Capstone Design Abstracts

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StartGait

Team Members: Alec Fischetti, Ben Hurd, Jason Julien, Ryan Maietta, Yuuki Sato, Justin Schwartzseid
Collaborators: John Kauer & Dave Newbold
Advisor: Waleed Meleis

Abstract

In the United States alone approximately 60,000 people are diagnosed with Parkinson's disease each year, in addition to the estimated 10 million people already diagnosed worldwide. Parkinson's has no known cure. While there are drugs to reduce the intensity of some symptoms, others are not treatable through this method. One such symptom known as "freezing of gait", or FOG, is characterized by a patient finding him or herself shuffling or coming to a full stop instead of walking. This reduces the quality of life for the patient, partially caused by the increased risk of falling that comes with a FOG episode.

StartGait is a small hip mounted device that uses algorithms to analyze movement data collected by the internal accelerometer, gyroscope, and magnetometer to predict FOG episodes and help overcome them by cueing audiovisual stimuli in the form of a laser line on the ground and a metronome-like sound to step in time with. The laser provides a visual to step towards to continue walking while the metronome gives the patient a rhythm to walk to, in order to help them stay out of FOG. These audio and visual cues have been proven to work in various studies. *StartGait* aims to bring confident mobility back to Parkinson's patients in a simple, reliable and economical device.

StartGait runs all its embedded processes using an Intel Edison compute module. The script it runs and related libraries are written in C++. The Edison system is mounted on Sparkfun-supplied breakout boards to provide breakout pins for accessing its internal registers, while also allowing for battery powering of the system. Through these pins, the Edison base-system is connected to the breakout board, which houses the Adafruit BNO055 Absolute Orientation Sensor, LED, piezoelectric speaker, and green line laser. The LED displays different colors depending on the system's mode, and changes colors depending on the number of sensors that are calibrated while in detection mode. The LED is off when no sensors are calibrated, and changes from red, to purple, to blue as each sensor is calibrated. When the system is ready to record movement data, the LED changes to green. A Sparkfun capacitive touch breakout board is also connected to provide user input to the system. Tapping the device's touch sensor once will change the mode from always on to detection, and tapping it twice will toggle the device's power. The Edison base-block, breakout board, capacitive touch sensor, and the connecting wires are all housed within a lightweight cylindrical 3D printed case, that clips comfortably on a patient's waist. The case can be easily rotated to adjust the angle at which the laser hits the ground in front of the user.

Solutions to help overcome FOG do exist, but often fall short in many aspects. For example, walkers or canes with mounted lasers provide a visual walking aid, but are bulky and droppable. Others are smaller but have enormous price tags and are too simple. *StartGait* is a device that is inexpensive as well as mobile and easy to use in order to reduce the occurrence of FOG. With the lightweight hip-mounted case, patients can take *StartGait* anywhere without any trouble. Plus, the simple and compact design allows for a much cheaper solution than anything currently on the market.

A Kinect Game for Gesture and Speech

Team Members:

Pooja Jhaveri
Steven Troetti
Prashant Naidu
Kevin Do
Kenny Jean-Baptiste
Chris Barton

Advisor & Collaborators:

Professor Danielle Levac
Professor Kathryn Connaghan
Bouve College of Health Sciences

Professor Waleed Meleis
Electrical & Computer Engineering

Abstract

Cerebral Palsy (CP) is a disorder frequently characterized by impaired limb and speech motor control. Therapy to address these impairments typically involves repetition of motor and speech tasks over many sessions. A reward-based game application is therefore an ideal therapeutic tool to encourage exercise participation and maintain motivation.

We have developed a Unity-based, Kinect-enabled video game designed to provide physical and speech therapy to children with CP through an engaging, interactive virtual environment. The player assumes the role of a young spy-in-training and is given tasks and mini-games to progress through his/her training. Tasks and mini-games elicit expansive physical motions of the upper extremities, upright sitting posture, and speech projection with the aim of increasing speech volume and strengthening motor control. Data correlating speech volume and upper-body motion is collected and formatted on a webpage accessible to clinicians and researchers.

The project consists of a game scene where a player is asked to capture an object and verbally describe it. Such tasks are designed to elicit increasing range of motion and speech intensity. The game platform sends task data to a server and these data are ultimately displayed on a web user interface accessible to a clinician.

Next steps would be to evaluate game usability with a small group of end-users. Following larger-scale trials, this platform will serve as a clinically relevant tool to encourage repetitive practice and collect clinical data to explore the links between expansive gestures and speech production.

Audio Expression Box

Team Members: Victoria Suha, Jack Davis, Chris Babroski, Nick Knaian, Mark Lang

Advisor: Professor Bahram Shafai

Abstract

The Audio Expression Box is a system that allows a musician to use his/her hand motions to control audio effects which modulate an audio stream. The system consists of a method of tracking a user's hand motions, a digital signal processing (DSP) application which creates audio effects and applies them to an audio stream, a user interface which gives the user feedback and customization over many aspects of the system, and a server which handles all communication between the applications.

For the audio effect creation, we utilize a graphical programming environment called MaxMSP. This tool allows us to create high level, low-latency audio effects with limited prior experience in digital signal processing. The system receives messages from the server, such as adding or removing effects to/from the signal chain, or updating effect parameters. The communication protocol for our Max application utilizes OSC, which is built on top of the UDP protocol. The audio source can be chosen to be a file on the local system, a streaming audio source such as Youtube, Spotify, etc., or an actual instrument if an external audio interface is used. The audio arrives at the input of our DSP application, runs through whatever audio effects are in the signal chain, and is output to the computer's speakers or audio jack.

We use a Leap Motion Controller as our motion tracking system. It is a commercially available hand tracking device that comes with an easy to use software API for interfacing with our own application. Using the Leap API, we poll hand coordinate data frames at our desired frame rate and normalize the coordinates so each axis contains a coordinate between zero and one. In real time, the system tracks the user's hand position in a 3-dimensional space, and sends the data to the server, which forwards these coordinates to the DSP application and user interface for further processing.

The system's user interface renders a 3D representation of where the user's hand is within the field of vision of the motion tracking application, renders a visualization of the signal chain, and demonstrates the current state of the DSP application. It also gives the user methods for customizing the system, such as adding/removing audio effects, updating parameter values, or mapping coordinate axes to specific effects parameters.

The server is the block of our system that ties the three applications together. It is responsible for handling all communication between applications, and manages the communication protocols by setting up OSC and TCP ports.

Eighth Octave: An Automatic Piano Tuning Device

Group members: James Serra, Kathleen Fownes, Nate Helmick, Tianming Yang, Xingyao Wu, Damian Bzdyra
Group Advisor: Masoud Salehi

Abstract

It is estimated that over 30 million pianos have been sold in the United States since the 1930s. Besides the initial cost of the piano, the most expensive part of owning one is tuning it. Tuning requires a highly specialized set of skills and tools, and if a piano owner pays for someone else to do it, it will cost thousands of dollars over the span of ownership. Eighth Octave provides a convenient alternative for the casual piano owner, a tune-it-yourself mechanism that, for a one-time purchase, equips the owner with all they need to keep their piano in shape. The user simply plays a note and the microphone picks up the audio signal, which is filtered, processed, and translated to a note in the piano scale. The user can choose what note to tune to or just use the automatic setting on the user interface (UI).

In order to accomplish this mission, we have designed a complete system composing of an electret microphone which gathers frequency data from the piano, several microcontrollers used for data exchange and signal processing, and a user friendly touch screen interface. The mechanism also includes a motor, which clips onto the top of the piano and reaches in to turn the pegs. The frequency of the input signal is calculated by measuring the positive and negative slopes of the waveform, which provides the period. A UI touch screen is used for prompting users to control this system, which can be controlled both manually and automatically. Manual operation allows the user to adjust the motor rotation themselves via the UI pushbuttons whereas the automatic setting will let the system adjust itself based on the target note and input signal. In order to protect the string, a stop button was implemented to cease motor functions in case the string tension is too high. For the connection between motor, microphone and microcontrollers, a serial port is used because it allows communication through a USB port and also supports Python which is the main language used for building up the whole system. The Python script controls the UI as well as the motor. Due to the precise nature of tuning a piano, a motor was needed that could handle minute adjustments. This stepper motor has an angle per step of 0.039 degrees, giving an incredible amount of control over the system, and assuring that the piano string is always in tune and never over-tightened.

For testing and validation, first a digitally generated signal, then a tone, and then finally a real instrument were used. Testing was carried out in both an anechoic chamber and the typical lab setting. The results showed a marked increase in uncertainty when the surrounding area was not completely silent. However, the team believes that with more reliable frequency detection, Eighth Octave could be a practical and cost effective solution for homeowners with pianos.

Project VIEW: Visionless Interfacing Exploration Wearable

Team Members:
Ben Dunbar, Justin Hynes-Bruell, Bill Wisheart, Eric Shi, Gareth Moo, Tom Kolongowski

Advisors:
Professor Bahram Shafai, Professor Sarah Ostadabbas

Abstract

Humans primarily use their sense of sight and spatial awareness to navigate their surroundings, but lack the ability to employ their other senses as guidance systems. The project team has designed a wearable feedback device to aid in visionless navigation, with potential use cases in low light environments when artificial light is not an option, situations where 360 degree awareness is important (such as riding a bike on a busy road) and applications where a user is piloting a system remotely, but needs to be aware of the system's surroundings. Visually impaired persons could be dramatically affected by an affordable device which allows them to sense their surroundings in greater detail than other solutions on the market today.

This project involved the design of a haptic feedback platform disguised as an everyday accessory called the visionless interfacing exploration wearable (VIEW). The project attempts to allow users to navigate a space using their sense of touch via vibrational actuators. In order to make implementation feasible, the data delivered to the user has been tested and modified to be informative, easily interpretable, and reliable. The project team has designed an elastic wearable, containing an array of vibration motors, which is meant to be worn like a headband, and delivers feedback to a user about the space surrounding them. The wearable device is connected to an Arduino Nano and a motor driver printed circuit board (PCB) signal receiver. In order to reliably test the device, the receiver works with a wireless RF transmitter, made from an Arduino Uno, that can be easily programmed to transmit different vibration patterns, depending on how the device is being tested, and how spatial data is being generated.

To test VIEW in a safe and controlled environment, a software suite was developed using both traditional and virtual reality (VR) platforms. Testing was carried out using both a joystick controller and an HTC Vive VR Headset. The testing results indicated that it is possible to learn to intuitively navigate using non-visual queues, and also have demonstrated success in helping users avoid collisions while using haptic feedback to navigate.

Baseball Bingo

Team Members: Derek Richardson, Emily Moxie, Paula Rooney, Erin O'Neill, Michael Szrom, Rachel Rudolph

Advisor: Masoud Salehi

Abstract

In the previous semester's Capstone 1 course, group M2 proposed the Employee Engage application. The goal of this project was to monitor digital improvements and track stadium health within Fenway Park in a live and consistent manner. After subsequent communication with the engineering and management teams of the Boston Red Sox throughout the summer and fall, it was determined that this project had become obsolete, as the Boston Red Sox management team had decided to pursue a commercial option to aid in their daily operations and the tracking of stadium health.

With the goal of the project to create something valuable for the organization, and with additional direction from the Red Sox technical team, we determined that an application that could enhance fan experience and interaction would be most beneficial to the organization. The premise for the application is essentially a bingo game, populated with baseball plays that commonly occur throughout a game. As the user watches the game, either in the stadium or at home, they can highlight the plays on their bingo board that happen during the game. The ultimate goal for the user is to get five plays in a row in order to achieve BINGO, either horizontally, diagonally, or vertically. The reward for the user would be points for each game won, which can ultimately be redeemed for prizes such as autographs, player meetings, or other rewards determined by the Red Sox organization.

Along with supplementing fan experience, the app will be used by the Red Sox technical team to track user traffic, interaction, location, engagement and more. These properties will enable data analytics on fan interaction to make smart, data driven decisions that will ultimately save money and improve the Fenway experience. Throughout this process we plan to ensure the project can be expanded even after the end of our Capstone term, and the ultimate goal of the Ballpark Bingo application is to see the implementation of a tangible product with an active user group.

Motion Acquisition Reconnaissance System (M.A.R.S.)

Team Members: Anthony DiGregorio, Alex Cornwall, Mike Freeman, Timothy Rosenbloom, Adam Beairsto, and Michael Kennedy

Advisor: Professor Bahram Shafai

Abstract

The MARS team formed with the goal of developing an aerial drone with the capability of detecting motion through building walls and other materials. This system has a wide array of applications including security monitoring, military reconnaissance, and locating trapped individuals in a disaster scenario. The ability to see motion through solid objects combined with the mobility of an aerial drone allows our system to collect information on locations that would have previously been inaccessible to military personnel or emergency responders. The scope of the MARS project was to use advancements in software defined radios and signal manipulation technology to create a small, lightweight radio frequency device capable of recognizing motion through solid objects, and to integrate this device with a drone so it can be operated in unreachable locations.

For the aerial vehicle aspect of MARS, a hex-copter design was chosen due to the large amount of lift produced in comparison with a standard four-propeller drone, as well as the stability provided by having more propellers. To control the drone, a computer using Mission Planner software connects to the Pixhawk flight control board via a 933MHz telemetry radio. This software relays altitude, power, compass heading, and GPS location for the drone back to the base computer. The operator can then prime the motors with an option in the Mission Planner GUI and use a remote control or the Mission Planner software to fly the drone. Once the drone is in the desired location, a command to detect motion can be issued via the base computer.

The motion acquisition component of MARS works through a multistep process. First, the system sends out a known signal on two different antennae and detects the reflection. Then, it uses this information to remove the overwhelming reflection from the wall in front of it in a process known as nulling. Once the channel is nulled, the system sends the known signal again, and changes in the reflection can be used to detect movement. The system is built with three Raspberry Pis running GNU Radio software. Each Pi is connected to a HackRF software defined radio that precisely controls the signal characteristics. The signals are then sent through directional antennae to focus detection in the area in front of the drone.

For testing and validation, the MARS drone was placed in front of a section of drywall, and a channel was established. A team member then entered the channel while another team member monitored the received data. We then tested the system with the drone in flight to prove the drone remained stable in flight and did not interfere with the signals used for detection. With the positive result of these tests, we confirmed the viability of the MARS design.

SEA-Brush

Team Members: RishabSharma, Abdannour Derbar, Hanqing Luo, Abdullah Alshammasy

Advisor: Professor Waleed Meleis

Abstract

Autism is a developmental disorder that severely affects communication and interaction. Children with this disorder suffer from poor social understanding of cues and other social messages by which most unaffected children seemingly do not exhibit. Thus, the need arises to accommodate these children at least in their early informative years. Some activities that generally require rote learning or certain cues, that might be unfamiliar to autistic children but need to be learned, demand a different approach. One area in particular in which autistic children need support to complete tasks that require multiple steps is brushing teeth. Research showed that autistic children have sensitive gums and teeth. Coupled with the fact that brushing one's teeth is an activity that inherently relies on signals prompted by oneself, this activity proves to be quite a chore for autistic children.

The need then arises to design a toothbrush that effectively helps these children learn how to brush their teeth properly. Our idea is that we try to make the activity easier to both autistic children and parents by designing a toothbrush that caters to their sensitive needs and provides a more efficient brushing method. This special device must motivate and engage them to brush their teeth independently and effectively without causing harm or discomfort. Research has showed that lights, music, and vibration help coach these children, as do social cues. The SEA-Brush (Specially Equipped Autistic Brush) is a device made to cater to these needs of autistic children who require assistance brushing their teeth and utilizes all of these mentioned functions in order to make the activity easier and a lot more effective.

Our device integrates lights, music and vibration all into one brush in the hopes of motivating and engaging a child with autism in the activity of brushing his or her teeth. Although the device is not too complex or fancy, it employs the key features catered to aiding children with autism with this activity. Other market toothbrushes do contain such features, but not all together. One may have lights, while another may have music or vibration. There is no real market for toothbrushes catered towards children with autism. Our device is focused on helping children between the ages of 5-10 with brushing their teeth. They will have the choice to play music, lights or vibration/toothbrush automation when they brush their teeth. They can employ all of the features or only ones they like. Our design is a large cylindrical brush that is made of a type of transparent plastic that lights up when the LED lights of the toothbrush are turned on. There are two main buttons on the brush. One that gives power to the brush by turning on the lights and the vibration and second allows the user to control the vibration. The vibration is the automation of the brush head and also causes a bit of vibration to flood through the body of the brush. This type of vibration has been known to be soothing to the hands and gums of these children. There is also music programmed into the brush. When the brush is turned on, a melody of children's songs will play for about 2 minutes, the recommended brushing time. Once they stop playing, the child should know that time is up for brushing teeth. Although the design may not be aesthetically pleasing, it is a safe a secure design for children. Brushing can always be a safety hazard as there have been cases where children with autism have accidentally choked or hurt their throats while brushing. The large design prevents any choking hazards. The main point is to try to make the lives of these children and their parents easier by providing an alternative tool they can use to brush their teeth that has been specifically catered to their needs.

Pedal Protect

Team Members: Jeremy Breef-Pilz, Nick Kubasti, Alex Piers, Kim Tran, Charlie Ziegler
Advisor: Professor Masoud Salehi

Abstract

As biking becomes an increasingly popular form of transportation in urban environments, the need for improved safety becomes evident. The percentage of cyclist commuters has increased by as much as 400% percent in certain cities. As a result, there are approximately 50,000 accidents in the United States per year. While many safety measures, such as helmets or correct clothing, are designed to mitigate damage in the event of an accident, we believe an additional solution to prevent accidents is necessary. Market solutions, including blind spot detection and user alert, exist; however, they are either extremely expensive or incomplete. We determined that there was a market need to be satisfied.

Our team designed a comprehensive accident prevention and driver accountability bike safety system. Our designed contains two modules: a rear-facing back for sensing and data processing and cyclist-facing front for user alert. The back includes a high-precision LiDAR to determine distances to cars, inertial measurement unit needed for crash and car detection, wireless communication module, and camera all driven by a Raspberry Pi Zero with 6600 mAh lithium ion battery. The front consists of a wireless communication module and user alert LEDs powered by an Arduino microcontroller and 500 mAh battery. When cars approach the cyclist and break the LiDAR beam, they are detected and their velocity is estimated; based on the distance from the cyclist, car velocity, and bike velocity computed from the accelerometer, the time until the car passes is estimated. The time is converted into five states, which are transmitted to the front module, and LEDs are turned on to alert the user of approaching cars' distance. Additionally, in the case of an accident—detected by dramatic changes in the IMU zenith angle—data and video are stored so the user can assess fault of the accident and hold drivers accountable.

For testing, we connected the system to a bicycle and biked on the roads around Northeastern University. We verified the mechanical and electrical stability of our device over several loops of the campus. The sensors collected data as intended and the camera recorded videos of cars passing the bike, clearly capturing the front license plate. We simulated crashes in a controlled environment by tipping a moving bicycle over and found the device correctly detected the crash and saved video from the incident.

We believe our cost effective and comprehensive system will fulfill a gap in the current market of bike safety accessories.

Modular Wireless Speaker System

Team Members: Fouad Al-Rijleh, Brian Crafton, Samantha Gray, Samuel Letcher, Zach Paulson, Kevin Wilson

Advisor: Professor Bahram Shafai

Abstract

The most popular trends for consumer electronics have been flexibility, ease of use, and portability. Our motivation is to utilize available technology to create a system that enables synchronous wireless playback on multiple devices. Our goal is to improve the adaptability and ease of setup on a typical sound system. The system we designed provides synchronous wireless audio playback and the ability to use any number of speakers with no restrictions on size or brand.

Our sound system is a collection of nodes connected to a central server. Each node is comprised of a Raspberry Pi connected to a speaker. Our server consists of a GUI (Graphic User Interface), and audio server which manages streaming. Users interact with our system though a media player GUI in order to manage speakers and control playback. From the media player a user can scan the network for available speakers, choose which to play music through, and select songs for playback. In addition, the GUI allows the user to visually understand what nodes are connected. Available nodes are represented in the GUI as an IP address paired with an status indicator. Underneath our GUI is a server that manages streaming audio packets to receivers. Our receivers decode audio packets and playback streamed audio through connected speakers. Any number of nodes can be paired with the server. Playback is done equally through all nodes, creating a sound system that can have speakers added and removed on the fly.

For testing and validation we used our own isolated network to connect to the Raspberry Pi's so that we could avoid obstacles connecting to NU Wave. We initially tested our system with one node to verify that we could wirelessly play music to a single speaker. Later in development, we began streaming to multiple nodes at once, to verify synchronous playback. Wireless playback proved to be a challenge, due to the non-determinism that arises while using any operating system. Context switches and network delays were our two biggest sources of time skew. In order to avoid these problems, our audio server also acted as an NTP (Network Time Protocol) server for each client. By time stamping packets and streamlining client-side code we were able to create synchronous playback. We believe this solution enhances upon flexibility, portability, and ease of use over comparable systems and improves modern sound systems.

Aware Chair

Team Members: Neil Suttora, Brian Wilcox, Bernard, Liang, Kyle Jones, Greg Dabrowski

Advisor: Waleed Meleis

Abstract

Power wheelchairs are used commonly among those who suffer disabilities that impede their movement. However, there are some who live with disabilities that make operating a power wheelchair in various scenarios a difficult task. There are some experimental products in research labs that have incorporated collision-avoidance as a component to the power wheelchair system using sensors. However, a lot of these projects are targeted for elderly end users who navigate less frequently than younger wheelchair users. The main objective of this project is to innovate a collision-avoidance power wheelchair that is cost effective, functional for an indoor environment, awareness of curbs, and user-friendly.

The Aware-Chair is a power wheelchair that allows a user to navigate through various environments without fear of any collisions with people, walls, and miscellaneous objects. The wheelchair will function based on the distance between a wheelchair and an obstacle which may lead to a collision. At a predetermined distance away from an obstacle, an LED pad will light up yellow showing that an object is in the path of the wheelchair, in hopes that the user is able to navigate the wheelchair away from the obstacle independently. This is referred to as the "slow zone." If the user can move away from the obstacle, they no longer are in the slow zone and the LED pad will be blank. If the user ends up getting too close to an obstacle, the user is now in the "stop zone" and the LED pad will light up red and stopping the wheelchair in the direction (Front, Left, Right) the obstacle is in relation to the wheelchair. The user rotates the wheelchair such that they can move away from the obstacle getting back to regular functionality.

The wheelchair itself consists of a power system which provides energy to its electro-mechanical components. Additionally, the wheelchair has several sensors incorporated in the design so that the power wheelchair contains a full scope of the environment in all relevant directions. These sensors will provide feedback to the user in terms of sound and restricted movement. Additionally, these sensors will be integrated with the controller and motor of the wheelchair to provide ample feedback as a user may be entering the slow zone/stop zone.
In the market, there is a lack of collision-avoidance wheelchairs being innovated, let alone sold because the needs of each user are difficult to assess on a wide scale. Most of these projects are never brought to market and they fail to make a solution that is optimal for users atany level of experience. Also, these projects fail to provide any form of functionality for curb detection. The team's product makes up for the gaps present in similar products. As a whole,

The Aware-Chair provides a comfortable and easy to operate collision-avoidance power wheelchair that has added functionality targeted for all audiences.

SMART+1 Pillow

(A Smart Pillow with Sound, Massage, Alarm, Ramping, Tracking and Lighting)

Team Members: Zhilan Li, Zhaoxuan Liu, Lakshimi Venkatesh, YuLin Yu, Yue Zhang
Advisor: Professor Masoud Salehi

Abstract

According to medical and health reports, humans need to sleep six to eight hours every night to maintain physical well-being, good mental and emotional health. Sleep takes around one-third of a person's lifetime, which is equivalent to twenty-five years out of a seventy five average life expectancy. Researches show that the number of people who have sleep disorders and problems in the modern society is increasing due stress, domestic responsibilities and educational demands.

Products related to sleep in the market could be categorized into two categories. The first category is sleep tracking products that can monitor your sleep cycles through phone or wearable devices. The second category is physical products that improve your sleeping experiences such as sound machine or massage pillow. However, the sleep tracking products only focus on collecting and recording sleeping data without providing any solution and feedback to users. Whereas the other only has one or two features to improve the quality of sleep, and the effect is not considerable as how our group expect. Considering sleeping problem is found in a large population of today's world, we want to come up with the best and most efficient solution for this problem. Our product, SMART+1 Pillow, is defined as a pillow with several integrated features that leads to significant improvement of the quality of sleep. Smart Pillow uses specific sleeping tracking system to collect and analyze data, and create a common platform that can automate features to provide a complex treatment solution for people who suffer various types of sleep disorders.

Smart+1 Pillow comes with two modes, a manual and auto mode. All the features within the pillow could be controlled by a Bluetooth user interface APP manually or automatically based on the change of sleeping data. Its functions include Sound/music, Massage, Alarm, Ramping/leveling, Tracking and Lighting (abbreviate as SMART+1) features. Our design is achieved by using four different PCBs. First, a Bluetooth Low Energy board that can provide a UI to the pillow through the Bluefruit app. Second, a music shield that features the VS1053, a codec chip that can decode a wide variety of audio formats and an amplifier that can output stereo audio. Third, an Arduino Mega 2560 Microcontroller. Fourth, our own design PCB that have multiple ICs to control different functionalities in our pillow.

Our sleeping tracking system has two accelerometers that are programmed to gather sleep data. We captured and trained multiple set of sleeping data from the accelerometers using a K-means Machine Learning Algorithm that we develop in MATLAB. We aim to classify the sleep data into six classes (Awake, REM, Sleep Stage 1-4). The classification on the sleep tracking data are based on a 3-D features, motions data from the two accelerometer and sleep duration. For our massage feature, we employed 8 vibration motors and embedded them in the neck area of the pillow. A LED strip is placed around the pillow for lighting purposes. We also use an inflatable air pillow and pump to create our leveling feature that will allow users to adjust the height of the pillow based on their needs. Smart Pillow is a more effective solution compared to the sleep products that currently exist in the market, and targets a wider range of consumers who have sleep problems and desire to improve their quality of sleep in a more efficient way

Tool for Audible Angular Measurements (TAAM)

Team Members: Daniel Lang, Jonathan Marrero, Enrique Urdaneta, Kevin Wong.
Advisor: Waleed Meleis.

Abstract

The Tool for Audible Angular Measurements (TAAM) is an electronic leveling tool, which supports an output that is interpretable by users without sight. The design includes audio outputs of different types, such as beeps and number readings, to appeal the user's existing sense of hearing. The device provides accurate measurements while still maintaining a simple and straightforward user interface. It provides an audible cue at the standard angles measured by generic leveling tools (0°/180° and 90°/270°) as well as an added function allowing the user to know the current position of the level and to find a specific desired angle.

We intend to solve the problem presented to blind people when working with leveling tools that don't offer an audible output to the user. Since humans tend to rely heavily on their sight, it is understandable that being blind can potentially impair one's ability to perform regular activities. With this in mind, much thought has been put into the development of tool that provides assistance for the blind. Woodworking is an example of one such profession that a number of blind people have been able to pursue. It's important that woodworkers are detail oriented and pay careful attention to small details in order to meet specifications and to keep them safe. The level in particular is an important tool for the completion of precisely crafted products. Levels are generally made from small clear cylinders filled with liquid ethanol while leaving an air bubble in the chamber. The reason a blind person is unable to use the liquid + air leveling tool is plainly because its output is 100% visually perceived. There are no sounds or physical indications to show the angle. To address this problem, we created an electronic level that evaluates the angle of its orientation with respect to the plane perpendicular to the direction of Earth's gravity and communicates this information to a user with visual disability via an audio queue.

Our goal focused the functionality of our level on touch and sound. We don't want the user to go through any arduous processes to operate the level. The circuit is low powered and only needs around 3.3 to 5 volts and about 2mA of current. To satisfy this, we implemented the use of a nine volt battery, controlled by an on/off switch. In order to obtain the level's angle of orientation, a gyroscope chip is connected to a microcontroller within the level. The microcontroller has a default setting so that it would send a beeping sound to the speaker when the gyroscope reaches an angle of 0˚, 90˚, and 180˚. The level features a read button that tells the current angle being measured. All the audio files are stored in an SD Card and the microcontroller interacts with the SD Card through a breakout board. In addition, a keypad on the front of the level would allow the user to input an angle desired. When the user wishes to set an angle, they would type in the number of the angle on the keypad. When the angle desired is selected, they would press an "enter" button and the level would beep when it is physically oriented at that angle. If the user makes a mistake while entering an angle or wishes to reset the level, they would press the "clear" button and the level would default back to beeping at 0°, 90°, 180° and 360°. The user would then be able to retry entering in the angle again.

The main competing products are the electronic digital levels available in the market. But as mentioned earlier in this summary, they don't present any audio output to the user. The other main competing product is the Angle Cube by iGaging. This is a digital, electronic, magnetic level/protractor gauge that gives the option to the user to enter a desired angle and once the tool is placed in such angle it will inform the user though a small LCD screen. Our device is better than these competing products because it covers both the conventional leveling tools and the Angle Cube functionalities, by incorporating them into one device and by providing the outputs in an audible way so users with impaired sight can use it.

DORI (Deployable Observation & Reporting Instrument)

Team Members: Emily Pankosky, Kevin Meador, Olivier McNicoll, Matej Herega, Richard Stoeffel, Melissa Healy
Advisor: Professor Bahram Shafai

Abstract

The motivation for this project stems from the absence of any reliable/dependable safety precautions/installations for at home pool use. Drowning is the third most common cause of accidental death in the United States. The Center for Disease Control estimates that an average of 3,536 fatal accidental drownings, unrelated to boating, occurred each year from 2005-2014.
Pool monitoring cameras and software exist and are available for purchase by large organizations, such as community pools, but are often expensive installations involving both surface, as well as submerged cameras. These systems also require constant monitoring of a CCTV stream to be effective in preventing accidental death or injury. DORI addresses many of the drawbacks of these expensive systems and is best applied for home use in pools where it is easily deployable, requires no installation, and notifies supervisors immediately of an emergency.

Drowning is so pervasive as a cause of accidental death because it is difficult to detect and respond in time to save its victims. Victim's behavior is often very difficult to distinguish from the act of treading water. Victims often struggle silently to keep their head above the water while quickly losing energy and sinking. It is very uncommon for a victim to be able to flail, scream, or shout for help while in distress. In the absence of any lifeguard trained to recognize this type of behavior, consumers with home pools are at an especially great risk of an accidental death by drowning occurring at their home.

DORI is a complex system which integrates multiple sensors, a time of flight depth sensing camera, and an ultrasonic sonar array to locate and monitor the motion of objects underwater. The sensors provide DORI with a 360 degree field for monitoring the pool floor, allowing the robot to rotate to center any found objects in the camera's field of view. A high power single board computer does video processing on board. A surface hub connects to DORI over TCP and if DORI registers an individual in distress, it emits an alarm signal to the hub which emits an alarm sound and red warning light. BLE is also enabled on the surface hub for future app development, allowing notifications directly to the user's smartphone.

Testing was successfully performed to verify functionality of various subsystems, specifically the waterproof enclosure, sensors, and reporting components. We drilled a hole in the enclosure and fed a cable through it via a cable gland. By placing a simple LED circuit in the enclosure it was shown that the enclosure could be submerged underwater with neither leaks nor damage to the electronics. The Kinect's ability to detect and determine the status of a swimmer was verified by having the Kinect look through a container of water surrounded by a transparent barrier. Lastly, DORI's reporting component was tested by using a raspberry pi. Upon completion, DORI is ideally utilized in private pools as a robust yet compact system that allows owners to provide their family and friends with a safe swimming environment.

Brain-Computer Interface for Mobile Device Interaction

Team Members: Gerald LaMountain, Yufeng Wang, Henry Yan, Yinyin Ye
Advisor: Professor Masoud Salehi

Abstract

The team has designed and built an interaction system for providing a means for individuals with severe speech and physical impairments (SSPI) to control and interact with a mobile device. One problem with current technologies for this application is that they often require extensive camera systems and other external components, or even intrusive surgeries. By taking advantage of the purely non-invasive nature of electroencephalography (EEG), electromyography (EMG), or other biosignals, the system enables its users with a viable alternate access to the many services and applications available on mobile devices. As a modular system, it can be adapted for individuals with different degrees of physical impairment, without the restriction of the traditional touch and speech interfaces of mobile devices.

To operate the system, biosignals must be collected from the user and then translated to system commands through a predefined mapping. Our system primarily utilizes a motor imagery based BCI modality, in which users perform mental rehearsal or simulation of physical motion of their limbs. EEG signals are collected during these activities, and using these signals we are able to determine the nature of the attempted motion. The setup includes electrodes attached to the user's scalp and connected to an OpenBCI biosensing board. The data samples are sent to a Raspberry Pi device over a Bluetooth Low Energy (BLE) connection, where they get processed in a continuous fashion. The pipeline on the Raspberry Pi performs filtering, dimensionality reduction, and feature extraction on the input data. Specifically, we perform the common spatial patterns algorithm (CSP) to compute channel mixtures with optimal variance characteristics. These variances are then extracted to serve as features for classification. The classification process uses linear discriminant analysis (LDA) to predict what type of motion the EEG signal represents. The system then takes this prediction and map it to a navigational command that gets sent to the mobile device via BLE connection. A listener on the mobile device picks up the command and passes it to the Android application that enacts on it. The Android application presents the user with a menu of tasks that can be performed on the device, which is navigated by commands from the BCI subsystem. The Android ecosystem does not allow user applications to control other applications programmatically, as that will be a security risk. Thus, under the hood the Android application acts as an input keyboard and controls other applications via this keyboard interface. For testing and validation, the team first started testing the data processing pipeline with EEG alone. Using published EEG data from a BCI competition in Berlin, the team confirmed that the methods we used for classifying motor imagery using EEG were valid and yielded decent performance. In the types of less controlled environments where our system might be used however, we saw a significant decrease in performance. Since our design allows for a mixture of different biosignals, we attempted to improve performance by augmenting augmented our system with EMG signals with good results. In this way, our system can be modified on a user-to-user basis in order to leverage any residual muscle activity that the individual possesses.