the RFID reader, which limits access to the locker to the person in possession of the correct RFID tag card. The actuator subsystem contains the two actuators, which work in tandem to move the latch and door of the locker. The connections subsystem is centered around a programmable microchip which uses feedback from the RFID reader and two push-buttons to control the movements of the actuators. Each of the subsystems is powered by two nine-volt batteries.

Operation of the automated locker door opener begins with the user (and the RFID tag card) standing in front of the locker in which the device has been installed. The user pushes a green button and the RFID reader activates and scans for an RFID tag that has been granted security clearance. Upon recognition of an accepted RFID tag, the RFID reader sends a signal to the microchip. The microchip then activates the first of the actuators to lift the latch on the locker door, followed by the second actuator extending to open the door. The second actuator retracts upon full extension, so that the user is not impeded from closing the locker door at any time. When the user is finished accessing the locker, the door is closed and the red button on the exterior surface pushed. The first actuator then lowers the latch of the door, which secures the contents of the locker.

Security is ensured by two main mechanisms: read range and static actuator resistance. The read range of the HID ThinLine II Proximity Card Reader is approximately 6 inches. This ensures that the user is standing in front of the locker when the device activates rather than passing in the hall when the green button is accidentally depressed. The actuators also have a static resistance of 50 pounds of force which prevents possible thefts by physically denying access to the locker contents. The approximate cost to build and implement this device was $550.

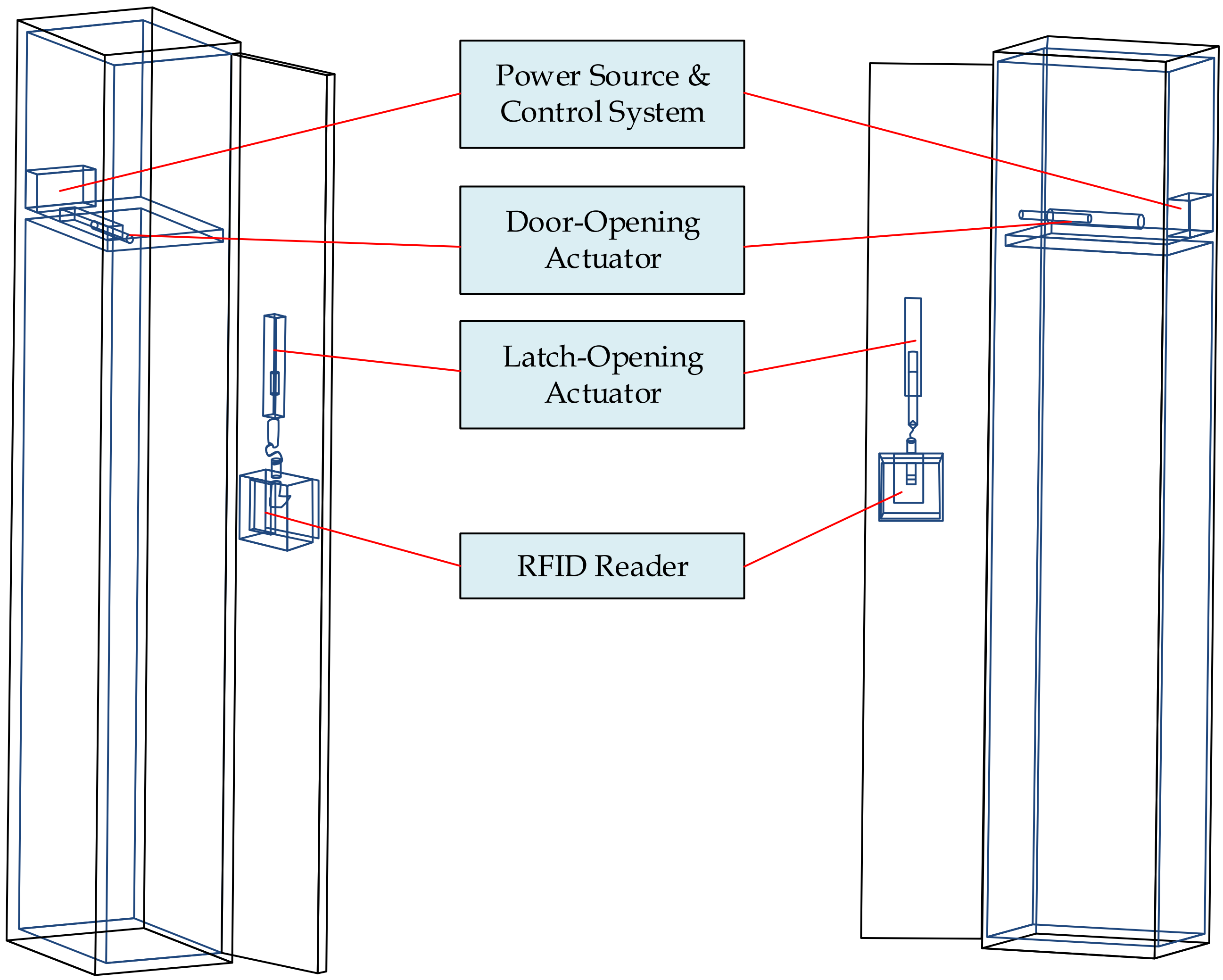


Fig. 13.7. Assembly drawing of the Locker Independence Design illustrating the various design components.

# ELECTRONIC FOREARM PROSTHESIS

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## INTRODUCTION

The client for this design project is a kindergarten student with bilateral ulnar and radial hypoplasia, a condition that has resulted in the absence of forearms and the presence of only two fingers on each hand. The condition limits his strength and range of motion, and causes him difficulty in everyday tasks such as writing, brushing his teeth, and using the restroom independently.

There are many existing prosthetic devices to assist individuals with missing limbs; however, these solutions are not viable for this client since he has functional fingers that extend from his humerus. Prosthetic devices on the market today do not allow the client to utilize his fingers which prevent him from building strength and developing a greater range of motion. A device was developed last year for this client that operated using pulleys. This device proved to be too difficult for the client to use since it required too much finger strength. The device was also far too large for a child and was uncomfortable for the client to wear and use.

Learning from the previous design, the approach for this project was to develop a device that would be easy to operate, small, and lightweight. While many design concepts were considered, a joystick (see Figure 13.8) was chosen as the mode of operation for the device. The motivation for this approach was to make the device easy to use, durable, reliable, and fun. With those motives, the client could enjoy using the device to help perform his daily tasks.

## SUMMARY OF IMPACT

The device provides a greater range of motion for the client (see Figure 13.9) by performing elbow flexion and extension, extending the user's reach, and allowing the user to grasp a variety of objects. These features allow the user to perform many tasks with more ease and even allow the user to perform tasks that he or she previously could not. Therefore the user's independence is increased by enabling the execution of tasks without assistance.

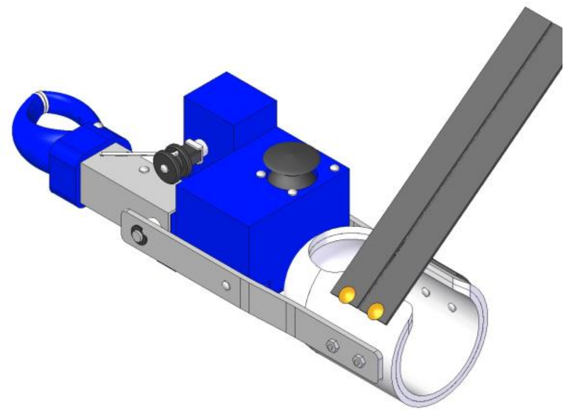

Fig. 13.8. Dynamic Transhumeral Prosthesis.

This device is useful to the client because it is easy to use, durable, reliable, and fun. The client understands how to operate the joystick to perform elbow flexion and extension or gripping. Also the device has proven durable enough to withstand typical day-to-day forces and is reliable because the device continues to function as expected. Since the joystick made the device similar to a game controller, the client enjoys using it.

## TECHNICAL DESCRIPTION

The design consists of four subsystems: socket, user input, elbow, and hand. All of these subsystems are securely attached so that they can function together.

The socket subsystem can be broken down into three major parts – custom fit socket, Velcro straps, and aluminum support bars. The socket is a custom fit to the client's arm to ensure comfort. The Velcro straps are used to secure the device onto his arm, while the aluminum support bars attach the socket to the user input housing.

The user input subsystem is based around a joystick. If the client moves the joystick up or down, it operates the elbow subsystem for flexion and extension. If the joystick is moved left or right, it operates the hand subsystem to grip objects. The joystick, servo motor, H-bridge, microcontroller, power board, and battery are all contained in a rapid prototyped user input housing.

The elbow subsystem consists of four major parts – a pulley, cable, dowel pin, and aluminum bar. The pulley is attached to the servo motor that is operated by the joystick. The dowel pin is attached to the aluminum support bar and user input housing and allows the aluminum bar to rotate about it. The cable is attached to the aluminum bar and pulley, so that as the pulley rotates it moves the aluminum bar for flexion or extension.

The hand subsystem is comprised of four main parts: a stationary finger, moving finger, bar, and linear actuator. The linear actuator is controlled by the movements of the joystick and is positioned inside of the stationary finger. The bar is connected to the linear actuator and moving finger. Therefore when the linear actuator moves, it causes the moving finger of the hand to open and close and grip objects.

The cost of materials and supplies for this device was approximately $425.

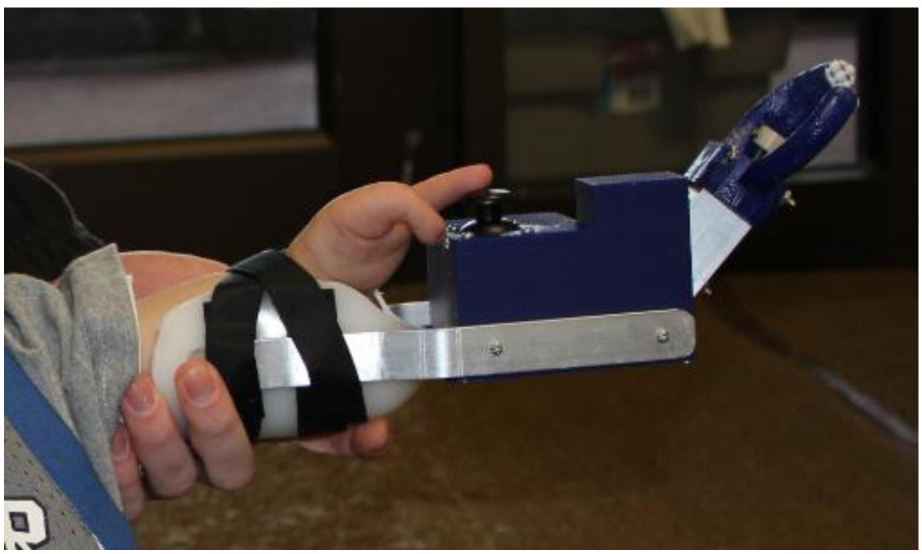

Fig. 13.9. Client operating the finished prototype with his left hand.

# GIVING HIGH SCHOOL STUDENTS LOCKER INDEPENDENCE: AUTOMATED LOCKER OPENING

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## INTRODUCTION

During high school, locker use is an integral part of a student's social routine during the school day. Many students cannot use a standard combination locker or keyed lock by themselves due to various disabilities. The client, Terre Haute South Vigo High School, has approximately 12 students who can benefit from a device that would allow them to secure and access a locker independently. Although this consists of only one percent of the student body, there are students at many other high schools across the country that could benefit from this device. If the same percentage held true for the 14 million students enrolled in high schools across the United States, there are about 140,000 students across the country that could benefit from an automated locker opening device.

Existing solutions are unable to address all disabilities simultaneously. For example, keyed lockers eliminate the use of a combination lock which accommodates users with visual impairments and memory limitations; however, wheelchair users and students with limited dexterity still find it challenging to manipulate the small key. Other solutions eliminate the use of a key through a keypad, a remote control, or a magnetic fob. Although these solutions provide easier mechanisms for unlocking the locker, none of them address latch lifting or locker door opening. The newly developed technology provides a solution that addresses these considerations as the user is able to press the button on the wireless key and the system will unlock the locker, lift the latch, and open the locker door (see Figure 13.10).

## SUMMARY OF IMPACT

Locker use is an important activity for high school students as it functions both as a means to access their

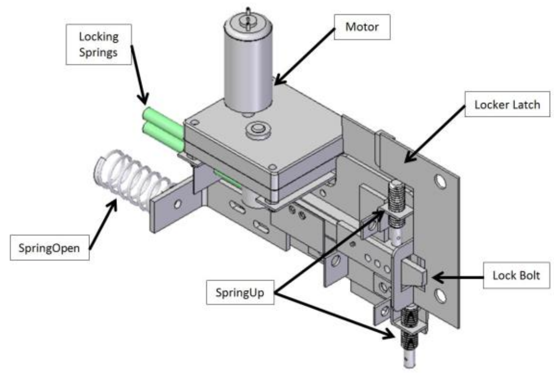


Fig. 13.10. A schematic drawing of the assistive device. The device fits on the inside of the locker door in place of a combination lock. The motor, lock bolt, and locking springs comprise the wireless entry system.

belongings and as a short social period between classes. Many students are not able to independently open their lockers and require the assistance of a faculty member. This makes the student stand out in a negative way by making them feel confined and restricted while additionally using the time of a faculty member that may be needed elsewhere.

The device assists students with muscle, memory, and visual impairments as well as wheelchair users. By removing the need to use the combination lock and by opening the locker door automatically, these students can use their lockers independently. Independent locker use enables students to open their locker and access their belonging in the same way as other students. This allows them to interact with other students during passing periods without a faculty member standing with them. This independence also allows faculty to use the time between periods to prepare for their next class or other activities that may be necessary.

## TECHNICAL DESCRIPTION

The final design is composed of three systems as labeled in Figure 13.10. The systems are the Wireless Entry system which unlocks the locker, the SpringUp system which lifts the locker latch, and the SpringOpen system which opens the locker door. Wireless Entry is composed of a handheld wireless radio frequency (RF) transmitter carried by the student, a wireless RF receiver inside the locker, a DC gear motor, a lock bolt, and springs. The transmitter transmits a signal to the receiver causing the motor to spin, pulling back the bolt, and unlocking the locker. The SpringUp system then pushes up the locker latch using a spring plunger. The SpringOpen system consists of a spring on a lever arm to push the door of the locker open. After the locker is open, the motor will continue its revolution and the locking springs secure the lock bolt in the locked position. After the lock bolt returns to the locked position, the locker can easily be pushed shut, securing the student's belongings. The interior components are protected by a metal case. The device also has a mechanical override in the case of failure in the device. The mechanical override can be accessed by the loosening of two tamper proof screws on the outside of the locker, moving back the override cover, and manually retracting the lock bolt. The assistive device successfully accomplishes the goal of providing a way for high school students who may have limited hand dexterity, limited trunk mobility, vision impairments, or those who use wheelchairs to independently secure and access their locker.

The final device (without the protective encasement) is shown in Figure 13.11 and the cost of materials and supplies was approximately $350.

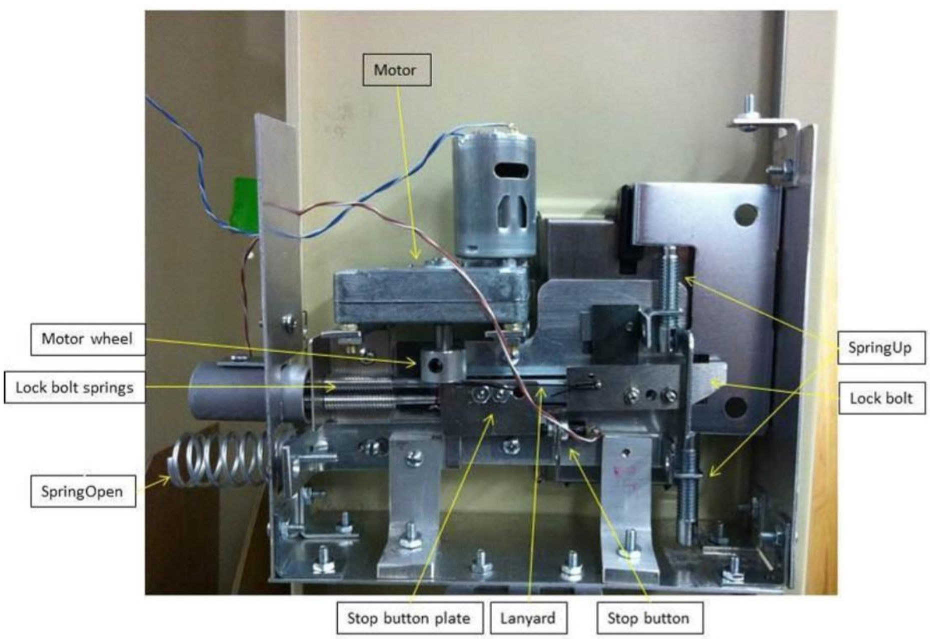


Fig. 13.11. The final mechanical components of the automated locker opening device.

# ASSISTIVE TECHNOLOGY TO IMPROVE GRIP STRENGTH

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## INTRODUCTION

Many senior citizens, stroke patients, and individuals with degenerative neurological and musculoskeletal diseases experience the gradual decline of muscle control and a significant reduction in hand grip strength coupled with an inability to coordinate fine motor movements. The client is a 59 year-old woman with Spinal Cerebellum Ataxia, a progressive, genetic neurological disorder that results in the gradual decline of muscle control. Due to the degenerative nature of her condition, the client has recently experienced a significant reduction in her hand grip-strength and in her ability to coordinate fine motor movements. While retaining full intellectual capabilities and upper arm strength, the client's independence has been limited considerably due to an uncontrolled tight clenching of her fingers and a substantial tremor of her hand. The client would benefit from a non-cumbersome device that improves her grip strength and aids her in daily tasks including grasping, eating, and using writing utensils. A therapeutic element to prevent the rapid deceleration of muscle strength, in the case of patients with degenerative neurological disorders, would also be a strong asset to any device.

## SUMMARY OF IMPACT

The assistive device (see Figure 13.12) operates by means of a novel ratchet mechanism that allows the client to control the movement and position of her hand while providing additional support to her fingers by locking them into the desired configuration. In addition to the practical function, the design provides a therapeutic activity that will aid the client in her physical therapy and assist in her efforts to decelerate the progression of her disease. The design accomplishes this by holding the client's fingers in a straight position when they are not in use, similar to the function of previously used therapeutic devices, to prevent curling of her fingers. The current design is superior to other methods of therapy because it does not completely inhibit the use of her hand due to bulkiness and allows for an easy transition between the "default/therapeutic" mode and the "active" mode.

## TECHNICAL DESCRIPTION

The design consists of a right-handed fitted glove, secured to the user's hand via a Velcro® strap. Ratchets on the proximal interphalangeal (PIP) and the metacarpophalangeal (MCP) joints of each finger connect to distal, thin supports. Polypropylene was initially selected for the support material to accommodate for the dichotomy between the need for strength and the need for flexibility. The polypropylene was ultimately replaced by a metal as it became apparent that strength was critical for complete functionality. Each ratchet is sewn into the glove via the casings and the release mechanisms of each ratchet are connected to one another via the supports. The PIP ratchet release mechanisms are activated through the connection with the MCP aluminum supports. The MCP ratchet release mechanisms connect directly to the lever via supports.

The fabric glove spans from the client's fingers to the wrist. Nylon was selected as the material of construction for its durability and cleanability. The glove fingertips were removed so that the client can maintain a sense of touch. The thumb is likewise not encased to preserve full range of motion. The Velcro® strap around the wrist prevents the device from slipping.

Upon assembly of the design, the team encountered several challenges that required significant changes to the original design in order to ensure functionality of the device. Casings were added to encompass the MCP ratchets to guarantee that the ratchets did not snag on the fabric when in use.

The cost required to develop the device was approximately $100, which includes all supplies and materials.

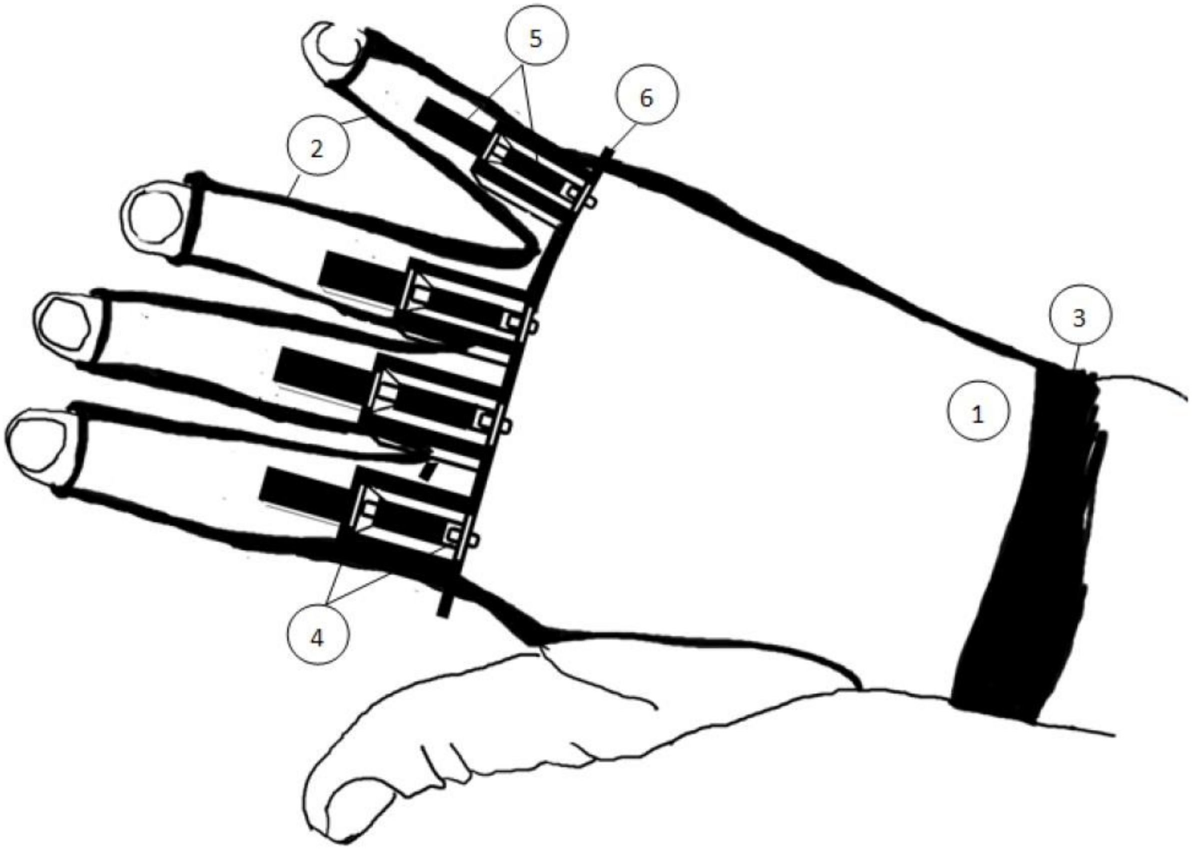


Fig. 13.12. The design consists of (1) a fitted nylon glove, (2) pieces of Under Armour® material for increased maneuverability, (3) a Velcro® strap at the wrist for securing the device, (4) ratchets at critical joints, (5) aluminum supports and (6) a protective casing.