19th Annual Biomedical Engineering Senior Capstone Design and Master’s Applied Project Poster Exhibition

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19th Annual Biomedical Engineering Spring Senior Capstone Design and Master’s Applied Project Poster Exhibition

April 26th, 2013

Biomedical Engineering Product Design
Global Health Technology Center
Harrington Biomedical Engineering Program
School of Biological and Health Systems Engineering
Ira A. Fulton Schools of Engineering
Arizona State University
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Welcome!

On behalf of the students, staff, and faculty of the Harrington Biomedical Engineering Program in the School of Biological and Health Systems Engineering, it is our pleasure to welcome you to our 19th Annual Biomedical Engineering Poster Exhibit and Symposium. As you leaf through the abstracts and stop by the posters, we hope you are impressed with the health care technology innovations that our capstone students and masters applied project candidates have developed. These projects have the potential to significantly impact a wide range of pressing health care needs in both developed and less resourced regions across the globe.

The diversity of health care solutions addressed by our senior capstone design and master applied projects is a testament to the breadth and depths of faculty, industrial, and clinical mentor expertise and the dedicated state-of-the-art facilities that are available to them. It also reflects an intensifying innovation culture and growing entrepreneurial spirit that exists within ASU and the greater Arizona community. We celebrate the continued success of our students in local, national, and international design contests and entrepreneurship competitions. With the growing entrepreneurial opportunities that now exist in Arizona; our students are poised to exploit the commercial potential of their innovations.

Our biomedical engineering design teams continue to channel their innovative and entrepreneurial spirit toward humanitarian efforts addressing the global grand challenges in health care and dire needs of the disabled and disadvantaged people around the world. In addition to designing rehabilitation devices and diagnostic health care technologies for African countries, we are now expanding our efforts in Asia, Central and South America where SBHSE faculty are engaging in new global partnerships. We share a common goal to develop the health care technology leaders for the 21st Century who can improve the quality of life at a global scale.

As we near the completion of our Biomedical Engineering Product Design and Global Health Technology Center and forge exciting new clinical, industrial, and entrepreneurial partnerships, unprecedented opportunities abound for our students. The future of our School of Biological and Health Systems Engineering remains very bright for many years ahead along this exciting and rewarding journey! Please come join us!

Dr. Marco Santello
Director, SBHSE
Harrington Endowed Chair and Professor

Dr. Vincent Pizziconi
Founder and Director
Biomedical Engineering Product Design and Global Health Technology Center
Bioengineering Capstone Design and Master’s Applied Project Instructors

We proudly present the 2013 Senior Capstone Design and Master’s Applied Project healthcare technology innovations.

Dr. Jeffrey T. La Belle
Assistant Professor
BME Capstone Design Instructor
Harrington Biomedical Engineering Program
School of Biological and Health Systems Engineering

Dr. Vincent Pizziconi
Associate Professor
BME Capstone Design Instructor
Master Applied Project Coordinator
Harrington Biomedical Engineering Program
School of Biological and Health Systems Engineering

Dr. Vikram Kodibagkar
Assistant Professor
Master Applied Project Coordinator
Harrington Biomedical Engineering Program
School of Biological and Health Systems Engineering

Biomedical Engineering Faculty Advisory Design Group

Dr. Jeffrey T. La Belle
Assistant Professor
Harrington Biomedical Engineering Program
School of Biological and Health Systems Engineering

Dr. Vincent Pizziconi
Associate Professor
Biomedical Engineering Product Design
Global Health Technology Center Founder
Harrington Biomedical Engineering Program
School of Biological and Health Systems Engineering

Dr. David Frakes
Assistant Professor
Harrington Biomedical Engineering Program
School of Biological and Health Systems Engineering
School of Electrical, Computer and Energy Engineering

Dr. Micheal Caplan
Associate Professor
Harrington Biomedical Engineering Program
School of Biological and Health Systems Engineering
School of Biological and Health Systems Engineering

Undergraduate Academic Chair

Dr. Jeff Kleim
Associate Professor

Graduate Academic Chair

Dr. Stephen Helms Tillery
Associate Professor

Academic Success Group:

Laura Hawes
Student Services Coordinator, Sr.

Tami Coronella
Academic Advising Manager

Jessica Kentgen
Academic Success Specialist

Kacy Vega
Academic Success Specialist

Director

Dr. Marco Santello
Harrington Endowed Chair and Professor
SBSHE Staff

Wendy Van Duyn
Assistant to Director

Tomi St John
Business Operations Manager

Charla Triplett
Associate Director of Industrial and Clinical Relations

Shaunna Price
Business Operations Specialist

Alana Labelle
Laboratory Manager

Nellie Voise
Academic Financial Specialist

Shevonda Shields
Research Advancement Administrator

Emily Bennett
Research Advancement Administrator

Solo Pyon
Systems Support Analyst
Biomedical Engineering Product Design & Global Health Technology Center

Capstone Teaching Assistants

Didem Yamak
Doctoral Candidate

Nathan A. Baldwin
Doctoral Candidate

Design Studio Center Staff

Kimia Seyedmadani
Masters Candidate

Robert Espinoza
Masters Candidate

Priyadarshini Gopalakrishnan
Masters Candidate

Jane Lacson
Masters Candidate

Sandhya Santhanaraman
Masters Candidate

Austin Roth
Bachelor Candidate

Katherine Ruh
Masters Candidate

Kasyap Barot,
B.S.E

William (Brady) Alling
Masters Candidate

Chitra Meduri
Masters Candidate

Manuj Malhotra
B.S.E
Middle and High School Design Center Interns

**Jordan Hines**
Chandler high school, 10th grader

**Schuyler St.Leger**
Kyrene Altadena Middle School, 7th grader

**Della Tao**
Basis Phoenix, 9th Grader

**Shiv Karthik**
Basis Corona del Sol High school, 12th grader

(not shown)
Tiffany Juan, Carolin Hom, Chelsey Poling, Colin Barry, Shadi Smoudi,
Biomedical Engineering
Senior Capstone Project Abstracts
1: Prosthetic Design

1-1: Active Prosthetic Ankle with Lateral Movement, A-18
Bronwyn Bitsilly, Emily Christman, Zach Coover, Scarlett Schmale, and Kyle Thomas
Mentor: Dr. James Abbas, School of Biological and Health Systems Engineering, Arizona State University

There are many options of prosthetics for lower extremity amputees, however many available prosthetics are limited in range of motion and fall short of supplying the natural movement that the human ankle provides. Current actively powered ankle prosthetics are restricted to only dorsiflexion and plantar flexion, which limits the user’s abilities. Limitations of user’s abilities can lead to hip or back pain, the inability to perform daily tasks or even cause the user to fall. Our ankle prosthetic addresses the lack of movement of the ankle joint by implementing the degrees of motion of inversion and eversion. The purpose of our device is exhibit a prosthetic that allows the basic motions of inversion and eversion so that this can be implemented into an actual marketable prosthetic. Our ankle prosthetic uses three springs set-up in a tripod formation as well as a tie rod acting as the ball and socket joint of an ankle. This alone can act as a passive device that still allows greater degrees of movement for the user. Ideally, we would like to incorporate a ball screw and motor that would work together to actively reposition the ankle joint if it is inverted from its neutral position. The essence of our finalized product is to demonstrate the ability of an ankle prosthetic that supplies users with greater motion. Whether it is to juke an opponent on the basketball court or to simply walk down the street and step off a curb with ease, our design of an ankle prosthetic with lateral movement gives the user increased possibilities.

1-2: Bio-Muscles Prosthesis, B-2
Josh Rogers
Mentor: Dr. Jeffrey La Belle
School of Biological and Health Systems Engineering, Arizona State University

Current models of prosthetic design must rely on movement using electrical or pneumatic motors and solenoids. These processes tend to be inefficient and power consuming. When compared to the natural, fluid motion of the human body prosthetics relying on motors tend to move in a clunky, unspecific fashion. An alternative method of movement incorporates the use of a Nickel-Titanium alloy known as Nitinol. This alloy has a 50-50 combination of each metal and has a unique property of contracting when it has reached a state of thermal activation. This contractile property allows the wire to somewhat mimic the functionality of skeletal muscle. Though Nitinol is not the only material capable of mimicking skeletal muscle. Thermoplastics such as Acrylonitrile butadiene styrene (ABS,) have the ability of shape memory. To determine which material is better suited in a prosthetic device a design of experiments (DOE) was created. Among material selection, wire diameter and length were also varied. The results of the DOE indicate that the longer, larger diameter Nitinol wire is better suited for use in a prosthetic device.
Our client, Doris Kayange, is a Malawian woman who lost her entire left leg to bone cancer when she was a teenager. She has outgrown her current prosthetic and needs a more comfortable, more functional replacement. Our design includes a Velcro-nylon strap attached to a flexible carbon fiber-resin composite saddle. The saddle is custom molded to her left hip from a cast obtained from a previous iteration of the project. Spring-loaded hinge joints at the hip and knee should provide improved walking gait and a pivoting ankle joint will allow for a wide range of motion. The thigh and shin leg shafts are aluminum rods due to their water resistance and enhanced durability, and foam padding for the saddle should provide comfort whether in motion or at rest. The group obtained exact measurements of the client’s leg length and total height, from which appropriate estimations were made for the remaining unknown dimensions. The saddle dimensions were taken from an exact cast of her hip. To enhance aesthetic appeal and the patient’s adherence to wearing the device, a rubber foot will be tinted to match the user’s skin color and will allow shoes to be worn.
1-4: Transfemoral Adjustable Prosthetic (TAP) Leg, B-16
James Bonelli, Zoran Bundalo, David DeJeu, and David Konves
Mentor: Dr. James Abbas, School of Biological and Health Systems Engineering, Arizona State University

The Transfemoral Adjustable Prosthetic (TAP) Leg is an adjustable length prosthetic, allowing the end user to change the length of the prosthetic’s pylons as he or she grows in height. This prosthetic differs from other transfemoral prosthetics due to its capability to allow for a natural swing and standing phase without complicated electronic components. The leg is able to adjust to fit a person of any height between 5 and 6.5 feet tall and weighing up to 200 pounds by adjusting the length of both a lower and upper pylon. Incorporated into the lower pylon is an inner and outer shell, with a shock absorber, which can be replaced if worn out, in the inner shell and a standard connection port to attach a prosthetic foot. The outer shell has two sliding tightening bands to tighten around the inner shell for a continuous modular adjustment. The outer shell terminates at its top with a male-type screw port. The knee incorporates three disks, the outer two of which rotate freely and attach to the lower pylon. A mechanism to lock out and not rotate when standing, but rotate freely when walking is incorporated to allow for a swinging function. The center disk connects to the upper pylon through a male-female screw port. The upper pylon incorporates an inner and outer shell of shorter length than the lower pylon with two tightening bands, and terminates with a standard port for attachment to a sheath.

1-5: Myoelectric Prosthesis Feedback System, B-17
Victor Orioke, Ranil Joshua, Vivek Devadas, Mitzi Thelakkaden, Brandon Hendrickson, and Shean Howlett
Mentors: Dr. Bruce Towe, Dr. James Abbas, School of Biological and Health Systems Engineering, Arizona State University

Currently, the problem of supplying feedback to the prosthetic user is either solved by the device itself or ignored completely. Recently, major strides have been made to the advancement of prosthetic arm control and feedback. Specifically, a very recent prosthetic hand connects directly to the patient’s nerves to allow for direct control and feedback to and from the patient’s brain. However, such systems will be exceedingly expensive to implement, making them unaffordable to many amputees. These patients that cannot afford the cutting edge prosthetic, but still want an effective feedback system, can turn to our product as a highly affordable alternative. The main objective was to develop an inexpensive real-time feedback system for use with preexisting myoelectric prostheses. Thus far, product specifications and product metrics have been finalized and initial development of a prototype has been completed. These are all in accordance with additional searches conducted through current patents and the FDA QSR to insure the design meets all requirements. Lastly, the prototype has undergone detailed DOE experiments to insure its function and the safety of its failure modes.
Pelvic Organ Prolapse (POP) is a weakening of the connective and smooth muscle tissue that makes up the majority of the pelvic floor. The weakening of this tissue causes organs to shift or descend, potentially causing severe discomfort, pain and loss of quality of life. The condition affects almost 40% of women who have given birth and requires surgical correction in more than 330,000 American women each year. Current treatment methods use a biomaterial patch developed for hernia repairs to strengthen the tissue, but there is a high failure rate that can require additional surgery. An alternative biomaterial proposed for this condition is to develop a biodegradable electro-spun scaffold that will support the load of the pelvic organs, match the mechanical properties of the anatomical location, and promote tissue repair. This scaffold will be used in conjunction with established surgical treatment. The feasibility of this scaffold will be tested by a specially designed uniaxial testing machine to determine the mechanical properties of the nano-fibers and scaffold. These results will be applied to mathematical models and standards to check the suitability of the biodegradable scaffold for use in the repair of pelvic tissues.
Regenerative medicine is a multidisciplinary field that aims to develop whole organ replacement. For the upper airway this would involve several tissues with different cellular, mechanical and physiological properties, including the trachea, vocal folds, epiglottis, and specific cartilage structures. These structures are required for the functions of the larynx such as breathing, coughing, swallowing, and vocal production. Currently, treatment for laryngeal cancer and some traumas requires the removal of a subset or all of the larynx. This leaves patients unable to speak normally and breathing uncomfortably through a hole in their neck. The long-term goal of this project is to assist surgeons in the development of the tissue engineered larynx. This year, three key sub-solutions under development are: (1) a fully functional model of vocal cords to measure sound production; (2) An anatomical model of a complete larynx for macroscopic scaffold structure development; and (3) initial development of nano-spun biocompatible scaffold materials to replicate the mechanical and proteinaceous structure of specific tissues of the larynx based on the extracellular matrix scaffolds of these tissues.

3: Biomedical Imaging
3-1: Amputee Camera, A-1
Harrison Verhey
Mentor: Dr. Jeffery LaBelle, School of Biological and Health Systems Engineering, Arizona State University

Right now there has been no way for doctors located in underdeveloped countries to develop custom fit saddles for prostheses. These doctors have asked for a method that allows them to simply take pictures of the amputation site, and from those pictures they have the ability to create custom prostheses. There is one specific case this is being developed for. There is a patient in Africa who has an amputation up to her hip, and doctors have not been able to properly model her amputation site for making prostheses. My goal was to develop a method that allows doctors to create accurate models of amputation sites, and it should be very low tech and easy to transport to underdeveloped countries. I have taken existing programs and devices that create 3D models by using photography, and have been developing a method for modeling amputation sites consistently and accurately. The program I have been using is Autodesk 123D Catch, this will eventually be replaced with a program developed by another team, and this is the program that could potentially be sold. I have been designing a prototype method for using a camera alongside the 123D Catch program to create the 3D replicas of limbs. Printable models will eventually be possible.

3-2: A Patient Specific Heart Modeling Process including the Myocardium, B-3
Lillee Stomski
Mentor: Dr. David Frakes, School of Biological and Health Systems Engineering & School of Electrical, Computer, and Energy Engineering, Arizona State University

Being well prepared for surgery is a key element to having a success in the operating room. Pediatric surgery requires the most preparation and careful consideration as the patients are much smaller than the typical person undergoing surgery. This design project is to create a process that generates a patient specific heart model that includes the myocardium surrounding the heart. These models will be both virtual and physical and will serve several functions inside and outside the operating room. The first function is to assist surgeons in preparing for surgery focused on congenital heart defects in pediatric patients. The second is to be used as an educational tool to display more specific heart conditions that are not represented by heart models used in the educational field. A third function of these models is to be used as a tool to help explain to non-medical personal what is happening in patient’s hearts, this includes such individuals as the parents of the patients. These models will be created through a multi-step computational process that will take CT data and turn it into these virtual and physical models. The myocardium will be clear and surround the opaque heart structures that include the defect. The biggest benefit of this project is the finished model is patient specific unlike current models available in the market and includes the myocardium. The final product that was produced underwent extensive review and revision to deliver the final models that best represent the patient-specific data. The final models deliver to the lead users meet all regulations and are ready for use in the defined market.

3-3: The Neurolizer: The Next Generation of Neurally Applied Polarized Light Imaging, B-15
Nicholas Cates, Trung Dang, and Summar Klug
Mentors: Dr. Jeffrey LaBelle, School of Biological and Health Systems Engineering, Arizona State University and Dr. Jason Kaufman, Aman Verma, Midwestern University

Diffusion tensor imaging (DTI), an MRI mapping method that uses the diffusion of molecules, is useful for studying the neural connectivity in health and disease pathways, as well as for pre-operative neurosurgical navigation. However, problems arise due to partial volume effects in which fiber tracts of different orientations inhabit a voxel and thereby void the MRI software's ability to determine directionality. Polarized light imaging can determine the orientation and inclination of these neurological samples due to the birefringent property of white matter, thereby giving it the ability to validate the DTI generated images. The polarized light imager for neural matter application being developed by our group is called the Neurolizer and is the most accurate, precise, and user friendly imager of its kind. With its unique LED powered diffuse light source, a light-sealing inner-outer chamber configuration, and a precise automated stepper motor, image capture can occur at every 1 degree interval without light interference, maximizing the amount of data that can be collected in a single run, and minimizing the chance of data error. With a simple GUI interface as well as a slide mount that can handle variability in slide dimensions,
the researcher has complete control over the data collection process without being over-limited by sample size. Based around its stepper motor design, the Neurolizer quickly and efficiently provides researchers with the most accurate data, importing all images into the computer via USB for future analysis and verification purposes.

4: Biomedical Instrumentation

4-1: Emergency Cervical Traction (EC Traction), A-5
Darcy Frear and Now Bahar Alam
Mentor: Dr. Neil Crawford, Barrow Neurological Institute

If not corrected quickly enough, unilateral and bilateral locked facets can cause paraplegia or quadriplegia. These injuries are most common in car accidents and occur when the ligament between two cervical vertebrae is damaged and the joint overlaps the vertebra. The current traction devices are not up to par and EC Traction has the solution because it utilizes a system of forces that can apply them at various angles rather than using one force vector. The final prototype moves in an x and y plane to change the angle while applying force. The actuator will provide the amount of traction necessary to move the head in the accurate position. The final hospital product will be able to fit on the bed (for easy transport) and be computer controlled. This will enable doctors to set up the patient quickly and can stop the device if something wrong is detected. This device will reduce both unilateral and bilateral locked facets quickly so minimal surgery is required for the patient.
4-2: Brain Contact Sensor, A-8
Sunghae Begala & Saad Elaqad
Mentors: Dr. Sarah Stabenfeldt & Dr. Bruce Towe, School of Biological and Health Systems Engineering

The purpose of this project is to create a biomedical instrument that will sense direct contact with the cortex of the brain. The team, which is composed of two members: Saad Elaqad and Sunghae Begala, has come up with a concept which will accomplish this within the specified product needs of the customer. The main customer for this product is Dr. Sarah Stabenfeldt, who is also the main mentor overseeing the project. The co-mentor of this project is Dr. Bruce Towe, an expert on Bioinstrumentation, who has thus far been of great assistance to the Design Team in advising them about possible solutions and considerations to take into account while completing the design steps. We are utilizing a red light emitting diode (LED) to reflect light via a photo-optical fiber and then is refracted off to be sensed and then read by a data acquisition unit (DAQ). This will aide Dr. Stabenfeldt in establishing a more reproducible experiment; whereby, she can establish exactly from where she is impacting in her experiments with rats and get the most accurate information to further her research in the biochemical effects of BTIs. Our design consists of a stereo-tax holding two photo-optical fibers with a basic circuit design that shines and transmits the initial light. The complete design is financially inexpensive and although the concepts rely on physic optics (a complicated subject area), the design itself is fairly simple and will be overall effective.

4-3: Delivery System for an In Situ Gelling, Temperature Responsive Hydrogel for the Embolization of Aneurysms, A-19
Michael Rose
Mentor: Dr. Brent Vernon. School of Biological and Health Systems Engineering, Arizona State University

Treating cerebral aneurysms is a major task for the medical device community. There are different variations and degrees of cerebral aneurysms and each have their own demands in terms of treatment. Aneurysms with a dome-to-neck ratio of less than 2 have proved difficult to treat using conventional treatments. A recently developed in-situ gelling, temperature responsive material has showed promise in the embolization of aneurysms of this type. The material is to be injected through a catheter as a liquid and then gel at the aneurysm site as it heats up. The purpose of this project has been to design and optimize a delivery system for this material. The delivery system consists of a microcatheter, guide catheter and a guidewire. A major challenge is inhibiting the material from starting to gel in the catheter. To overcome this challenge, the guide catheter is insulated as much as possible to prevent the material from heating up. Key design features such as guide catheter wall thickness, material selection for both catheters and a tapered end for the microcatheter will help accomplish this goal. The benefits of this design are that it lowers the threshold of pressure required for the material to flow through the catheter, minimizes premature material gelling and can access harder to reach aneurysms that located in smaller vessels.
High blood pressure puts you at risk for heart disease and stroke, two leading causes of death in the United States. An estimated 68 million people, roughly 1 in 3 U.S. adults, have high blood pressure and these diagnostics contribute to the nation’s medical debt. The amount of money accredited to high blood pressure costs the nation a total of almost $131 billion annually in direct medical expenses and roughly $25 billion in lost productivity. In 2009, Americans visited their health care providers more than 55 million times in order to treat their high blood pressure, which makes solving this problem a necessary step towards improving blood pressure devices so that they are take-home, affordable, and can monitor a patient’s blood pressure continuously. Our mission is to create an innovative and effective way to easily monitor blood pressure by utilizing an electrochemical pressure sensor and piezoelectric components to inspire the development of a continuous blood pressure sensor with our unique sensor’s capabilities. The sensor will acquire a reliable, sensitive, and fast response to ensure the accuracy and precision of the sensor signal produced. Our blood pressure monitor will be invaluable to physicians to determine appropriate treatments and diagnostics more quickly and effectively.
4-5: Bag valve mask with adjustable tidal volume and feedback system, B-9
Aaron J. Goshinska & Zachary M. Scott
Mentor: Dr. Jeffrey La Belle. School of Biological and Health Systems Engineering, Arizona State University

The use of bag valve masks (BVM) as mechanical ventilators by emergency medical service personnel has become the gold standard of pre-hospital resuscitation. However, studies indicate that the prevalence of user-induced gastric insufflation and hyperventilation during BVM use reduce the quality of emergency health care. To prevent gastric insufflation, our team designed and developed a mechanism that allows the user to adjust the air volume output of the BVM device. This mechanism consists of two leak valves and a rotatable cuff. The leak valves release air, reducing the volume output of a ventilation while the rotatable cuff revolves to open or close the leak valves, specifying the ventilation volume of the device. To prevent hyperventilation, a pico-bead thermistor (1 kΩ, 0.35 mm, NTC), installed inside the one-way valve and set in series with a 601 Ω resistor and 9 VDC battery, detects airflow events, which are initiated by ventilations. These events act as the input signal to the feedback system. The microcontroller measures the frequency of the input signal (i.e. monitors the rate of ventilation) and has the capacity to alert the user of inaccurate ventilation rates and subsequently assist the user in reestablishing the correct rate. The specified thermistor-resistor-battery combination was selected, via an extensive design of experiments, due to its ideal sensitivity and responsiveness. Together, the adjustable volume mechanism and feedback system improve the quality of manual ventilation by personalizing tidal volume delivery and ensuring the precision of ventilation rates.

4-6: Mechatronic Endovascular Catheter Deployment Device, B-14
Alice Chen, Sarah Halls, Marcos Icedo, and Paulina Velez
Mentor: Dr. David Frakes, School of Biological and Health Systems Engineering, Arizona State University, & Jefferson University Hospitals

Every year, an estimated 30,000 people in the United States experience a ruptured cerebral aneurysm. The most convenient treatment is through endovascular surgery, which consists of placing a needle into the femoral artery of the leg to inset a small catheter. Through x-ray guidance, the catheter is advanced through the body’s arterial system to one of the four blood vessels that feed the brain. Although surgeons wear gear to protect them from the radiation emitted from the x-rays, it is very difficult to protect extremities such as hands and faces during the surgery. Serious concerns are emerging because there are 15,000-20,000 endovascular treatments each year at the USA by which surgeon’s health is risked by spending between 1-2 hours in the surgery room. Currently, there are a few robotic catheter systems used for treating cardiac arrhythmia problems that improve the navigation of the catheter, keep the catheter in a stable position, shorten intervention times and shorten the radiation to which the surgeon is exposed. However, current robotic systems are very expensive, so most hospitals do not have them. The Mechatronic Endovascular Catheter Deployment Device would be the threading the guide wire/catheter inside of the human body manipulated by a remote control outside of the surgery room by the surgeon. The device will allow the guide wire/catheter to either translate or rotate. The device will be cost effective and less complex if compared with the existing technology plus it will allow the surgeons to be inside the operating rooms less time which means that the amount of radiation that they are exposed to will decrease significantly.
There is an important need to improve navigational aids for the visually impaired who currently constitute more than 5% of the American population. We employ small colored ground markers to define a walkway and to give navigational information to an iPhone camera application. The markers are differentiated from other objects by way of the specific marker colors that are detected by the iPhone and then it uses voice output and phone vibration to direct the person’s walk direction. The iPhone decodes information in the arrangement, size, and color of the markers so as to allow the user to select among multiple paths and to be informed about curbs, barriers, cross streets, dangers, etc.

The application has the following features:

1. A color calibration function so as to adapt to different lightings and backgrounds.
2. The marker colors and sizes encode information that the phone recognizes and speaks.
3. Customized user interface.

This application seeks to improve mobility of the visually impaired through improved communication with the environment.
5-2: iHear: A Customizable Hearing Aid Application for the iPhone, A-11
Jessica Albanese, Caroline Hom, and Chelsey Poling
Mentor: Dr. Mark Spano. School of Biological and Health Systems Engineering, Arizona State University

Hearing aids are expensive medical devices that require regular replacements to assure proper functioning. Over the course of this two-semester long capstone course, we have been working to develop a suitable alternative to the traditional hearing aid that will be much more accessible and affordable. Since many people now possess smartphones, such as Apple’s iPhone, we thought it would be best to create an iPhone application that would allow someone to use their cell phone as a hearing aid. Upon starting iHear, the hearing aid application, the user will calibrate their iPhone to best suit their needs by first taking a diagnostic hearing test built in to the application. Once this step is completed, the user will be able to use their iPhone as a hearing aid. The microphone will pick up the voices and sounds around the user, the application will filter out the noise and amplify certain frequencies, and the user will be able to hear the world around them much more clearly through their headphones. Our application is completely customizable. The best part about this application is that it will be available to download for free.

5-3: Your Oral Health—an Instructional iPhone Application, B-4
Samantha Aguirre and Scott Phelps
Mentors: Dr. Mark Spano, Research Professor, School of Biological and Health Systems Engineering, Arizona State University, Dr. Tony Hashemian, Assistant Dean of Global Health, Arizona School of Dentistry and Oral Health

The Surgeon General’s National Call to Action to Promote Oral Health clearly outlines several dental dilemmas facing our Country ranging from the fact that a little less than two thirds of adults reported having visited a dentist in the past 12 months and for every adult 19 years or older with medical insurance, there are three without dental insurance. Your Oral Health—an instructional iPhone application, combines an intuitive user interface and graphical design to emphasize prevention as the key to maintaining excellent oral health for adults ages 18-40. Combining university resources with assistance from Dr. Tony Hashemian (Assistant Dean of Global Health—Arizona School of Dentistry and Oral Health) and Dr. Mark Spano (Research Professor, Biological and Health Systems Engineering—Arizona State University), we are working to meet very real needs as we help to improve oral health for adults ages 18-40. This free oral health iPhone application developed on Apple’s mobile iOS programming platform includes push notifications to remind users to brush, floss and rinse to help them establish regular daily dental hygiene habits. Additional prevention resources include instructional videos, diagrams illustrating the progression of disease, information from the American Dental Association and contact information for hygiene and dental school clinics and other locations where patients may receive professional care at a discounted price. We expect that regular use of our application will help individuals develop healthy daily habits and a more comprehensive understanding of prevention as they improve their oral health.

5-4: Detecting Early Signs of Autism Through Joint Attention, B-10
Matthew McDermand, Austin Roth, Brendan Watson
Mentors: Dr. Mark Spano, , School of Biological and Health Systems Engineering, Arizona State University and Dr. Christopher Smith, Southwest Autism Research & Resource Center

Autism spectrum disorder (ASD) and autism are both general terms for a group of complex disorders of brain development. These disorders are characterized, in varying degrees, by difficulties in social interaction, verbal and nonverbal communication and repetitive behaviors. Currently, 1% of children in the United States are diagnosed with autism. It has been found that early intervention of autism can lead to a better outcome with respect to the level and severity of autism. However, the average age for the diagnosis of autism is three years. The objective of our device is to help assist physicians in diagnosing autism at an early age, by means of a joint attention test. Joint attention is the shared focus, of two individuals, on an object. It is achieved when one individual alerts another to an object by means of eye-gazing or other verbal or non-verbal indications and it is known to develop gradually or not at all in some children with ASD. An iPad application is in the works, which can be used to quantify joint attention in children as young as 6 months. The face detection software on the iPad will be utilized in a way that can
detect when the child moves his head in real time. The data from this directed attention test will go to researchers that can further examine the relationship between autism and joint attention.

6: Biosensor and Medical Diagnostic

6-1: Multiplexed Diabetes Management: Integration of Insulin Detection, A-3
Zachary W. Decke
Mentor: Dr. Jeffrey La Belle, School of Biological and Health Systems Engineering, Arizona State University, & Mayo Clinic Arizona

With the Multiplexed Diabetes Management (MDM) monitoring device, we aim to revolutionize the way in which people are able to manage their diabetes or pre-diabetes. By providing more diabetes-related marker information with each drop of blood, users will have the resources needed to make informed decisions about how effectively they are managing their disease. My role for this project is the initial integration of insulin detection and the continued development of the overall device. In Phase 2 of the design process, the MDM project moved into the prototyping activities related to microfluidics and insulin detection, and further economic and business development. As critical components of the overall MDM device, the microfluidic system’s design and the development of the insulin sensor were carefully refined and tested in order to verify the accuracy of the final product specifications for the device. In regards to the microfluidic system, a reliable, easy, low-cost design was developed that successfully transports fluid from the inlet to the electrode sensing chamber. A design of experiments analysis was completed to determine the optimal design parameters for maximize transport speed and distance. In regards to the insulin sensor, the calibration curve (n=3) and optimal binding frequency, which will be useful in programming the MDM device, were determined. The lower limit of detection was calculated to be 8.47pM, which is well below the normal physiological range.
6-2: TearTouch, A-7
Erica Engelschall and Neil Saez
Mentor: Dr. Jeffrey La Belle, School of Biological and Health Systems Engineering, Arizona State University, & Mayo Clinic

Currently diabetic patients can only use painful finger pricks to self-monitor their glucose levels. This leads to large levels of noncompliance (the national average is 2 tests per day, when physicians recommend 5-10 tests). Noncompliance can lead to future complications that are a large burden on the healthcare system. With more than 350 million diabetics worldwide, and a $218 billion impact on the U.S. healthcare system, solving noncompliance is a necessary step to improving the current status of diabetes. TearTouch aims to improve noncompliance through a noninvasive glucose monitor that can be gently touched to eye. A small amount of tear fluid is collected and sampled off of the eye with no irritation, providing an accurate glucose measurement without a painful finger prick. The design consists of a soft gel-like ocular cushion that interfaces with the eye and works by a capillary action microfluidic to obtain accurate and consistent volumes of tear fluid with every test. The design also eliminates the need to have extra paraphernalia, such as alcohol swabs and lancets. Providing another method to diabetic patients for testing their blood glucose noninvasively takes the fight against diabetes one step closer to improvement.

6-3: Bio-Muscles for Prosthetics and Rehabilitation, A-17
Kyle Donnelly Marian Grucky, Taylor Graber, Zachary Killeen
Mentor: Dr. Bruce Towe, School of Biological and Health Systems Engineering, Arizona State University

In the clinical trials market, there is a need for animal testing in order to ensure safety and efficacy. There is a current need within this field for a rodent-compatible pulse plethysmograph to monitor blood volume in the subject’s peripheral vasculature. This is especially helpful when testing drugs like vasodilators or peripheral blood flow enhancers. Current methods for measuring changes in peripheral blood volume, such as a Laser Doppler Flowmeter, lack the appropriate sensitivity. Our design intends to meet this need by creating a small package that is USB powered and interfaced. It involves a simple GUI that gives the user a clear PPG readout, providing values in real time and storing the data in an excel spreadsheet as it runs. Since it runs solely off USB, there is also no data acquisition unit that needs to be purchased, keeping the cost very low. While there are some rodent pulse oximeters available commercially, they work to measure O2 saturation, rather than blood volume, so the field is wide open for our product.
Volume depletion, can lead to migraines, dizziness, and significant decreases in an individual’s ability to physically perform. Because proper levels of hydration are necessary in order to maintain both short and long term health, the ability to monitor hydration levels is significant to health from a clinical standpoint. Although devices capable of monitoring hydration levels exist, these devices are expensive, invasive, inaccurate, or do not offer a continuous mode of measurement. The ideal hydration monitor for consumer use needs to be characterized by its portability, affordability, and accuracy. Also, this device would need to be noninvasive and offer continuous hydration monitoring in order to accurately assess fluctuations in hydration data throughout a specified time period. One particular method for hydration monitoring that fits the majority of these criteria is known as biological impedance analysis (BIA). Although current devices using BIA do not provide acceptable levels of accuracy, portability, or continuity in data collection, BIA could potentially be modified to fit many, if not all, desired customer needs. By following the steps of product design and development, a device capable of detecting a potential difference between two points on a segment of the body was developed. The device uses an imperceptible current of 500 µA at a frequency of 50 kHz to derive an impedance value for the segment under examination. Using the derived impedance value in a developed multiple regression equation, the total body water as a percentage of total weight can be estimated. Our device emits a signal and outputs a received signal that is altered due to impedance. Our configuration uses two signal emitting electrodes and two voltage-sensing electrodes. From experimentation, we were able to determine that the distance between the electrodes and the magnitude of the signal are significant in the potential difference received from the system.

While capillary refill time is currently used as an indicator of general cardiovascular health in clinics, hospitals, and even in research, there is no standardized method of taking capillary refill time. This is unfortunate, as CRT has proven to be a good indicator of many cardiovascular issues, but with little quantitative data it can be hard to make any real connections between refill time and specific cardiovascular conditions. Our product will automate the entire test from the compression and release of pressure on the finger, to the actual measurement, to the display of the resulting capillary refill time. This product idea has been moved from initial conception through concept development and selection to a full set of specifications and product architecture. The architecture has been further developed, through prototyping, into a functioning device that meets our customer needs. Our sensor uses impedance plethysmography to obtain a capillary refill time, and operates with consistent and reproducible pressure on the finger using a simple air pressure cuff. Our product gives repeatable results that minimize human error from the previously error prone manual test. Compared to the manual test, our capillary refill time sensor provides a more accurate and precise measurement of CRT while maintaining a high level of portability and ease of use.
Development of a disposable Interleukin-18 (IL-18) Point-of-Care Biosensor for Cardiovascular Disease (CVD) detection, B-1

Amit Jha
Mentor: Dr. Jeffrey La Belle, School of Biological and Health Systems Engineering, Arizona State University

Development of a disposable biosensor for Cardiovascular Disease (CVD) detection based on Interleukin-18 (IL-18) sensitivity was proposed to fill the technology gap between rapid and portable CVD point-of-care diagnosis. 1 in 3 American adults suffer from CVD and the lack of point-of-care biosensors support the need for development of a point-of-care CVD biosensor. Our sensor will be Electrochemical Impedance Spectroscopy (EIS) based. EIS biosensors have the advantages of being rapid, label-free, portable, and highly sensitive. The long-term goal of this project is to incorporate multiple biomarkers into the biosensor to increase CVD specificity. The short-term goal of this project is to develop a CVD biosensor specific to IL-18. IL-18 was chosen for this CVD biosensor due to its ability to detect plaque vulnerability of the heart. Design phase I was mainly spent defining the problem, identifying the main consumers, concept testing, and developing a set of finalized device specifications. Design phase II was mainly spent developing prototypes to meet certain finalized specifications. An alpha and beta prototype was developed for the sensor. The alpha gold disk electrode (GDE) prototype represented a bench-top model of the sensor; while the beta screen printed electrode (SPE) prototype was closer to what the commercialized device would resemble. A set of procedures was also developed for manufacturing the prototypes and ensuring the prototypes met defined specifications. Risk analysis and human factors engineering was utilized to minimize potential risks. The end result of the development effort was that all targeted specifications for both prototypes were met. All product development processes carried out throughout this design phase have been followed in accordance to FDA Quality System Regulations Guidance.
Every year, more than 795,000 people have a stroke and more than seven million people have survived a stroke in the US today. After stroke, neural plasticity in the form of cortical reorganization has been observed as a result from nervous system damage. Repetition and attention are key factors that have been experimentally identified for driving neural plasticity. In animal studies investigating motor skill learning, monkeys and rats have performed 400 to 600 repetitions, while in human studies, subjects have performed hundreds of repetitions. However, the average amount of upper limb rehabilitation repetitions is about 32 per session in human patients. Furthermore, cognitive impairment in stroke patients is as frequent as 50% of the patient population. Hence, there is a need to quantify the number of repetitions performed during rehabilitation so that patients may receive a more proper dose of therapy and to remind patients to use their impaired limb outside of therapy. The rehabilitation device presented, the Therapist Assistant (TA), consists of an instrumented wristband and glove compound. The gadget is equipped with an accelerometer designed to detect the number of reaching movements performed. A vibrating motor is dorsally placed on the glove to provide somatosensory feedback to the patient. The accelerometer and vibrating motor components can be placed on various locations of the back of the hand via Velcro attachments and are connected to a microcontroller housed on the wristband. The microcontroller performs the signal processing and is equipped with a rechargeable battery. Finally, the entire electronic ensemble can be removed to wash the clothing materials. By providing a history record of the paretic limb usage during and outside of therapy, the TA will aid the therapists in having a better control over the repetition dosage for their patients.
A leading cause of injury in the elderly is falling. A common product found in hospitals and homes today is a pressure plate device that alerts healthcare providers when a patient gets out of bed. Such a system is valuable because it enables caregivers to assist patients with mobility, thus eliminating much of the risk of falling. The problem with a pressure plate device is that it is only located in designated areas, and does not remind the patient to use their assistive walking device. Our team has developed an accelerometer-based system that will operate based on the position of the user with respect to the ground. The ADR (assistive device reminder) is designed to be directly attached to the patient via a leg band on the thigh. When the user is sitting or lying down, the device is inactive, but when the user stands up it will alert them which will remind them to use their assistive walking device. Upon standing, the ADR reminds the user to use their assistive walking device with a vibrating alert, thereby reducing their risk of falling. The device will remain functional during travel as well as when the patient is at home, which is a vast improvement over the pressure plate device.
7-3: Cycle Rehabilitation Device, B-18
Julie McGuire
Mentor: Dr. Jeffrey La Belle, School of Biological and Health Systems Engineering, Arizona State University

Knee overuse injuries are common among elite and professional cyclists and triathletes. On average, professional cyclists are in the saddle anywhere from two to six hours per day. During one hour of cycling, upwards of 5,000 revolutions can be made with the pedal. The amount of force on the lower extremities of the body adds up quickly. The training tools available on the market right now mostly measure an athlete’s power output, or their wattage. Unfortunately, wattage does not tell you the force that is being put on the body while cycling. Often times a cyclists rides with cadence (revolutions per minute of the pedal) too low, which results in an average power output and nearly double that amount of torque. If an athlete were able to read the amount of torque they were putting on the pedal at any given time, it could make them more efficient in not only their shifting and pedaling but also greatly reduce their risk for an overuse injury. The goal of this device is to accurately measure torque and cadence in a small, real-time display screen that can be mounted to the handlebars of a bicycle and act as a signal to cyclists of when to shift. This device could revolutionize cycling by retraining athletes to ride their bike based on the direct forces to their body instead of by power. Over time, athletes will be able to train longer and healthier, thus helping attain the next level of the sport.

7-4: Surgical Fatigue Reduction Glove, B-8
Jinkyu Kim and Gabe Oland
Mentors: Dr. Marco Santello, and Dr. Christopher Buneo, School of Biological and Health Systems Engineering, Arizona State University

Regardless of surgical skill or experience, muscle tremors caused by fatigue in the hand and forearm can impair fine motor control and result in operating room errors. By using a heating element to thermally induce vasodilation in the intrinsic and extrinsic muscles of the hand and forearm, the VasoWrap surgical fatigue reduction glove targets muscle tremors on a cellular level. The increase in blood circulation resulting from vasodilation allows for faster metabolic waste removal and more efficient delivery of oxygen and nutrients to the cells, thereby prolonging the onset of muscle fatigue and improving surgical precision. During prototype testing under simulated operating room conditions, use of the VasoWrap showed a 9% reduction in muscle fatigue (111°F with an on-off cycle of 1 minute on, 2 minutes off). The Surgical Fatigue Reduction team members Jinkyu Kim and Gabe Oland performed all experimentation under the guidance of the Dr. Marco Santello and Dr. Christopher Buneo of the School of Biological and Health Systems Engineering at Arizona State University. The final glove design, which is worn directly over the hands and forearms, is completely covered by outer gloves and surgical attire, thereby posing no threat to operating room sterility. It is also thin, flexible, and durable, causing no extra discomfort for surgeons that already “double-glove.” As the estimated product price is approximately $30 per glove, medical facilities around the world will be highly inclined to purchase our inexpensive product in order to reduce surgical errors, lower re-operation rates, and improve patient recovery outcomes.
Stroke is the leading cause of disability among adults in the U.S., affecting more than 700,000 individuals annually. Of this 700,000 nearly 65% may never fully recover. However, this should not be an indication that these individuals will never fully recover. The victim of a socially, economically, and physically detrimental condition should never have to believe that the possibility of a full recovery is impossible. The emotional distress exhibited by a stroke survivor is truly remarkable, but the magnitude of distress is not necessary. Currently, the main tool available for physical therapists to assess a patient’s performance is known as the Fugl-Meyer test. An array of physical motions and tasks proctored by the physical therapists, the examination usually takes around 20-30 minutes to complete and contributes little to no information as to how well the patient is progressing. Our device provides an objective, efficacious, and time effective alternative to the Fugl-Meyer and other tools like it. The device records the actual motion of the patient in 3-dimensions and records it for comparison to later exams; this will allow the interested party to view their progress day-to-day, week-to-week, and year-to-year. Because patients can administer this test on themselves or with minimal assistance from the therapist, it allows the therapist to spend more productive time with their patients. Normally, it would take a stroke survivor years to witness any significant change in their physical abilities. By allowing them to see tangible information of how they truly are succeeding, it provides an individual with the motivation and confidence to continue working towards their goals, and drastically curbs the emotional distress involved with not noticing the advancements that are taking place.
In rural areas of Kenya, such as the small town of Oyugis, power supplies are scarce and the ability to access preventative medicine is much more difficult than in developed nations. For example, the administration of vaccines is much different in this region compared to the United States. The government provides shipments of vaccines to places like Oyugis, but these vaccines cannot be kept for more than a day as the current medical facilities do not have the capacity to maintain the appropriate cold chain for these vaccines. Therefore, vaccines are only available on the day they are delivered. The purpose of Vaccines for Rural Africa is to provide a two-part system that will allow these rural areas to have access to a non-electric, sustainable method to refrigerate vaccines and keep the cold chain intact. The components of this system consist of a cold storage unit and a bicycle-powered ice-maker. The cold storage unit, constructed from coated plywood, insulation, and an easy-to-sterilize plastic interior container, will store the vaccines. This unit will have a separate central container where the ice will be placed and will be able to keep the vaccines between 2-8°C for approximately eight hours, depending on various environmental factors. The ice-maker will be powered by a compressor connected to the bicycle, which will act as the motor. The compressor pumps R134a throughout the system in order to compress the refrigerant, bleed heat to the environment, and eventually cool a container in which it will be possible to generate ice. Testing has shown that the cooling unit is quite efficient, but that the cooling system will need further work in order to make the system more efficient. Ultimately, the engineering concepts and medical device design processes implemented in this project have demonstrated solid understanding of the relevant material.
The G3Box Maternal Surgical Clinic aims to improve the problems in South Sudan associated with maternal mortality and design a clinic capable of handling maternal emergencies. The surgical clinic is designed inside of two combined shipping containers and provides a sanitary and durable operating room with medical equipment capable of performing Caesarean Sections, treating Hemorrhage, and performing other life saving procedures for the women and infants. The space is designed and constructed to the United States Standards for Health Care Facilities and is equivalent to hospitals and clinics found in the U.S. Our final product development has produced a prototype that shows the outcome of our final product design. During the past semester the design team has been working to develop this prototype and test for its strength and durability. Making sure that the product can withstand the amount of weight within the clinic with all of the equipment, doctors, and patients, as well as transportation from one location to another.
8-3: SEAT: Sittin’ Easy at All Times, A-13
Joshua Hammer, Andrea McFerren, and Steven Mullane
Mentors: Dr. James Abbas, Dr. Jeffrey LaBelle, School of Biological and Health Systems Engineering and Dr. Jan Snyder, Ira A. Fulton School of Engineering, Arizona State University

Pressure ulcers are a dangerous and difficult to prevent medical condition suffered by millions of people around the world. Janet, a 9-year-old girl living in Malawi, is paralyzed from the waist down due to spina bifida. Because Janet spends the day sitting, she suffers from pressure sores which prevent her from attending school or living a safe and healthy life. To address the needs of Janet and others like her, we have developed a seating cushion designed to reduce pressure sore formation. The SEAT, or Sittin’ Easy at All Times, is a portable, modular, all-weather therapeutic cushion that can be used anywhere, including chairs, wheelchairs, or even the floor. SEAT’s core is soft, pressure-redistributing memory foam, and the sitter contact surface fashioned from medical-grade sheepskin, a material which has been shown to reduce pressure sore formation in several clinical trials. Our design process encompassed exhaustive literature and market review, FDA regulation-guided development steps, and laboratory testing of our concept. Alpha prototype testing indicated our material selection is durable and weather-resistant, with a projected functional life span equal to or greater than our competitors. A full-scale beta prototype of SEAT will be delivered to Janet in Malawi over the summer by Dr. Jan Snyder, and may serve as a blueprint for further entrepreneurial endeavors in the future.

8-4: Hand Operated Mobility Device for Traveling to Market in Kenya, A-15
Neekta Hamidi, Thelma Okocha, and Ami Thakrar
Mentors: Dr. Jimmy Abbas, Dr. Vincent Pizziconi, School of Biological and Health Systems Engineering and Dr. Jan Snyder, Ira A. Fulton School of Engineering, Arizona State University
Project Africa

The purpose of our Hand Operated Mobility Device is to fulfill the needs of Susan, a disabled patient in Kenya, who is unable to use her legs due to infection of poliomyelitis. The intent of this device is to provide Susan with the ability to travel comfortably and efficiently, specifically to the local market, where she sells vegetables to provide her family with an income and accumulate revenue to save for her son’s future. The developed design presents similarities to a hand-cycle, allowing the customer to use the strength and coordination of her arms to mobilize the device; this will allow her to maximize her upper-body strength and also improve the function of her arms. The design also accommodates additional appendices such as a cup holder, as she lives in a warm climate, an adjustable umbrella, to avoid rain and external exposure, and baskets, to carry her vegetables. Key features of this device includes its structure, which is created from recycled bicycle parts to promote sustainability and ensure that our customer can continue the usage of the device if a specific part of the devices breaks. The foundation will be made of aluminum rods to ensure durability and longevity, and be coated with an industrial rust coating (Rust Bullet), to prevent rust. We plan to send the device in parts, which will be reassembled in Kenya to avoid high costs and shipping issues. It is our goal that we create a device that will allow her to gain independence and to provide for her son; additionally, we also hope that other paraplegic customers can use this device.
Many individuals with quadriplegia suffer from complications related to prolonged time spent in wheelchairs. A common complication with serious results is spasticity caused by an inflammation of the ischial tuberosities of the pelvis due to positioning related vascular restriction. To reduce these symptoms, patients will typically use a tilt table to alleviate the pressure at their hip joints. However, due to the stress placed on the body during patient transfer, using such a table can cause additional damage to the patient and their caregivers. The physical strains put on both the patient and caregivers’ back during these transfers are of particular concern. The primary goal of this design effort is to design a bed that has the full functionality of a tilt table without the need of additional or supplemental equipment in the home. This is achieved by merging the functions of a tilt table with a standard bed. The key features of this product will allow its users to raise and lower the bed as well as tilt the bed to a completely vertical position. By combining multiple functions into one device, the need to transfer the patient from bed to chair to tilt table will be eliminated. Additionally, the device will give caretakers the ability to adjust the height of the patient’s bed to aide in patient transfers and daily care. Overall, by allowing the patient to use the tilting function on a daily basis without additional equipment or effort, this hybrid bed-tilt table’s multifunctional construction will support the health of the patient and their caregivers.
Affiliated Senior Capstone Projects: Innovation Space

Assistive Device

1-1 Elevating Wheelchair
Christopher Miranda, Andrew Lai, Peter Georgiou, Rachel Bone
Prasad Boradkar, David Frakes, Graphic Design, Supply Chain & Management, Industrial Design,
School of Biological and Health Systems Engineering, InnovationSpace, Arizona State University
Vantage Mobility International, Inc.; Paralyzed Veterans of America

Wheelchair users have always lived life at a lower altitude than their able-bodied counterparts. There are products on the market designed to lessen the difference, but their capabilities are limited and they can also be cumbersome and expensive. Our product solves the problem of reduced wheelchair-bound height by allowing users to elevate the wheelchair seat itself using gas springs, which have been integrated to the frame of the wheelchair. The gas springs provide wheelchair users with 10 inches of additional height, raising them near to standing height and allowing them to reach above and speak at eye level. The gas springs used in our product are similar to those used in office chairs and are just as easy to operate. The wheelchair users simply places his or her palms on two integrated push bars located at the sides of the chair, presses and holds a button to engage the gas springs and then pushes downward moderately on the two push bars in a dip-like motion. The assistive force provided by the gas springs then lifts the seat upward. Acting in concert with the assistive gas springs, the user need only lift about a third of his or her body weight, which is an easy task for typical users in the manual wheelchair market.
Master’s Applied Projects

1-1: REM Alarm Clock, Microcomputers
David Beighe
Mentor: Dr. Jitendran Muthuswamy, School of Biological and Health Systems Engineering, Arizona State University

Difficulty waking up to an alarm clock is usually the result of sleep inertia, as the body has difficulty waking from deep sleep. The result is grogginess, irritability, impaired motor skills and decreased cognitive ability. The goal of this device is to detect the stage of sleep and only wake the user from light sleep. The aim is to accomplish this by measuring rapid eye movements from the subject with the use of an accelerometer, wirelessly transmitting the data, and processing the data so it can wake the user at a time that minimizes sleep inertia. This utilizes the principle of sleep stages and the cyclical nature of sleep. Essentially when a human enters the REM state they entire from light sleep typically, and from REM they go back into light sleep. By knowing when the subject is in REM sleep and how long his or her sleep cycles last, the device can reasonably “guess” when a person is in light or deep sleep. The aim of this project was to build a microcontroller-based device capable of detecting motion through an accelerometer, process the data to determine when the subject is in REM, and send this data wirelessly to a computer for analysis. Ultimately, this device would be a rather simple, but accurate, monitor that can be made available at an affordable price for college students and shift workers.
1-2: Stress Sensing Device Printed on Flexible Substrate, Biosensor
Kevin Uchimura
Mentor: Dr. Jeffrey La Belle, School of Biological and Health Systems Engineering, Arizona State University

Sensing dangerous levels of chronic stress will enable health professionals to counsel at-risk individuals; this may mitigate the detrimental health outcomes associated with chronic stress. These stressors include physiological stress as well as psychological stress. Both conditions, when experienced long term, result in homeostatic adaptations that may be detrimental to health. By sensing the user’s heart rate, the time intervals between heartbeats was acquired at rest and after exercise for a period of five minutes. The interbeat interval data was recorded with an existing commercial device and a prototype device being developed by the authors. The prototype of the novel device being developed was compared against the emWave® in a study investigating each device’s ability to monitor stress after physical exertion. Power spectral density analysis was performed to determine how each device’s capabilities in the frequency domain. In order to facilitate user comfort and ease-of-use, the prototype circuit was printed on a flexible substrate.

1-3: A Follicle Stimulating Hormone (FSH) Biosensor for monitoring fertility, Biosensor
Sandhya Santhanaraman
Mentor: Dr. Jeffrey La Belle, School of Biological and Health Systems Engineering, Arizona State University

Follicle Stimulating Hormone (FSH) which is produced by the pituitary gland in the body and a measure of the ovarian reserve in women, is a primary indicator of fertility. FSH, along with Progesterone, Estradiol and Luteinizing hormone help to determine the cause of infertility. By developing a sensor that detects these hormones simultaneously, it can serve a dual purpose; to monitor fertility, and in some cases, prevent unintended pregnancies. Bench top experiments using the technique of Electrochemical Impedance Spectroscopy (EIS) following antibody immobilization on gold disk electrodes, reveal that FSH can be detected in purified and blood samples. EIS shows that the optimal binding frequency of the antibody to its target is at 312.5 Hz. With reproducibility in three electrodes, the impedance response with change in concentration was 10.909ln(x) + 816.88 with an R squared value of 0.968. The Lower Limit of Detection was found to be 13.0725 pg/ml which is at least an order of magnitude lower than the physiological range of FSH. These primary results indicate that FSH can be detected using EIS and when developed, can be used as a point of care device for monitoring fertility.

1-4: The Feasibility of an Electrochemical Glutamate Sensor
Katherine Ruh B.S.E.
Mentor: Dr. Jeffrey La Belle, School of Biological and Health Systems Engineering, Arizona State University

Glutamate is a blood biomarker that is a major neurotransmitter. When a chemical stress event occurs such as Traumatic Brain Injury (TBI) that affects the chemical levels there can be consequences that are not visible on the outside of the body. When a chemical stress event occurs it increases the Glutamate Levels, or other biomarker levels, in the blood which can in turn be very toxic or damaging to human beings. Especially during a Traumatic Brain Injury glutamate levels are affected in a negative way in the brain causing an increase in concentration of glutamate in the blood. Therefore there is a need to monitor certain forms of chemical stresses such as Traumatic Brain Injury. The overall goal is to develop a system to see these kinds of changes that occur in a complex solution such as blood. By using electrochemical techniques such as Cyclic Voltammetry and Amperometric i*t glutamate was studied to see the feasibility of creating an electrochemical glutamate sensor. A sensitivity and specificity test were specifically completed. For the sensitivity test the target used was L-Glutamic Acid and the enzyme used was Glutamate Oxidase. For the specificity test the non-targets used were Albumin, due to its high concentrations in blood, Epinephrine, due to its association with chemical stresses such as TBI, and Glucose, because of the possible effects it could have on the sensor and the rising number of people in the world with diabetes which increases the concentration of glucose in the blood. The outcome of the project was the beginning steps in finding the lower limit of detection for the biosensor as well as a look into other biomarkers effects on the proposed biosensor in purified solutions.
The Alternating Pulse Reversible Current Electrode is a hand held electrode that is design to stimulate the cervix of a rat on the 15th day of its gestation cycle. Recently there have been experiments conducted at St. Joes Health Medical Center (SJHMC) that indicate that the electrical stimulation of the cervix induces cervical ripening. Cervical ripening is described as a three-step process in which the cervix undergoes softening, effacement, and dilation. It is important that the cervix begins to ripen during the later stages of gestation in order to prevent complications when the cycle has come to term. Researchers at SJHMC have run into several issues when conducting cervical ripening test in the rat model. Their issues have been identified as instrumentation problems. These problems consist of high current density passing into the tissue resulting in tissue burn, and regional acid and base build up damaging tissue. The Alternating Pulse Reversible Current Electrode aims to mitigate these experimental problems in two ways. First, it implements two additional electrodes in a ring like fashion that alternate their pulses. The previous electrode used a two-point electrode with in phase pulses. The additional electrodes distribute the current over a larger area, reducing the current density. Second, the electrode is designed to reverse each electrode polarity so that the current will travel in two directions. This will decrease regional acid and base build up.

Musculoskeletal injuries in endoscopists – A kinematic analysis
Deepika Mohankumar
Mentor: Dr. Marco Santello, School of Biological and Health Systems Engineering, Arizona State University; Mayo Clinic Arizona

Endoscopy procedures are known to be associated with musculoskeletal injuries including carpal tunnel syndrome, tendinitis, nerve entrapment, and back pain. Endoscopists often undergo surgical treatment or have to make significant alterations to how they perform endoscopy procedures. The relation between musculoskeletal injuries and endoscopy maneuvers is not well understood. We propose that studying upper limb kinematics of endoscopy maneuvers may provide insight into the mechanisms underlying overuse injuries. The aim of the study was to quantify upper limb movement patterns during performance of simulated colonoscopy. We measured the time endoscopists (n = 12) spent within four portions of the entire wrist range of motion (r.o.m.). Kinematic data was recorded by a magnetic position/orientation tracker. Endoscopists were asked to perform two procedures for the same amount of time (10 mins.) that differed in terms of difficulty. A second study was performed on first year fellows (n = 5) to determine the effect of practice on the kinematic patterns of wrist motion by comparing three sessions performed three months apart. The first study showed that endoscopists spent a considerable amount of time in the “extreme range” and “out of range” portions of the wrist r.o.m. regardless of DoF, difficulty of procedure, years of experience, and occurrence of injury. The results of the second study showed that endoscopy fellows spent similar amount of time in the different ranges in the three sessions. Although the sample of subjects used for the two studies is relatively small, the current results indicate that patterns of wrist motion at the extremes of the wrist r.o.m. are insensitive to training and that they may, in the long run, contribute to the occurrence of overuse injuries. Further studies are needed to determine a potential link between the observed wrist movement patterns and the occurrence of musculoskeletal injuries in endoscopists.
Effect of ultrasound-activated neurostimulator implant on the change in pain threshold in the periphery, Instrumentation
Allison Combs
Mentor: Dr. Bruce Towe, School of Biological and Health Systems Engineering, Arizona State University

Peripheral vascular disease (PVD) of the lower extremities can be a source of debilitating leg pain and associated tissue damage caused by decreased blood circulation to the periphery. Literature suggests that electrical stimulation can be used as an approach to inhibiting pain, including pain due to PVD. This study presents the application of a novel electrical stimulation approach for the treatment of pain in the periphery. As many electrical stimulation techniques have downfalls, mainly due to invasiveness of the surgical implantation or discomfort experienced by the patient during therapy, the presented device and technique are anticipated to improve upon many of these limitations by providing a potentially-injectable neurostimulator that is inactive until powered externally by an ultrasound transducer. Two such devices have been implanted in the thigh of the rat hindlimb alongside the sciatic nerve. The devices have been tested in vitro (pre-implantation) and in vivo and found to be functional. The output of each device has been quantified. A waterbath setup has been developed for testing the effect of the stimulator on the phenomenon of pain threshold in the rat. A set of control trials on pain threshold was performed on the implanted rat without activating the internal devices in order to develop a baseline for later comparison of the experimental trial’s results. The average control group pain threshold was found to be 43.13°C (σ=1.49, n=20) and 43.0°C (σ=1.70, n=10), for the right and left leg, respectively. Experimental studies are still being performed and, upon consolidating the results, will be analyzed and compared with the control results to determine efficacy of the device in changing pain threshold experienced by the rat. The electrical approach seems promising from the perspective of its improvement upon current electrical stimulation downfalls as well as from its proven efficacy in testing done to-date.

A Review of Game Theoretic Principles in Human Motor Interactions: A Focus on Joint Actions, Motor Control and Psychology
Michaela Carrieres
Mentors: Dr. Christopher Buneo and David Guffrey, School of Biological and Health Systems Engineering, Arizona State University

Motor movements are perhaps the most significant way we have of interacting with our environment and those around us. Humans are extraordinary in the way we cooperate with one another to accomplish tasks. This cooperation may come about for various reasons, such as to reduce the amount of individual effort involved in a task, to increase payoff by attaining a more rewarding goal, or simply to reach a goal at all. This review sheds some light on the concepts of game theory, the study of strategic decision making in situations that involve conflict and/or cooperation, and how these concepts relate to motor interactions especially in social situations. We can treat any human interaction as a game and analyze it in this way. Particular attention is paid to joint actions, types of cooperative games in which individuals act together to reach shared collective goals. In the review, game theory is explored in social and motor control contexts in which cognitive variables and neural mechanisms describe behavior, and is used to interpret results of an ongoing study at ASU that is referred to regularly as the “joint target-reaching game”. In this game, players make arm movements to jointly move a cursor on a screen to a virtual target in a limited time frame without direct visual, auditory, or haptic feedback from their partner. By investigating how we learn to coordinate our actions with others, we begin to further identify and understand more functions of the brain, and can ultimately use this information for therapy, robotics, and in improving neuroprosthetics.
1-9: Designing a Reporter Gene to Determine Chromatin Protein Function, Synthetic Biology
Wesley Houston, Behzad Damadzadeh
Mentor: Dr. Karmella A. Haynes, School of Biological and Health Systems Engineering, Arizona State University

My goal was to build a histone methylation-associated reporter gene to test the function of chromatin proteins. These synthetic chromatin proteins are being constructed to test various attributes: amino acid sequence of the methyl-histone binding domain, binding domain copy number, relative positioning of tandem binding domains and activation domain strength. The aim of this project is the expression of chromatin proteins in transgenic cells that also carry the reporter gene, producing cyan fluorescent protein (CFP) upon activation. Following successful construction, the gene will be placed into a chromosomal FRT site in U2OS cells by way of enzymatic Flp-mediated recombination. The reporter's promoter will then create histone methylation, either by the Gal4-EED fusion protein system or the human histone methylation signal. This project was done to better understand chromatin protein engagement in living cells as well as protein binding dynamics of Polycomb, amino acid primary structure and activation domain strength. The result of the project was a successful ligation of the two BioBrick parts (KAH182 and KAH201) composing the CFP-producing gene. This project was the first step in defining and quantitatively describing design principles, making the engineering of chromatin a possibility.

1-10: Using CRISPR/Cas system to generate promoter libraries (reporter parts)
Qi Zhang, Xiao Wang
Mentors: Dr. Karmella Haynes and Dr. Sarah Stabenfeldt., School of Biological and Health Systems Engineering, Arizona State University

CRISPR/Cas system (Clustered Regularly interspaced short palindromic repeats) is one of the Bacteria and Achaea immune systems which is able to introduce double-stranded breaks to invading nucleic acids and cause DNA silencing. The system we generated contains two parts. The CRISPR part comprises Cas9 protein gene, TracrRNA gene and crRNA gene and the reporter part contains sequence-specific promoter which can be detected by the spacer on the crRNA and the GFP gene. We have designed a CRISPR gene with several specific spacer sequences that can be applied to assist and direct sequence change upstream of the reporter promoter in the reporter part. By employing the methods of molecular biology experiment including plasmid extraction, electrophoresis, polymerase chain reaction (PCR), digestion, ligation and transformation, we successfully engineered several plasmids containing the CRISPR part and the reporter part for creating the promoter libraries in the future. Generally, my applied project is to synthesize the reporter parts in CRISPR/Cas system.

1-11: Review on the state-of-the-art of prosthetic hands, Biomechanics
Snigdha Khanna
Mentor: Dr. Marco Santello, School of Biological and Health Systems Engineering, Arizona State University

This review focuses on the currently available commercial prosthetic hands to determine the state-of-the-art of the field and provide recommendations for future research and technology development that can better address users’ needs. I review two types of prosthetic hands: (1) body-powered hands (Otto Bock Hook; Hosmer Hook) and (2) myoelectric hands (Otto Bock Sensor hand; Michelangelo hand; Touch Bionics i-Limb Ultra and Digits; RSL Steeper Bionic Hand X and M finger; RSL Steeper Mechanical hand). The metrics being reviewed are cost, hand’s degrees of freedom, control mechanisms, and sensing abilities. The review also examined surveys of customer satisfaction and needs. Several advancements in the prosthetic technology that have occurred over the past few years have been identified including treatment protocols, prosthetic interfaces, materials, design of terminal devices, power, and microprocessor technology. Hosmer Hook (5XA) and i-Limb Hand and Otto Bock Sensor Hand were identified as the best prosthetic devices currently available in the market. This review suggests improving the sensing technology, and specifically on delivering proprioceptive feedback to the user of myoelectric hands. Further recommendation for future work include the need for better control mechanism by using implantable electrodes and/or other methods to improve the mapping between surface EMG and prosthetic hands, a greater use of CAD/CAM technology in upper limb prosthetic design to produce better fit of prosthetic sockets, and improvement in the design of terminal devices.
1-12: A Nano-Mechanical Measurement Test System for Characterization of Synthetic Electrospun Tissue Scaffolds for Use in Regenerative Medicine, Tissue engineering
Derrick Buck
Mentor: Dr. Vincent Pizziconi, Dr. Stephen Massia, School of Biological and Health Systems Engineering, Arizona State University & Mayo Clinic

Pelvic Organ Prolapse (POP) is a serious medical condition from which a person’s pelvic tissue floor can no longer support the organs in the pelvic region (i.e. bladder, uterus, and rectum). Each year in the US, over 300,000 women undergo POP surgery using trans-vaginal synthetic mesh repair systems of which a significant number fail leading to significant patient morbidity characterized by inflammation, tissue degeneration, chronic pain and discomfort. The apparent mechanical mismatch between synthetic meshes and POP tissue has led an ASU Bioengineering-Mayo Clinic team of investigators to develop a nanoscale synthetic Dextran/Polyacrylic polymer scaffold that is aimed to closely match the mechanically properties of the extracellular POP tissue matrix. The aim of this applied project was to develop a mechanical test system that can characterize the nanomechanical properties of electrospun nanofiber scaffold designs now being developed in our bioinspired biofabrication laboratories. The nanomechanical test system is comprised of a linear actuator and a load cell that can characterize various designs of nanofiber test systems in vitro, as well as, with living cells in situ.

Priyadarshini Gopalakrishnan
Mentor: Dr. Vincent Pizziconi, School of Biological and Health Systems Engineering, Arizona State University

Sickle cell disease (SCD) is a blood disorder affecting millions of people in less resourced countries and is one of the major causes of death in sub-Saharan Africa and southern Asia. A prominent feature of SCD is the sickle or crescent shaped red blood cells, due to the presence of hemoglobin S (HbS), a defective form of hemoglobin (Hb). A standard diagnostic test for SCD is to screen for Hb which, if present, is an indicator of the HbS gene. This applied project set out to demonstrate a proof of concept that exploits alternative SCD diagnostic strategies for less resourced areas. One such potential alternative SCD diagnostic is the flow deformation behavior of SCD blood which may be used as a diagnostic discriminant of SCD due to the decreased deformation and increased intracellular viscosity of the sickled RBC. Model predictions suggest it may be possible to exploit one or more SCD blood rheological characteristics with the use of microfluidic platform technologies to design low cost point-of-care diagnostic test SCD. Simplified microfluidic prototype geometries can be used to verify paper microfluidic proof of concept as a low cost platform for point-of care diagnostic testing of sickle cell anemia in low resource Settings
1-14: Development of an ECM-mimetic, Electrospun Hydrogel Scaffold for Regenerative Medicine Application, Biomechanics
Chongji Liu
Mentor: Dr. Stephen Massia, School of Biological and Health Systems Engineering, Arizona State University

Pelvic organ prolapse (POP) is a common gynecologic complaint, which is often addressed surgically. Synthetic mesh augmentation in surgical correction of pelvic organ prolapse has been utilized since the late 1990s. Currently, many synthetic meshes can be found in commercial market, but there are still many potential risks and problems unsolved. Our final goal is to develop a dextran/Poly acrylic acid (PAA) based ECM-mimetic nanofiber scaffold that has the capability to deploy tunable mechanical and biological properties to mimic ECM. My project is to investigate the relationship between the thermal cross-linking time and the crosslink-king level and structure of the scaffolds. According to the previous research, carboxyl group (-COOH) in PAA could react with hydroxyl group (-OH) in Dextran to form ester bands under temperature 180°C. As a result, scaffolds without thermal cross-linking dissolve in water immediately when immersed in water while scaffolds after thermal cross-linking maintain their fibrous structure when immersed in water and swell to form stable hydrogel fibers. In this project, the scaffold is made of 27 wt% dextran & 7 wt% PAA solution by electrospinning. Scanning Electron Microscope is used to measure the scaffold structure changes after heat treatment. And Fourier transform infrared spectroscopy (FTIR) and attenuated total reflectance Fourier transform infrared spectroscopy (ATR-FTIR) are used to measure the cross-linking level of scaffold samples given different times of heat treatment by detecting and comparing the new formed C-O-C groups. Combining the SEM images with FTIR and ATR-FTIR spectra, we have found the optimal thermal cross-linking condition, which makes the scaffold maintain its original fibrous structure and meanwhile obtain the maximum cross-linking level.

1-15: Single cell imaging for pattern analysis on chromatin gene silencing, Synthetic Biology
David C. Dreher
Mentor: Dr. Karmella A. Haynes, School of Biological and Health Systems Engineering, Arizona State University

Chromatin is a complex formed of DNA and proteins that condenses the DNA, but this compression is neither random nor the only function of chromatin. The complex strengthens, repairs and regulates genes. Especially for gene expression it holds the potential for consistency, but if the kinetic properties are altered it can also exhibit a noisy characteristic leading to expression patterns. To further understand this behavior the Haynes lab is working on a synthetic biology approach: Instead of observing, we want to control and examine chromatin targeting and downstream gene expression. To do so we have to process taken images in a way we can detect single cells and their individual gene expression levels. Here I propose an immunocytology based cell staining protocol paired with a Matlab based application specialized for an already developed synthetic chromatin circuit. The gene circuit consists of an engineered chromatin variant which production is under control of an input activating promoter and a chromatin target region with a downstream promoter and reporter protein (luciferase), which is constitutively expressed. I show feasibility of automated single cell detection based on nuclei staining in crowded conditions and automated intensity data acquisition on the antibody stained reporter protein.
1-16: Alternative Energy to Light Kenya Health Clinics, Kenya
Josh Carroll
Mentor: Dr. Michael Caplan, School of Biological and Health Systems Engineering, Arizona State University

There is a need to develop alternative energy sources for places in the world which are not connected to the electric grid such as rural health clinics in Kenya. My creation is a demonstration of converting potential energy into electricity through the use of a crank, pulley system, and a generator. This design focuses on using supplies that have high durability and that could rely on lower level technology without batteries. The amount of energy available is dependent on the weights lifted and the distance they have to fall. The duration of the energy output into electricity can be increased by using a pulley system such that the descent of the weights from 1.5 meters can pull about 6 meters of rope. As the rope is pulled up it turns a shaft with the connected gear causing the chain to rotate. Having a larger gear on the shaft allows for an increased gear ratio such that one rotation of the shaft allows for multiple rotations on the generator. The rotating chain turns the generator which rotates a magnet inside copper coils to produce electricity which ultimately powers the light bulb. The current model illustrates the principles functioning. A 6 Watt 500 lumens LED bulb can be lit for several seconds producing much brighter light than the customarily used kerosene lamp which produces 8 to 82 lumens.

1-17: Experimental study of connection topology on synchronization of an array of electronic FitzHugh-Nagumo neurons, Neuroscience, Nonlinear Dynamics
Easwara Moorthy Essaki Arumugam
Mentor: Dr. Mark Spano, School of Biological and Health Systems Engineering, Arizona State University

Synchronization of coupled systems is a universal problem of fundamental importance and this occurs in a wide range of systems in nature including the human brain. Little has been known how the neurons in different parts of the brain collectively synchronize together not just while doing information processing but also during certain neurological disorders such as epilepsy. Most of the study that has been done so far is by computer simulated models and experimental observation on synchronization remains poorly explored. Here we have experimentally built an array of nine identical FitzHugh-Nagumo neurons in discrete electronics and have coupled through them in different connection topology schematics and varied the coupling strength (synaptic strength). All the identical oscillators have been kept at a threshold parameter value, which is exactly in between periodically firing and not firing state. The phenomenon of both local coupling (nearest neighbor) and nonlocal coupling (distant connection) for this in-between region have been studied and analyzed through nonlinear dynamical techniques and information theory concepts. This research provides a great platform for future study on synchronization of these coupled oscillators, where the other coupling schematics such as random and global (all-to-all and mean field) and the effects of noise can be explored.
1-18: Multiplexed EMG Grip Selection, Biomechanics
Jane Lacson
Mentor: Dr. Marco Santello, School of Biological and Health Systems Engineering, Arizona State University

The aim of this project is to design a decoding system that extracts electrical signals from surface EMG’s to control a prosthetic hand, which will perform a wide variety of grasps. The current solutions are very advanced prosthetic hands that cost anywhere from $5,000 to $100,000. The worldwide arm amputee population is 3 million with 2.3 million of those in developing countries. A cheaper solution needs to be invented for those 2.3 million. The prosthetic hand from this project will focus on four grasps (precision, key, power and index point). This experimental project will create a lightweight, energy efficient, user-friendly prosthetic arm controlled by surface EMG’s for under $300. This cheaper arm will contribute to the vast population of amputees in developing countries. In order to develop this arm, the user must have four select muscle groups that they can control. By flexing these muscle groups, they will produce signals and, these signals will be pre-processed for filtering and amplification via conditioning circuits. With these amplified signals, they will be outputted to pins on the Arduino that is used to determine when the voltage (generated via the muscles) has reached a certain threshold, causing a set of events to determine the particular grip pattern. These grip patterns are pre-programmed via the Arduino and selection is made based on a select muscle group. Once selected, another muscle set is used to activate the grip pattern. The ability to control the arm in relationship to the EMG signals was analyzed using Excel. The analysis was to determine whether or not trained versus untrained muscles affected the ability to control the arm. Due to the settings of the code, there was no significant difference between the ability to control the arm based on experience with the device. A larger sample size would be needed to draw more accurate conclusions.

1-19: Implementation of a Map-based Neuron Model to Aid In Identification and Prediction of Seizure Activity, Neural
William Brady Alling
Mentor: Dr. Mark Spano, School of Biological and Health Systems Engineering, Arizona State University

Epilepsy is a common neurological condition that can often strike without warning, making it very difficult for those afflicted to take immediate precautions. The development of seizure prediction techniques requires an robust model that can replicate neuron behavior on a large scale. The purpose of this project is to utilize such a model to identify and predict the factors that generate epileptic behavior in the brain as well as to investigate the efficacy of using electrical stimuli to counteract the negative behavior. To achieve this, a software application was created that implements a modified version of the model taken from Rulkov et al. that graphically displays neuron activity on a two-dimensional map. In addition, the model was re-created with circuitry as an array of application-specific integrated circuits (ASIC) in order to determine the utility, speed, and feasibility of the hardware format versus the software format. Both model formats will allow for easy parameter adjustment and DC current stimulation, making them effective tools for the study and demonstration of neuron behavior.

1-20: The Development of Self-Monitoring of Blood Glucose (SMBG) based on Android App, Smart Phone
Hanyu Zhang
Mentor: Jeffrey La Belle, PhD, School of Biological and Health Systems Engineering, Arizona State University

Chronic disease such as Diabetes Mellitus (DM) is reaching pandemic levels in the world. Today, Diabetes mellitus affects over 284 million people in the worldwide scale. There is not an effective cure for diabetes patients, so their only recourse is managing the disease via testing blood glucose daily. The low cost and ease of development and popularization of personal mobile devices technology, like iPhone, iPad and Android cell phones, provided a good platform to achieve the target of constant monitoring people’s health. Therefore, to develop an ease of use and powerful platform on smart phones for monitoring blood glucose provides us a good interface to combine the current self-monitoring technology with smart mobile devices, which will promote the development of multipurpose and patient-centric mobile medical devices. Here, we propose a Self-Monitoring of Blood Glucose (SMBG) device based on Android App.
1-21: Micelle imaging probe for detection and monitoring of neural injury, Synthetic
Jasmine Nejad
Mentor: Dr. Sarah Stabenfeldt, School of Biological and Health Systems Engineering, Arizona State University

Traumatic brain injury (TBI) is the leading cause of injury-related death in the United States. Current diagnostic techniques rely on qualitative analyses, but little progress has been made in the development of quantitative diagnostic imaging techniques. The long-term goal of this project aims to address this shortcoming through the development of a micelle imaging probe to monitor and detect TBI pathology in real-time using magnetic resonance imaging (MRI). The probes will function by monitoring acute pathological alterations present after TBI, specifically deposition of fibrin, using single-chain variable fragments (scFvs or nanobodies) capable of recognizing fibrin. These nanobodies have been identified in previous works using a phage library (Domain Antibody library, DAb) that displays randomized human-derived scFvs. To isolate the antibodies, four different clone stocks were plated and individual colonies collected and sequenced to confirm the presence of the desired gene sequences. The stocks were then expanded, induced for scFv production, lysed, and purified using fast protein liquid chromatography (FPLC). Purified recombinant protein products were concentrated and verified with sodium dodecyl sulfate polyacrylamide gel electrophoreses (SDS-PAGE) and Western Blot (anti-myc probe). The isolated nanobodies will then be conjugation onto the micelle probe system, generated from a biodegradable polymer, 1,2-dimyristoyl-sn-glycero-3-phosphoethanolamine-N-[methoxy (polyethylene glycol)] (DSPE-PEG), that self-assemble into ~20nm micelles. Current experiments focus on covalent conjugation of nanobodies using amine functionalized DSPE-PEG derivatives in standard amine chemistry for optimal functionality.

1-22: An Inexpensive Upper-Limb Prosthetic for Developing Countries, Biomechanics
Hunter Garner
Mentor: Dr. Marco Santello, School of Biological and Health Systems Engineering, Arizona State University

The first patented concept of a body powered upper-limb prosthetic was created by Peter Ballif in 1812. His concept of using a harness to transmit body power to operate a prosthetic hand is still being used today with only minor modifications. After 200 years of using this concept, however, we are still unable to provide low-cost prosthetics to those in need. On average a body powered prosthetic arm in the United States costs $6,000 - $15,000 depending on the level of amputation. For individuals in developing countries the cost associated with a prosthetic limb is unfathomable so they learn to do without. This project analyzes the upper limb prosthetics created by the International Committee of the Red Cross (ICRC) and the prosthetic limb created by Yamaguchi et al. at Arizona State University. Both of these products were created for developing countries to possess functionality at minimum cost, durability, simplicity, ease of repair, and adaptability to local materials. Although the ICRC prosthetic is considered the gold standard of inexpensive prosthetic limbs, it contains flaws that are addressed by Yamaguchi et al. However, the Yamaguchi prosthetic is also very flawed. By combining the strengths of each prosthetic it is possible to create a prosthetic limb that is durable, simple, easy to repair, adaptable to local materials, and is almost half the cost of the current ICRC upper-limb prosthetic.
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