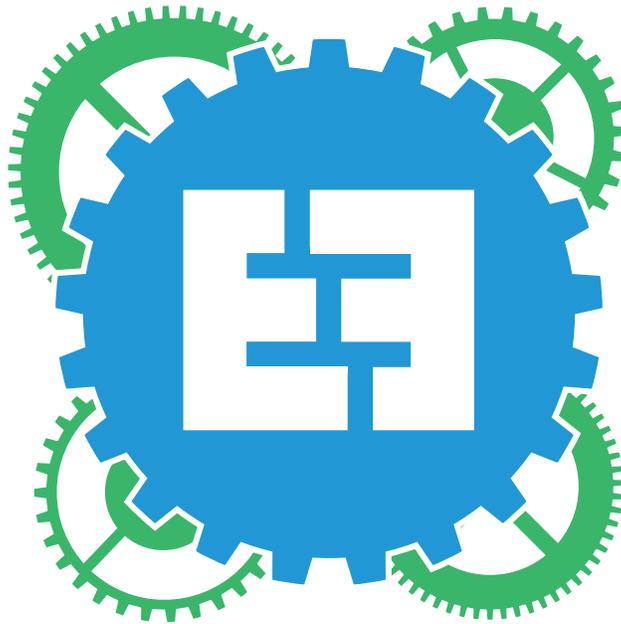


Northeastern University

2018 Annual Report



ENABLING
ENGINEERING

**Applying engineering to enable and empower
individuals with disabilities**

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Welcome to Enabling Engineering's 2018 annual report!

Who we are: Enabling Engineering is a Northeastern University student group that designs and builds devices to empower individuals with physical and cognitive disabilities.

What we do: Our students collaborate with clients on projects that provide greater independence, reduce medical burdens, and increase social connectedness. We help family members, clinicians and teachers care for people with special needs.

By giving students the opportunity to participate in Enabling Engineering projects, we are training the next generation of engineers to be knowledgeable about, and aware of, the needs of individuals with disabilities.

The need: By some estimates, 28 million people in the US, or 9% of the population, have a severe disability, which may include difficulty seeing, hearing, moving, or completing daily activities without assistance. Insurance often fails to cover expensive devices or services needed to carry out everyday tasks, and end users often prefer to be independent of caregivers.

We encourage you to read about our group's mission, recent group and project milestones, and our projects. There are many ways to get involved, either as a project team member, team leader, community partner, mentor, caregiver, client, or donor. Please contact us at enable@coe.neu.edu or visit our website at <http://www.northeastern.edu/enable>. Thank you for your interest in Enabling Engineering!



Enabling Engineering is a student-led, self-sustaining organization focused on enabling and empowering individuals with disabilities and older adults. Project teams work with end users and caregivers at local nursing homes and special education schools to assess a specific need, research potential solutions, and develop a detailed proposal for a project. Teams are matched with product design mentors who guide groups through the design process. Seminars cover relevant topics, including surveys of specific physical and cognitive disabilities and applicable engineering technologies. The organization represents a partnership among students, faculty researchers, alumni, mentors, clinicians, caregivers, and clients.

Recent group milestones:

- Supported more than **30 projects**, 10 of which were completed this year.
- Hosted a Project Showcase where **19 project teams** presented posters and prototypes.
- Organized over **100 students** as contributors to work on one or more design projects.
- Connected project teams with **23 clients and community partners**.
- Supported **6 NU Community Engagement Program (CEP)** as volunteers with the group.
- Hired our first full-time Program Manager.



Recent project milestones

- Developed an Adaptive Canoe seat to help an individual with spina bifida to canoe safely.
- Developed the EyeTalk eye tracking system to allow an individual with Locked-In Syndrome to communicate.
- Adapted three Go Baby Go motorized vehicles to allow children with mobility impairments to move independently.
- Built a scope that will help a visually impaired individual participate in shooting competitions.
- Built a cup that would help people with Parkinson's and neuromuscular disorders drink without aspirating fluid.
- Developed a device to help a client with mobility restrictions sit upright from a lying position.
- Built a sleep-wake system to encourage healthier and consistent sleep schedules among older adults.
- Developed the Smart Cast which provides pressure and EMG data to clinicians.
- Built a portable footrest to provide support to children using a wide variety of wheelchairs.

2018-2019 Management Team Members

Kaylin Devchand
Jordan Fernandes
Tyler Hill
Pragnya Kalidindi
Kerri Lehmann
Erin Provost
Liam Sullivan
Katharine Welch

Community Partners

AccesSportAmerica
For His Children Orphanage
National Braille Press
Parkinson's Family Support Center
ReGame VR Lab
South Shore Educational Collaborative
The Carter School
You're With us



Northeastern University
Enabling Engineering

northeastern.edu/enable
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Goal

Build a seat which will help an individual with spina bifida to canoe.

Members

David Earley
Catherine Han
Kerri Lehmann
Nancy Lieberman
Alexandria Lipski
Aakash Rohra

Collaborator

Ross Lilley,
AccesSportAmerica

Status

Complete

The Need

The end user cannot canoe comfortably because the typical canoe back does not provide enough support. The user is 30 years old, 5' 1", and has spina bifida, which is a condition in which the spine does not fully develop. This results in the user having a developed upper body but having minimal muscle mass in his lower half. The user's main challenge with canoeing was that the seat does not provide enough back support because the canoe seat only extends to his lower back.



The Project

To approach the problem we defined all the needs and constraints for the seat. It is to be lightweight, supportive, comfortable, and not hinder the motion of the user as they canoe. We held brainstorming sessions in order to gather possible solutions to our problem. After down-selecting our ideas, we ordered a seat that would fit into the size and shape of the base of the canoe. We then retrofitted the canoe by trimming the seat and taking pictures and measurements of how the seat fit onto the canoe. After this, we started to model in SolidWorks possible parts that we are interested in 3D printing. We

3D printed several prototype parts and ordered additional parts that we used to assemble the back support. The completed design now allows athletes with weak lower bodies to use this outrigger canoe comfortably and safely.



Current Status

The project is complete.



Goal

Build a custom guitar that would help an individual with restricted motor skills to play in his favorite band.

Members

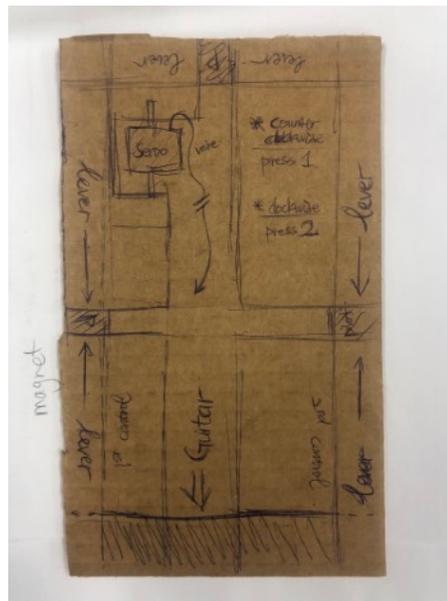
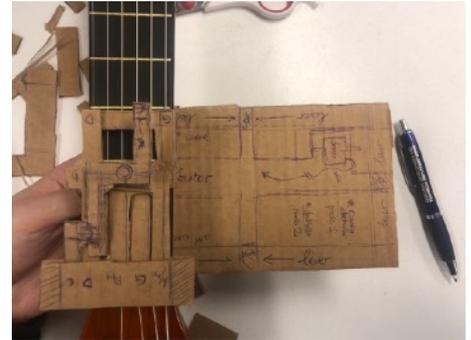
Daniel Feller
Petr Horvath
Zonghao Liu
Andrew Musco
Liam Sullivan

Status

In Progress

The Need

The client has limited use of the left side of his body, but wishes to play the acoustic guitar. The parents of the client have asked that we create an apparatus that allows the one-handed usage of an acoustic guitar. Ideally, this design would be able to press chords and allow the client to strum at the same time with his right hand. It is important to note that the client does not have much strength in his left hand either. The client is a big Beatles fan.



The Project

Our solution is a device that will press the strings on the guitar and form the chords so the client does not have to. It involves a system of cantilevers, each shaped to form a specific chord, activated by a system of strings connected to servo motors. These servo motors are activated with a button press in the prototype, but for the final version will be controlled by an easier method for the client such as foot pedals. This device will play Am, C, D, G, and Em chords. These chords are tailored to the Beatles song Blackbird, but will work for most popular songs.

Current Status

The project is in progress.

Goal

Build a toy car for a child with motor disabilities.

Members

Ehsan Ahmed
Zialynn Anderson
Maybellene Aung
Winston Heinrichs
Cameron Smith
Eliot Smullen

Collaborator

South Shore
Educational
Collaborative

Status

In Progress

The Need

The physical disabilities of the client prevent the child from controlling a typical power wheel. The child needs a way to control the vehicle with simple buttons or joysticks, while being securely and comfortably strapped in. In addition, the client's mother would like a way to remotely control the car as a safety measure.

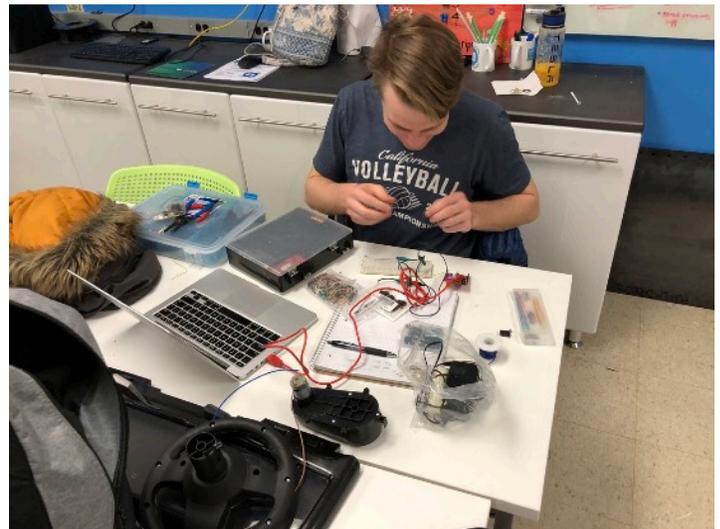
The Project

The client has physical disabilities that impair his motor function. We are addressing this by linking a Child Ride-On Car to a remote control and modifying the Car's steering capability and battery components so that a 3rd party can control the speed and direction the car takes. We are also addressing any support mechanisms that need to be implemented to contain the client comfortably according to his needs, such as head padding and a chest harness.



Current Status

This project is in progress.



Goal

Build a car for a toddler with cerebral palsy and legal blindness.

Members

Charlie Beurskens
Amanda Haines
Alana Persing
David Yi

Collaborator

South Shore
Educational
Collaborative

Status

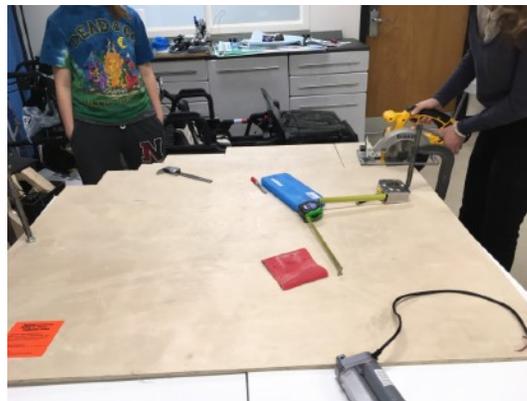
Complete

The Need

Client Boston has cerebral palsy, legal blindness, and managed seizure disorder. He is basically an infant in a toddler's body, so he needs support to hold his body in the car. He cannot use his legs to manipulate things well.

The Project

Based on that need, we created a seat harness and cushion in order to keep him in the car and comfortable. We also rewired the accelerator to a button on the steering wheel and painted the button a bright color he can see. We also implemented an electric steering



system using a remote controlled linear actuator attached to the steering system under the car. Boston and his 2 sisters haven't been able to play together like most kids, and with his sisters steering him with the remote controls, and Boston driving the car forward, they will finally get that chance.

Current Status

This project is complete.



Goal

Build a car for a child with limited motor skill and visual impairment.

Members

Lucas Ingalls
Alice Loukianova
Marcus Robinson
Ava Rohacek
Mitch Storey

Collaborator

South Shore
Educational
Collaborative

Status

In progress

The Need

A 4-year old with very limited motor controls and a visual impairment is in need of more freedom and independence, which we hope to provide by modifying a small motorized car that he will be able to use with his given limitations.

The Project

The alterations made to the small car include changing the location of the acceleration button, configuring a new turning mechanism, and installing a four point harness to better stabilize the client. With limited motor control and visibility, the acceleration pedal, was changed to a button mounted on the left side of the car, near where his left hand would rest. Because of his disability, he would also be unable to turn a steering wheel, so the method of turning the front wheels will be converted to more buttons or head switches which will control a linear actuator attached to the front axle. For him to be able to drive around on his own, he must also be very stable in his seat to prevent any possible injuries. To ensure this, a U-shaped support structure made of PVC pipe was anchored to the back of the car, with a four-point harness attached across it and to both sides and the rear face of the car.

Current Status

This project is in progress.



Goal

Build a scope that would help a visual impaired shooter to sense the target.

Members

Matin Raayai
Ardakani
Teresa Hoch
Kaitlyn O'Donnell
Akhil Pardeshi
Devin Reslow

Collaborator

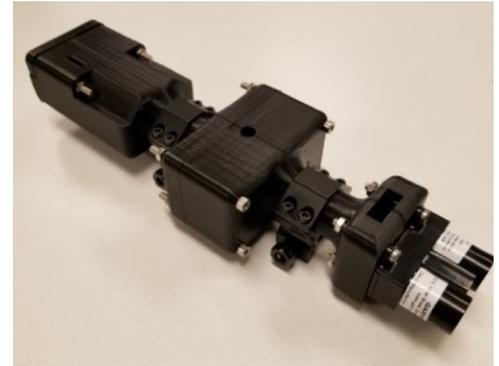
Brian Mac Donald,
National Braille Press

Status

Complete

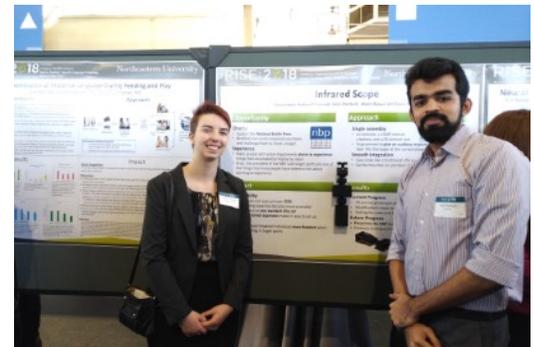
The Need

According to the World Health Organization (WHO) in 2015, there were 940 million people with some degree of visual impairment. Brian Mac Donald, the President of the National Braille Press, proposed an idea to build a target sensing device which will be used by the people with visual impairments to compete with individuals without any vision problems. The goal of the project was to create this scope, and use it in fundraising events that will be used to raise money used to help the visually impaired. Not only will the device help with fundraising, but it would also enable individuals with visual impairments to aim and shoot a gun with higher chances of hitting the target.



The Project

The system is broken down into the LIDAR, signal processing/controller, audio output, and power supply. The system is assembled into a single housing to make sure everything is compact and safe for use. The LIDAR is the measurement unit which uses technology based on light detection and ranging which returns values of measurement to the controller. The controller can then convert these values to distance measurements which will be used to determine if the target is in sensing range or not. The signal processing is handled by arduino and is also responsible for logic testing of the returned measurement signals and deciding what sounds to output via the connected headphone jack. The ideal range of this system is 50 feet.



Current Status

The project is successfully delivered to client.

Goal

Develop an alternative device to Philips lite aid.

Members

Charlie Beurskens
Nico Macias
Ben Pazlos

Collaborator

The Carter School

Status

In Progress

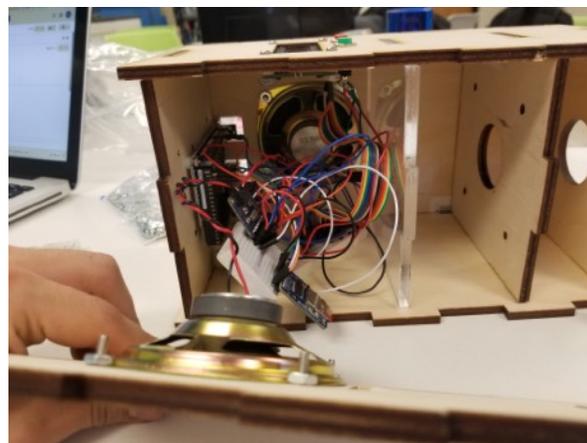
The Need

This device will provide an alternative to the Philips lite aid. The product should allow the children to practice auditory recognition, color recognition, and motor control.

The Project

The proposed device is a final version of the prototype that was completed last semester. The device will feature a 2x2 grid of peg holes, each featuring an indicator light and color sensor. The device will also house a lcd screen and buttons for the operator and a speaker to give instructions and positive audio

feedback. The general use process would be to have the teacher select the particular 1 of 3 recognition skills for the student to practice. For example if the student selected needed to practice auditory recognition, the teacher would select this and the Arduino would play through the speaker for example "Blue peg". In which case the student would than need to insert the blue peg into the hole, wherein the computer would confirm or deny the selection. A similar process would be carried out for color recognition and textual recognition.



Current Status

The first prototype is ready. The team is now working on building the final version.

Goal

Develop a wearable aid for people with hearing disability to better hear music.

Members

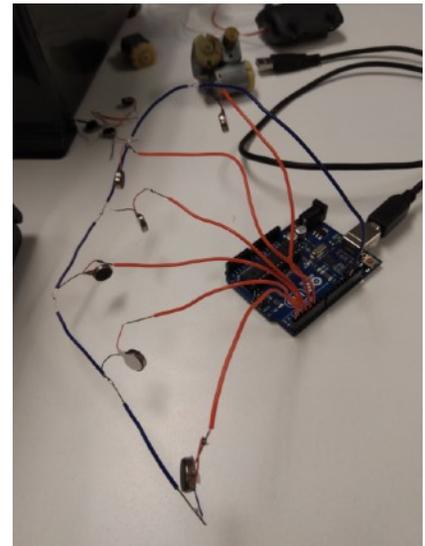
Josh Toby
 Jessica Cheng
 Sabrina Kantor
 Tristan Sweeney
 Adaeze Adigwe

Status

In Progress

The Need

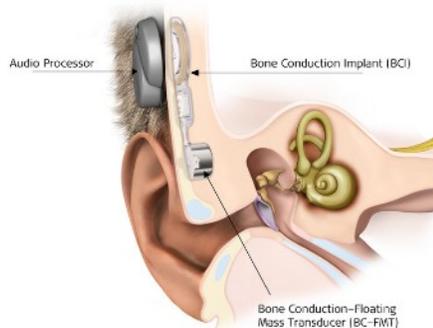
People who suffer from loss of hearing ability are inherently dependent on senses other than hearing for communication. Typically, people with hearing impairment are more sensitive to tactile information like touch and vibrations and there is even research indicating that conditioning the brain of young deaf people to process vibration the same way other people process sound could actually carry developmental benefits. Our client suffers from sensorineural hearing loss, which accounts for about 90% of all hearing loss cases.



The Project

The proposed device for this project is a wearable that utilizes a combination of vibrating motors to allow the user to experience sound physically via Bone Conduction. Since most hearing loss is a problem in the sensor in the auditory canal, using the bones of the skull/face help in

propagating the sound waves without having to interact with any of the outer or middle ear. The motors will be placed strategically on the user's face/temple/cheek so as to utilize the contours of the rigid bone structure to maximize sensory information. As a result of the principle of working of bone conduction, the user will feel a sensation of the



music seeming to be coming from inside his own head. The various frequencies in the music signal will be split up and each range sent to a different motor to help the user differentiate between bass, mids and highs.

Current Status

This project is in progress.

Goal

Build a cup that would help people with Parkinson's and neuromuscular disorder.

Members

Kirsten Ebanks
Jisoo Han
Katya Kopylkev
Alyssa Moreno
Macee Qi

Collaborator

Nancy Mazonson,
JFCS Boston

Status

Complete

The Need

To reduce the risk of aspiration pneumonia when drinking for people with Parkinson's Disease and other neuro-muscular disorders. This project is meant to provide a safer and more cost-effective mode of drinking for a wide variety of individuals struggling with any condition or disorder which increases the risk of choking and/or aspiration pneumonia and as such has no distinct client. We seeked feedback from individuals who commonly faced these difficulties to improve upon our design (such as the elderly and those with the above described conditions.)

The Project

By creating a design which modulates the amount of liquid at the top of the cup so that the person drinking does not have to tilt their head back will reduce the risk of choking and aspiration pneumonia. The handle,

which is designed to be easy to grip and accommodate tremors, allows for the individual to drink without the assistance of a caretaker.

Current Status

This project is complete.



Goal

Design a tool to help the client pull her hair in a ponytail.

Members

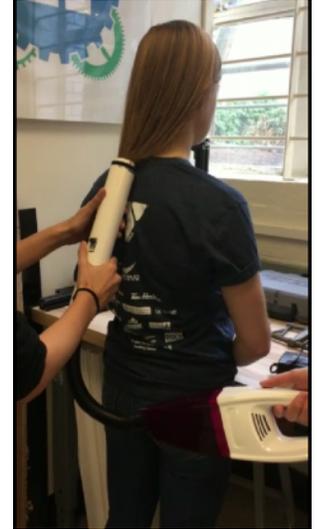
Chrissanthi Boutalis
Charu Kalra
Daniel Looney

Status

In Progress

The Need

Lindsay has muscular dystrophy, which makes it difficult for her to put her hair up or change her hairstyle on her own. The goal of this project is to design a mechanism to allow Lindsay to put her hair in a ponytail despite her limited range of motion. Her arms can barely reach her hairline and cannot reach the back of her head; she has poor finger dexterity but decent neck mobility. The ideal end-product would be functional within her range of motion, and would also be safe and reusable. Additionally, it would be easily removed independently. In the past, she has had an aide assisting her at home, but she would like a mobile device that allows her to independently change her hairstyle.



The Project

Working from the first prototype, modifications were made to the adapted vacuum cleaner for easier use. A sliding rail system was put together using two pipes, pipe clamps, and custom 3-D printed sliders and ends. With this new design, the vacuum pipe will be moved up and down with two timing belts that can be pulled from the front. The release mechanism has also been modified so that the hair tie is automatically released. When the vacuum pipe reaches a certain point, strings attached to the bottom cap of the rail system pull on the switch, causing the hair tie to be released. With these modifications, another person will not be needed to move the vacuum pipe upwards to collect the hair and release the hair tie.



Current Status

This project is in progress.

Goal

Develop a hand and feet powered bike for the client with Trifunctional Protein Deficiency.

Members

Charlie Beurskens
Yiwen Dong

Status

In Progress

The Need

The client is a 22 year old boy living in Wisconsin who has a rare disability called Tri-functional Protein Deficiency that affects his mobility. It is a condition that's very close to Cerebral Palsy. He cannot walk very well because his body cannot fully process the messages his brain sends. This effect intensifies as the message moves further from his brain. Thus, his extremities suffer worst. His range of walking distance is small, a couple hundred feet at most, and he is in constant danger of falling, so he would benefit from the increased mobility, independence, and safety of a bike. He has use of his arms better than his legs and his shoulder and back muscles are strong.



The Project

By allowing both hand and feet power, this bike will help our client. Almost all of the commercially available bikes lack a proper steering mechanism that allow incorporation of feet power or would simply be unusable for our client. Our design incorporate a three wheel trike design with two front steering wheels and a rear wheel for power. He rides by pedaling and pushing his handlebar. He steers by rotating his handlebar to a Ackermann system front wheels. The plan for this semester is to further develop the CAD model while simultaneously creating a physical prototype for our designs. The CAD model will be reworked to better fit our client's stature. The physical model will incorporate a prototype for the drive train system that can be operated to drive a stationary wheel. This will serve as a proof a concept for the feasibility of hand bar and feet pedal powering system. If time permits, the chassis will be built around the drive train in order to advance the eventual goal of providing a complete bike to our client.

Current Status

This project is in progress.

Goal

Build a tray as a means of distraction for the client to reduce him from putting his left hand in his mouth.

Members

Andrew Blunt
Deniz Boyu
Ian Leach
Meghan Quon
Sanjali Sur
Zoe Simonson

Collaborator

Kevin Crowley,
The Carter School

Status

Complete

The Need

Luis is a student at the Carter School in Roxbury who requires the use of a wheelchair throughout his day. Luis is unable to control his left hand, constantly bringing it to his mouth when sitting in class. Hygiene issues have resulted from this repeated action. The goal of this project is to develop a means of distraction to reduce this behavior as much as possible.

The Project

The selected design is an improvement on Luis' current wheelchair tray. The provided solution is a "sensory tray" which fastens to the default wheelchair tray and allows the attachment of different toys. The sensory tray gives Luis something to distract his left hand with, reducing the rate at which he makes contact with his mouth. The improved sensory tray features modular toy attachments which allow for easy removal and installation of toys. The sensory tray is made out of a thicker, waterproof wood that fits onto the default wheelchair tray using thumb screws that allow for quick and easy fastening when needed.

Current Status

This project is complete.



Goal

Build a device to help the client sit upright from a lying position.

Members

Dan Damato
Christina Flavin
Amie Loftus
Victoria Okoria
Nicole Tong

Status

Complete.

The Need

The goal of the 'Sitting Up in Bed Project' was to develop a specialized solution to allow the client in Switzerland to go from a side lying position to an upright sitting position at the edge of the bed. This will allow the client to transfer from her bed to the wheelchair without the need of a PCA. The client is currently renting furniture and an apartment, so the design of the device needs to be as minimally intrusive to her environment as possible.

The Project

We have developed a free-standing lift device that is customized to fit her bedroom environment. The client will lay on the platform of the device, which rests on her bed. The platform rotates from 0-90 degrees via a linear actuator and allows the client to go from side lying in bed to sitting up at the edge of the bed, where she can then transfer to her wheelchair independently.



Current Status

This project is complete.

Goal

Develop a system to encourage healthier and constant sleep schedules amongst elderly.

Members

Andreas Aghamianz
Emily Daniel
Yasmeen Emampoor
Guillermo Hernandez
Elizabeth Kairys
Diana Regalbuto
Graham Thomas

Collaborator

Jill Flores-Cordon,
Benchmark Senior
Living

Status

Complete

The Need

Sleep disorders, such as delayed sleep phase syndrome, can inhibit a person's ability to function effectively throughout the day. A large percentage of older adults are affected by fragmented and lower-quality sleep due to age-related conditions like insomnia and cognitive disorders. This can make it difficult for seniors to live independently without the help of a caregiver, and can increase the negative symptoms of conditions such as dementia.

Additionally, elderly individuals with cognitive impairments can suffer from a condition called sundowning where their confusion increases once the sun goes down. The goal of this project was to develop a system to encourage healthier and more consistent sleep schedules for elderly individuals with conditions that are causing fragmented sleep patterns.

**The Project**

The design is a light-based sleep alignment system that encourages its user to maintain healthy sleep habits throughout the day. The system needs to be non-intrusive and easy to set up with minimal effort on the part of the user so that it does not disrupt individuals' existing routines and living arrangements. The design consists of three components: a bright LED panel, a pressure-sensitive bath mat, and a combination desk lamp and alarm clock. In the morning, the lamp unit's alarm is turned off by stepping on the bath mat. The mat sends a Bluetooth signal to the lamp unit to confirm that the user has gotten out of bed. Until the user steps on the mat, the LED panel and desk lamp increase in brightness while an audio alarm plays. In the evening, the LED panel turns on again to prevent the user from going to sleep too early and help combat the effects of sundowning. Finally, a low-frequency bulb in the lamp turns on when it is time to go to bed. Using our system will help elderly individuals maintain a regular sleep schedule and support a more independent lifestyle in those with sleep disorders.

**Project Status**

This project is complete.

Goal

Develop a technology to provide pressure and EMG data to clinicians.

Members

Claire Goolsby
 Creighton Nakamura
 Kyle Mahan
 Joe Moore
 Zachary Waggoner
 Skylar Nesheim

Collaborator

Eric Folmar,
 NU Physical Therapy

Status

Complete

The Need

Fractures represent a significant medical problem in the United States with approximately 6.8 million fractures coming to medical attention annually. Many complications can occur during the healing process including compartment syndrome, ischemia, heat injury, pressure sores, and neurologic injury. Communicating pain and discomfort to physicians is a challenge particularly for high-risk patients who cannot effectively communicate such as those who are nonverbal, comatose, young children, or have nerve damage.

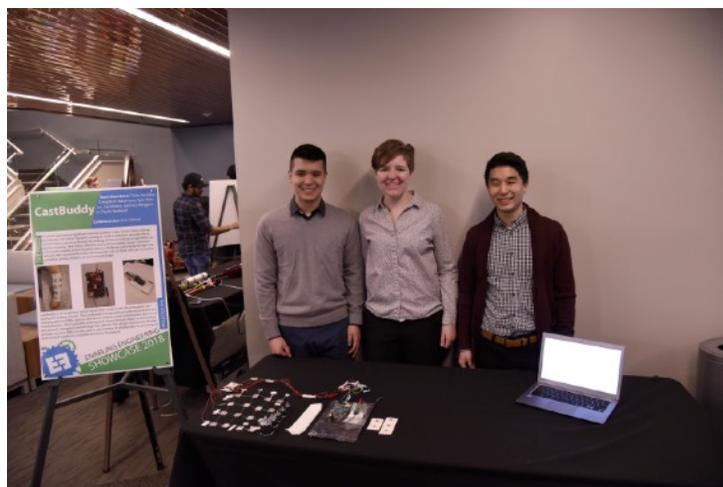
The Project

CastBuddy is an integrated sensor sleeve worn underneath the orthopedic cast during the healing process. The CastBuddy is designed to provide pressure and electromyographical (EMG) data to clinicians in order to avoid complications due to cast immobilization. The CastBuddy is designed to have minimal impact on the casting process and is targeted towards high-risk patients. The design incorporates flexible pressure sensors, EMG circuitry, and a user interface to display data for physicians to determine if conditions could be harmful to the patient.



Current Status

This project is complete.



Goal

Build a technology to facilitate child-therapist communication during at home AVG interventions.

Members

Ayorinde Akinrinlola
 Ryan Bradford
 Da-Jin Chu
 Quan Do
 Pragnya Kalidindi

Advisor

Danielle Levac,
 NU Physical Therapy

Status

In progress

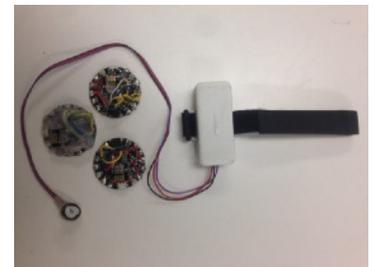
The Need

Virtual reality active video games (AVGs) are popular physical therapy interventions for children with hemiplegic cerebral palsy (CP) because they can motivate children to engage in repetitive arm movements. Adherence to home-based AVG exercise programs is often low and therapists require a way of monitoring children's game play in order to progress game challenge and provide motivating feedback. The purpose of our project is to develop the prototype for a sensor-enabled smartphone app that tracks arm movement, measures energy expenditure, records game difficulty levels and captures children's self-reported motivation, in order to facilitate child-therapist communication during at home AVG interventions.



The Project

The goal of this project is to design a shirt that uses motion sensors to monitor physical therapy patients during their home exercises. Physical therapists can then access this data in order to monitor their patients' progress. In addition, the client can use a smartphone app to enter brief data about games played and respond to questions about level of motivation, engagement and effort during game play. The app may also allow for video upload of game play so that therapists can monitor movement quality. A prototype shirt has been developed with four sensors, one sensor on each shoulder and one on each triceps. The sensors are connected to an Arduino, which automatically determines how many sensors there are and where each sensor is located. Users can choose to add more sensors if needed due to the plug-and-play design. The data collected from the sensors is sent to a Matlab program that records it. A script then uploads the data to a database. We have also designed a website that will integrate with the database so physical therapists can remotely monitor their patients' progress. The prototype also includes the basis for an app that connects with the website.



Current Status

This project is in progress.

Goal

Build a portable footrest able to fit on most varieties of wheelchairs.

Members

Andrew Blunt
Deniz Boyu
You-Wei Liu

Advisor

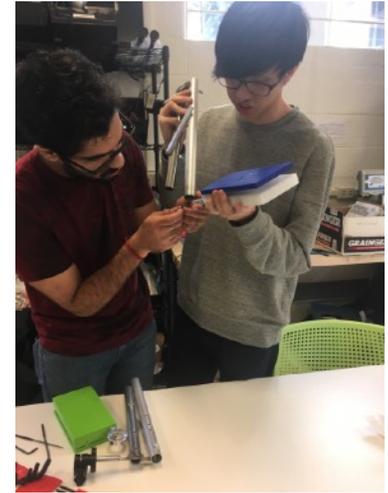
Lorna Hayward and
Sue Ventura,
NU Physical Therapy

Status

Complete

The Need

Children with disabilities at an orphanage in Ecuador do not have wheelchairs with foot rests causing their feet to dangle. This causes health related problems as well as being uncomfortable for the children. Professor Lorna brings a team to Ecuador every year and we would need to create a device which would be able to attach a footrest to the wheelchair. This device should be portable and should be able to fit on most varieties of wheelchairs.



The Project

The finalized design of the wheelchair is made up of two rods as the structure. The first inner rod is responsible for providing support as the main structure of the footrest as well as a base to attach the clamps that hold the wheelchair footrest to the wheelchair itself. The second outer rod is responsible for providing support for the footplate that the user will be applying strength on. There is also an aluminum bar in between the rods that are attached to the rods using holes and screws to hold them in place. The aluminum bar is responsible for adjusting the angle of the wheelchair for multiple angles allowing the footrest to move in the forward and backward direction. The inner rod is made from stainless steel allowing the welding of the inner rod to the clamp structure which is made of stainless steel as well. The outer rod is made of aluminum making it lightweight but also strong enough to hold the weight of the footplates and shoe holders. The footplate is made of 3D printing material used in the enabling engineering lab, it has two holes in the middle of the plate to screw the shoe holders that go on top of it. The main innovation that differs the footrest create by our group is the use of the aluminum bar mechanism.



Current Status

This project is complete and the prototype has been delivered to Ecuador.

During the 2018 Enabling Engineering Showcase event over 19 projects were put up for display.

