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Welcome

On behalf of the presenting students, staff, faculty and affiliated colleagues of the School of Biological and Health Systems Engineering (SBHSE), one of the six schools in the Ira A. Fulton Schools of Engineering at Arizona State University and the Harrington Bioengineering Program, along with our clinical and industrial partners, it is our pleasure to once again welcome you to our annual fall biomedical engineering symposium. Proudly displayed before you at this 26th annual symposium are the diverse health care technology innovations under development by our interdisciplinary and multidisciplinary biomedical engineering senior capstone design teams and masters applied project candidates that exemplify this SBHSE signature event. It is a testament to the unyielding leadership support and the wide range of expertise provided by our dedicated instructors, mentors, graduate teaching assistants and facilitators, and professional staff. Collectively, year in and year out, they support the development of the next generation of biomedical engineering researchers, design thinkers, product developers and innovators equipped with state-of-the-art skill sets, an entrepreneurial mindset and a rich and deepening culture of innovation at ASU. Now in its 4th consecutive year as the #1 leading culture of innovation in US universities, ASU continues to fuel the rapidly emerging entrepreneurial ecosystem in Arizona which has already significantly impacted the next generation of health care technology leaders to tackle even the most pressing grand challenges in health care delivery in the 21st Century. A testament to SBHSE’s entrepreneurial capacity building of the 21st Century workforce in health care technology is the continued flurry of successes acclaimed by our biomedical engineering design teams in taking top honors in local, regional, national and international design competitions and student recognition. Finally, SBHSE is proud to have yet another stellar group of ten senior engineering students selected by our global partner, Navme Nikuram University of Science and Technology (KNJUST), in Kumasi, Ghana to spend their senior year and also their graduate master’s studies at ASU and who among our multinational capstone teams and applied projects represented at this fall symposium, KNJUST and all our international BME students continue to bring a unique and enriching global perspective as witnessed at this symposium and evidenced throughout our SBHSE program. Please join us in celebrating SBHSE’s Class of 2019 innovators and do enjoy our 26th annual fall BME Symposium.

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SBHSE’s Class of 2019 innovators and do enjoy our 26th annual fall BME Symposium.
BME Capstone Projects

1: Laparoscopic Immobilizer
Angela Hemeshat & Christina Smith - SBHSE
Mentor(s): Dr. Brent Vernon - SBHSE | Dr. Anoop Grewal - FSE
In a study done by Norheim, 24.4% of surgeons practicing and performing various laparoscopic surgeries claim to have neck pain. An additional 20.8% of surgeons reported spine disease, and another 3.9% reported radioculopathy/myelopathy, concluding that laparoscopic and endoscopic procedures place surgeons at higher risk of cervical diseases. Additionally, these ergonomic issues have been shown to decrease surgeon performance and efficiency, particularly during multiport surgery (Xiao et al.). This discomfort may be directly attributed to sustained positions during surgery requiring fine upper-limb movement to continuously hold up and operate laparoscopic devices. Current methods of alleviating this discomfort include altering surgeon position through step-stools, requiring multiple personnel, or through robotic laparoscopy. However, these solutions continue to have ergonomic and financial issues of their own, and may drastically increase the price of surgery, as with robotic surgery, so that this method is inaccessible to all surgeons. Therefore, our goal is to create an inexpensive medical device to immobilize laparoscopic instruments, in order to alleviate pain by reducing time of sustained posture during minimally invasive surgeries. Through customer needs assessments, concept generation, and concept selection, we have developed a biomedical design that includes a ball-in-socket form with a locking mechanism to allow surgeons the manipulation of laparoscopic instrument placement. From this methodology, our team has created an alpha prototype with plans to further examine bio-adhesives to place onto the patient to adhere to our device. In addition to this, a business plan has been created for economic specifications. Technical specifications will be verified using SolidWorks modeling, Instron modulus testing, and elastica testing.

2: Effective Cardiopulmonary Resuscitation Modalities for Pectus Excavatum Patients after the Nuss Procedure
Dzifa Kwaku, Ernan Abu Alrahi, Jaffalie Twaibu & Maitha Alkatheeri - SBHSE
Mentor(s): Dr. Dawn Jaroszewski - Mayo Clinic | Dr. James Abbas - SBHSE
Pectus Excavatum (PE), a condition denoted by a sunken breastbone, accounts for more than 90% of congenital chest wall deformities. A surgical correction, including Nuss surgery, is recommended to a third to a half of PE patients. The Nuss surgery entails the intrathoracic implantation of one to three curved metal bars as braces that hold the sternum in the anatomically correct position. These steel implants are left in position for 2-3 years while the chest wall remodels. Although a proven effective treatment regimen for correcting PE, the Nuss procedure with the temporary presence of these metal implants may inadvertently impose unintended limitations and consequences related to the effectiveness to perform CPR and defibrillation on PE patients after surgery. The extent of the limitations that may be caused by the metal bars have yet to be verified and are related to 1) the effectiveness of chest compressions due to motion restriction from metal rigidity and 2) the ability for electrical current to reach cardiac tissue and interrupt the chaotic rhythm due to metal conductivity. The PERescue team is currently determining the effectiveness of CPR and defibrillation on PE subjects who have undergone the Nuss procedure using computer models and simulations, and, if warranted, is tasked to develop alternative treatment methodologies and technologies compatible with CPR and defibrillation.

3: Gastrointestinal Clot Extractor (G.I.C.E.)
Aderonke Adewuyi, Blake Browning, Maame Abena Afriia & Queen Nyemekye - SBHSE
Mentor(s): Dr. Barbara Smith - SBHSE
Acute upper gastrointestinal bleeding affects 240,000 people per year and the field of gastroenterology falls short of addressing this problem. The issue with acute upper gastrointestinal bleeding is locating and removing an excessive amount of blood clot obstructing the area and visualization of the wound, commonly seen in most trauma settings. This problem results in unnecessary invasive procedures and multiple blood transfusions. Available technologies are a major limitation in the field of gastroenterology and are not addressing current needs. Due to the fact that current technologies are failing to answer this essential problem, interviews with medical physicians have identified the repurposing of commercially available technologies to solve these unmet needs. This ineffective method of addressing the problem results in people paying 40% more in initial hospitalization cost. This also results in 20,000 cases a year of complications and death. In order to circumvent this issue, we propose a clot extraction device which will aid in removing the wound opening and extraction of the clot build-up obstructing the area. This technology will utilize an ultrasonic endoscope to image the wound in the stomach and a high-intensity, focused ultrasound transducer that uses histotripsy to break up blood clots in the localized area. Our aim of this work is to develop a quick and efficient procedure that will save time, money, and lives.

4: DEVA Graft
Melanie Parke, Ernytrude Adjei & Tanner Ivey - SBHSE
Mentor(s): Tammy DeLozier - Arizona Kidney Disease and Hypertension Center | Dr. Brent Vernon - SBHSE
To facilitate the transfer of blood from a hemodialysis patient to the dialyzer and to ensure optimum blood flow rate, a direct connection is made between the artery and vein, but in situations where this is impossible or has failed, an arteriovenous graft is used to create an indirect link between the vessels so that cannulations may be performed. However, because the body perceives the graft as a foreign body, blood-biomaterial reactions can occur, which lead to thrombosis and reduce the patency of the graft. Because of blood-biomaterial interactions, currently available grafts often do not work for long, and/or they require frequent de-clogging. There have been several attempts to reduce the rate of thrombosis and increase longevity by coating the surface of the graft with an anti-thrombogenic drug, like in heparin (Gore Proplanted). This has increased patency rates, but the need for serial de-cloggings over a period still persists. The primary goal of our DEVA graft design is to significantly reduce the rate of thrombosis, thereby removing the need for de-clogging. We propose to do this by introducing a drug eluting technology. Research has shown that tenorsis usually occurs at the areas where the graft is connected to the blood vessels. Our DEVA graft will be coated with the cell anti-proliferation drug, paclitaxel, at the point where it connects with blood vessels, and the surface of the rest of the graft would be coated with an anti-thrombogenic drug. To control and sustain the drug release, in a localized area, for a long period, an inert coating material will surround the drug. The DEVA graft will reduce the long term costs associated with de-clogging the graft.

5: Suturistic: A Novel Suture Technology to Prevent Incisional Hernia
Shahzadi Aimen, Mayar Allam, Maryam Alsuwailm & Fahgchi Shao - SBHSE
Mentor(s): Dr. Olivia Burnsed - SBHSE | Dr. Jordan Weinberg - St. Joseph's Hospital and Medical Center
Current sutures used in abdominal surgeries have been proven to be ineffective over time. Suture failure can result in muscle weakness at the area of incision which can further cause the underlying tissues or organs to protrude from the wound in a condition called hernia. This condition affects approximately 15-20% of patients who undergo an abdominal surgery. Even if a patient survives their invasive surgery, with generally no complications, a herniation of the abdominal wall can create severe and life threatening complications of its own. If critical organs exit the abdominal wall, massive blood loss can occur, which may be followed by tissue death. Taking this into consideration, our main mission is to innovate a new suture technology which aims to decrease the possibility of developing an incisional hernia after abdominal surgery. This will be accomplished by our elastic, bio-compatible, and absorbable suture, Suturistic. The high elasticity of the Suturistic would be able to accommodate forces and flex, to keep the tissues from protruding while holding them in place even under great internal pressure in the abdominal cavity. Absorbable materials are desirable for use in Suturistic in order to decrease the chances of triggering inflammation or harboring infections compared with non-absorbable sutures which eventually require removal after the initial surgery has been completed. In order to address all of the aforementioned needs, we are selecting the most optimal biomaterial coated with extracellular matrix (ECM) and collagen, which will encourage proper cell growth and reduce the formation of scar tissue and foreign body giant cells, thus preventing the wound from getting rigid. This discomfort may be further alleviated by introducing the Suturistic to all patients undergoing abdominal surgery, and help them heal better than the inflexible sutures in the market currently.

6: Microparticle Fabrication Device for Consistently Sized Microspheres Viable for Drug Delivery in Metabolic Stimulation
Byron Alarcon, Sheldon Cummings, Rex Moore & Levi Riley - SBHSE
Mentor(s): Dr. Michael VanAuker - SBHSE | Dr. Brent Vernon - SBHSE
When combining the fact that the United States is home to 328 million people with the notion that sedentary lifestyles and overeating are on the rise, it is no surprise that ⅔ of US adults and ⅓ of US children are overweight or obese. In the current obesity treatment market, the options for patients leave something to be desired. Most options - other than diet and exercise - involve orally dosed medications or invasive surgical procedures. For some patients, especially those with underlying pathologies, obesity comes as a symptom of it's own. If critical organs exit the abdominal wall, massive blood loss can occur, which may be followed by tissue death. Taking this into consideration, our main mission is to innovate a new suture technology which aims to decrease the possibility of developing an incisional hernia after abdominal surgery. This will be accomplished by our elastic, bio-compatible, and absorbable suture, Suturistic. The high elasticity of the Suturistic would be able to accommodate forces and flex, to keep the tissues from protruding while holding them in place even under great internal pressure in the abdominal cavity. Absorbable materials are desirable for use in Suturistic in order to decrease the chances of triggering inflammation or harboring infections compared with non-absorbable sutures which eventually require removal after the initial surgery has been completed. In order to address all of the aforementioned needs, we are selecting the most optimal biomaterial coated with extracellular matrix (ECM) and collagen, which will encourage proper cell growth and reduce the formation of scar tissue and foreign body giant cells, thus preventing the wound from getting rigid. This discomfort may be further alleviated by introducing the Suturistic to all patients undergoing abdominal surgery, and help them heal better than the inflexible sutures in the market currently.

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a disease such as hypothyroidism or Pader-Wiilli syndrome. For these and many others, diet and exercise alone are inadequate to yield metabolic balance and overall weight loss while the orally dosed medications and surgical procedures yield risky results.

Our technology uses biodegradable polymer microparticles made from poly(lactic-co-glycolic acid) (PLGA) to encapsulate drugs which can then be injected into the body via a hypodermic needle. These particles will then sit in the target tissue while being slowly degraded by the body's natural hydrolytic mechanisms. As the particles degrade, they release the drug to the target tissue. In this case, the target tissue is the brown adipose tissue (BAT) in the body which, when stimulated via certain drugs, can lead to greater metabolic activity and a reduction in obesity.

Looking outside the realm of the obesity treatment and prevention market, polymer microparticles used for drug delivery have the potential to be implemented in nearly every clinical setting where targeted therapeutics are required or could improve patient outcomes - such as cancer treatment, infectious disease treatment, and pain management. However, with so many avenues to explore and potential treatment markets to reach, the most practical, fiscally-rewarding, and feasible business plan will be to employ a ‘build-to-buy’ business model. The build-to-buy business model will essentially allow us to sell our technology to a pharmaceutical manufacturer of the product. SBHSE will be responsible for the implementation of the technology in the various drug delivery and therapeutic markets – including taking care of critical milestones such as FDA approval and manufacturability.

7: SEDA Scope: A Digital Heart/Lung Sound Separating Stethoscope
Enoch Darko, Angelica Gutierrez, Diane Indrudakuna & Shenavia Morgan - SBHSE
Mentor(s): Dr. James Abbas - SBHSE | Dr. Wazhma Aslamy - Arizona City College Group
French doctor René Laennec revolutionized the medical world by inventing the first stethoscope in 1816. Since then, the stethoscope has diagnosed countless conditions within the human body, most prominently related to cardiovascular and pulmonary issues. In 2008, more than 616,000 people died of heart disease which accounted for 25% of deaths in that same year. It was reported in 2018 that heart disease-related deaths increased to 43.8% in the United States. By 2035, more than 130 million adults in the US population are projected to have some form of cardiovascular disease, and the total costs of treatment for cardiovascular diseases are expected to reach $1.1 trillion (American Heart Association, 2019). Between 1980 and 2014, over 4.6 million Americans (73%) in the United States were estimated to have COPD, and the market was valued at more than $32 billion and those costs are projected to increase to $49 billion by 2020. SEDA Solutions is revolutionizing the current stethoscope design that will digitally separate heart and lung sounds. It will have the ability to identify whether a heart or lung sound is normal or abnormal. It will be able to differentiate for diastolic and systolic heart murmurs as well as wheezing and cracking from the lungs. The device will help medical professionals to better diagnose cardiovascular and pulmonary conditions. The SEDA Scope will display the sounds captured from the heart or lung on a screen. It will be able to record and store sound files to have the option of reviewing at a later time. The SEDA Scope will better familiarize medical students with normal and abnormal heart and lung sounds, leading to a clear diagnosis of cardiovascular and pulmonary disease. It will aid hard-of-hearing physicians to diagnose their patients and continue their practice. The SEDA Scope will conceivably save the lives of many Americans because it improves the differentiation between heart and lung sounds and allows physicians to give their patients a better diagnosis.

8: BioDetection: A Minimally Invasive Metal Detector
Jacob Aperi, Jarrett Eshima & Tristan Loveday - SBHSE
Mentor(s): Dr. Vikram Kodibagkar – SBHSE | Dr. Jitendran Muthuswamy – SBHSE | Charlotte Spear – Dignity Health
Minimally invasive surgery is becoming an increasingly popular approach due to lower rates of morbidity and infection and decreased intraoperative delays. With the application of robotic and laparoscopic probes, surgeons can perform entire procedures through small incisions in the chest and abdomen. The incisions are minimal, and these advancements, surgeons still face the problem of retained foreign objects (ROFs) inside the patient after a procedure. Of the nearly 200,000 operations performed at Mayo Clinic Rochester between 2003 and 2006, 68 resulted in additional surgical complications or delays from an RFO. Failure to identify the RFO during surgery often leads to complications including re-operation (64.8% of cases), sepsis, and death. Current image-guided approaches for ROFs have rates (67%), indicating that fewer than half of patients can be improved. Metallic ROFs represent the greatest challenge for recovery, and often require the use of a mobile X-ray C-ARM during operating, interrupting the procedure and increasing the patient's time under anesthesia. The BioDetection team is constructing a miniature metal detector for application in minimally invasive surgery. The proposed device, Minimally Invasive Metal Detector (MIMD), is intended to reduce surgical complications and delays resulting from an RFO by integrating the technology with current robotic surgical tools. Our device consists of an oscillating tank circuit, amplifier, signal processing hardware, and display software. The random and unpredictable nature of RFO events will promote a ubiquitous adoption of this device for the facilitation of RFO identification during minimally invasive surgery.

9: Adaptive Omphalocle Safety Restraint and Protective Device
Rommn Arizmendi, Matt Chrest & Shannon Grassi - SBHSE
Mentor(s): Candace Fradette - Phoenix Children's Hospital | Dr. Sydney Schaefer - SBHSE
The Adaptive Omphalocle Safety Restraint and Protective Device is a novel medical device to help families safely transport their children born with an omphalocle. An omphalocle is a birth defect of the umbilical cord causing the internal organs to balloon out of the abdomen. According to the CDC, 1 in every 5,881 babies born in the US has an omphalocle birth defect. This project is the result of various medical professionals witnessing patient families leave their children in the hospital for prolonged periods of time because they cannot safely transport them home in traditional car seats. Due to the fragility of the defect, traditional car seat harnesses cause problematic pressure on the omphalocle. This stress to the omphalocle can lead to rupturing of the defect and/or harm to the infant. Hospitals akin to Phoenix Children's Hospital provide car seats to families who do not have one to take their child home at the time of discharge, therefore our target market is hospitals who wish to provide the device for families in need as well as the public sector for families who would like to purchase the device independently. The current market standard is a car seat that has a market value of $1,500 and provides minimal protection to the omphalocle in the event of an accident. The team has met with and surveyed several medical professionals to discuss the specific needs and specifications for the ideal device. These specifications outline an ideal device that provides a safe car seat attachment and protective cover for force distribution around the birth defect. These specifications are crucial to verify that the device is within the scope of the project and that it is a feasible product to be designed and brought to market within the time frame provided.

10: Wipe-Aid: An Intraoperative Endoscopic Lens Cleaning Device
Emmanuella Adjie-Sowah, Pedro Lopes, Racheal Atanga & Rohan Joshi - SBHSE
Mentor(s): Dr. Michael Bohl - Barrow Neurological Institute | Dr. Rosalind Sadler - SBHSE
The endoscope is a device used for performing minimally invasive surgeries. Minimally invasive surgeries are considered to be safe and more cost-effective than totally-invasive surgeries because they require only a minor incision. Endoscopes utilize a probe which has a camera lens and a drug delivery hole at its tip. Often the surface of the lens comes into contact with blood and other body fluids during the surgery. This obstructs the view of the surgeon and slows down the surgical procedure. There are currently a number of methods by which a surgeon can clean the lens. These include using saline, CO2, or cleaning the lens with wipes in front of its surface. In some situations, the surgeon may have to completely withdraw the probe from the patient, clean the screen surface, and then re-insert the probe. This leads to a delay in the surgical procedure and a loss of focus on the part of the surgeon. It also leads to the increased instance of infections. Wipe-Aid is an endoscopic lens cleaning device which is designed to prevent obstruction of the lens and to clean it in cases of obstruction. It is based on the principle of a pitcher plant. The surface of a pitcher plant is slippery and repellent and thus prevents any fluid or particle from adhering to its surface. Wipe-Aid is an inexpensive single-use lens cleaning device which will improve the surgical experience of both the surgeon and the patient by maintaining the clean view of the lens throughout endoscopic surgery.

11: Automated Oxygen Regulator
Riley Barnett, Nicholas Grant & Joseph Schreiber - SBHSE
Mentor(s): Dr. William Tyler - SBHSE
The medical gas industry as of 2014 maintained a 708 million dollar share of the global market and is expected to increase over the coming years. Chronic respiratory diseases such as Chronic Obstructive Pulmonary Disease (COPD) are expected to increase, requiring oxygenation treatments to alleviate symptoms and increase a patient’s quality of life. FirstBreath offers a revolutionary solution in oxygen therapy that promotes patient health by removing the variability of oxygen therapy, while maintaining the human element. The FirstBreath Automated Oxygen Regulator © will directly improve patient lives by regulating the flow rate of supplemental oxygen based on real time patient data, designed to assist nurses and doctors to continuously monitor and adjust oxygenation of patients. This data is read into our system via a traditional pulse oximeter as SpO2 measurements. Those measurements are processed via a microcontroller device which makes use of decision-making technology to adjust the oxygen flow as needed. The Automated Oxygen Regulator © makes it easy for doctors and nurses to preset desired oxygen levels and receive alerts so that they can treat patients in an effective and efficient manner. We will increase the time nurses and doctors have to provide meaningful care to patients, rather than responding to countless alarms. The final design of the Automated Oxygen Regulator © will be made of uniform medical grade aluminum material designed to encase all essential components and include screen and gauges to assist medical professionals. The Automated Oxygen Regulator © is expected to be operational by May 2019. FirstBreath promises improved patient outcomes through consistency and the opportunity to improve healthcare.
12: Trek Tips: Reusable Pipette Tips
Raegan Barry, Morgan Cobban, Gabrielle Mills & Amber Sogge - SBHSE
Mentor(s): Dr. Jerry Courser - SBHSE
A single lab can burn through hundreds of pipette tips a day. This unsustainable use of resources produces 4 million pounds of plastic waste each year that not only takes years of degradation, but also must be treated as bihazardous materials and disposed of meticulously. An alternative would be a pipette tip that could be autoclaved and reused. In rural clinics especially, receiving new shipments of materials and proper disposal can be an extremely difficult task. Our product, Trek Tips, would eliminate this problem.

13: Continuous Insulin Sensor to Better Manage Type I and Type II Diabetes
Connor Beck, Taylor Brown, Jared Johns & Mukund Khanwalker - SBHSE
Mentor(s): Dr. Jeffrey LaBelle - SBHSE
Roughly 100 million Americans have been diagnosed with diabetes or prediabetes, and this number is quickly growing. The most common method of treating diabetes involves measuring blood glucose levels and administering a regular dose of insulin to the target population. This device was used to determine the device’s practical application and usefulness to the target population. The team’s device, I-Sense, utilizes an electrophysiological technique called electrochemical impedance spectroscopy (EIS). EIS will be combined with an insulin aptamer to provide continuous monitoring of insulin levels in a purified solution. I-Sense will be capable of measuring blood insulin levels continuously for 10 days, have a slim profile to reduce the chance of collisions when on the body, and strongly adhere to the body to minimize the chance of the device falling off. Furthermore, it will be able to sustain the heat required to autoclave for sterilization. The current market for pipette tips is valued at $1.77 billion as of 2017. Prototyping is underway, and it is estimated that the average pipette tip produced by our company, Sana Terra, will cost 70 cents, a cheaper alternative in the long run. Manufacturing is progressing as schematics provide the fluid analysis necessary to continue with further prototyping.

14: Ergonomic Chair for Robot-Aided Surgery
Ahmad Basiri, Steven Stamm & Michael Tyson - SBHSE
Mentor(s): Dr. Paul Del Prado - District Medical Group & Maricopa Integrated Health System | Dr. Thurmon Lockhart - SBHSE
In the United States, approximately 693,000 robotic-assisted procedures have been performed to date. Many surgical specialties and subspecialties rely or are enhanced by robot-aided surgery, including orthopedics, transplant surgery, and neurosurgery. While conducting robot-aided surgery, surgeons are typically seated in a forward-leaning position with their heads placed onto a console and their arms supported by an elbow rest. This position forces the back muscles to be in isometric contraction, which over the period of a procedure can lead to musculoskeletal disorders and injuries for the surgeon. Available products on the market are unable to support the lumbar and trunk regions during these surgeries when the surgeon leans back. However, there are currently no designs for maintaining a comfortable position when leaning forward. Currently available products range from $1,200 to $2,600 despite failing to address the need for support while leaning forward. In 2016, statistics estimated the total medical chair market at $4.28 billion, representing an annual growth of 6.7%. The BTS Impetus team is projecting to capture 0.25% of the medical chair market for maintaining a comfortable position when leaning forward. Currently available products range from $1,200 to $2,600 despite failing to address the need for support while leaning forward. In 2016, statistics estimated the total medical chair market at $4.28 billion, representing an annual growth of 6.7%. The BTS Impetus team is projecting to capture 0.25% of the medical chair market.

15: DURALance: The Surgical Tool with a Dural Elevating and Cutting Mechanism
Ambike Bhraguvanshi, Alexander DaSilva, Richard Li & Jake Xu - SBHSE
Mentor(s): Dr. Michael Bohi - Barrow Neurological Institute | Tomasz Taubert - Tomar Electronics
Neurosurgey is the pinnacle of surgical expertise, requiring the utmost concentration and skills of a surgeon. A small mistake, like cutting a blood vessel or into the brain itself, can result in a detrimental loss of function or life. Current tools to perform surgeries require surgeons to switch tools, using up critical time and leading to mistakes in surgeries. Presently, there exists a need for neurosurgeons to streamline their workflow by utilizing a tool which can perform the actions of multiple tools at once. DURALance addresses this need by including the membrane elevating function of a Dural elevator with the cutting function of a standard surgical blade, and combining the functions to be used simultaneously in a singular surgical tool for multiple neurosurgical procedures, such as for brain tumor removal. By including a cutting mechanism which is guided by a Dural elevator, the DURALance will ensure the safety of blood vessels below the Dura membrane of the brain during neurosurgeries. Keeping in mind a need to address the comfort and functionality of the tool while addressing the learning curve of the surgical staff using the tool, the DURALance will undergo multiple prototype phases to be perfected into the ideal product to be used in neurosurgery. From then, DURALance will be tested in a cadaveric setting to test functionality for surgical operations and design reiterations will be performed, if necessary, to create the ideal product needed to provide complete critical neurosurgical surgeries. Surgical Instruments are a substantial part of the Medical Device Industry, with a $ 10.5B market value which is increasing at a rate of 7.5% each year. The DURALance device will prove to be an important addition to the surgical instruments market as a multifunction tool with the capability to dominate over the currently limited capabilities of single function tools.

16: CerBroField: An implantable Tumor Treating Field; An Electrode Array System
Kolby Black, Xavier Richmond, Tevon Sinica-Williams & Jesse Zeyp - SBHSE
Mentor(s): Dr. William Tyler - SBHSE | Dr. Ben Hendricks - Barrow Neurological Institute
Glioblastoma multiforme (GBM) is a fast-growing type IV glioma cancer. The localization of tumors in the supratentorial region of the brain presents challenges that inhibit efficient drug delivery during radiation and chemotherapy. In most cases of GBM, the tumors are 16 months or less. As of 2011, patients were able to receive a low-frequency alternating electric field treatments or Tumor Treating Fields (TTFields). CerBroField presents an implantable TTField, acting upon rapidly-dividing cancer cells without affecting normal neural cells. The low-frequency profile of CerBroField disrupts cancer cells during the mitotic phase, which in turn prevents cancerous cells from dividing normally, leading to apoptosis. The implantable electrode array of CerBroField administers a TTField that interferes with GBM tumor cell division. With a direct localization of the TTField, we target 22,850 potential patients from experiencing systemic effects due to the toxicity of other chemotherapeutics. CerBroField is regulated and classified as a Class III medical device by the FDA. Currently, CerBroField is a recommended interventional therapy for recurrence of glioblastoma, providing the expectation for second and third line treatments as well. CerBroField aims to provide a superior solution to those suffering from GBM and positively impact the lives of thousands.

17: PTA Lesion Model Demo
Alex Rico, Destinee Martin-Karim, Ethan Blank - SBHSE & Geremiah Charles - SEMTE
Mentor(s): Matthew Gerveler - Becton Dickinson | Casey Hebert - Becton Dickinson | Dr. Brent Vernon - SBHSE
Peripheral artery disease is a circulatory condition in which the peripheral arteries in the legs are narrowed, limiting blood flow to the lower extremities. The common cause of this is atherosclerosis, the accumulation of calcium, plaque, or fatty deposits at the walls of arteries. This disease is estimated to affect about 3 million people per year in the United States. One prevalent treatment method for this health problem is through the use of percutaneous transluminal angioplasty (PTA) catheters. PTA catheters are used to dilate blood vessels to return normal blood flow in the body’s limits. These catheters use a balloon inflation technique to disperse or break up plaques within the walls. These balloons can also be coated with drugs intended to prevent arterial restenosis. In many cases, peripheral artery disease can take place below the knee. Lesions below the knee have a greater likelihood of having stronger calcification within arteries, allowing for the lesion to even become completely blocked. As a result of this, PTA catheter treatment methods can run into problems, such as the balloons deforming around the plaque or lesion. Our group has been recruited to the medical device company, Becton Dickinson (BD), to help resolve this problem. In order for BD researchers to test the PTA catheters under realistic simulated conditions, we are tasked with developing an anatomically accurate, physiological lesion model of arterial lesions below the knee. This model will represent a range of real plaque and arteries from peripheral artery disease. To do so, our group will work with BD facilities testing competitor products, bio-materials and prototyping. The ultimate goal of this model is to increase accuracy for testing angioplasty catheter devices to optimize patient outcome and reduce potential irreversible damage to vital arteries.
18: Solacium: The Microelectrode Delivery Catheter for Peripheral Nerve Stimulation

Earl Brown, Kianna Browning, Bailey Gasvoda & Alexandra Morales - SBHSE

Mentor(s): Dr. Jitendran Muthuswamy - SBHSE | Dr. Stephen Foldes - Barrow Neurological Institute

There are over 50 million people in the United States that suffer from some sort of chronic nerve pain. The most commonly prescribed treatment for this nerve pain is prescription medication, which contributes to the opioid epidemic currently plaguing the United States. Nerve stimulation is a growing treatment in the field of pain management, but patient access is limited due to delivery complications. Current microelectrodes for nerve stimulation are challenging to implant and are restricted to delivery of a single electrode at a time. Because of the process of injecting and cutting the electrode and the process of injecting the drug, nerves and causes them to shift, a long healing process is needed before the stimulation can be done. Solacium aims to ease the electrode injection process and increase patient use of nerve stimulation for pain management. Solacium will deliver a string of microelectrodes down the length of the nerve in a single injection. In conjunction with an ultrasound vibrator to improve and target the area, the apparatus will deliver a polymer string containing hundreds of microelectrodes. The polymer string will be absorbed by the body, leaving only functional electrodes. These electrodes can then be triggered to stimulate the nerve and relieve the patient's pain. In phase II, we will begin testing and refining our prototype based on the virtual models we are currently developing.

19: Customizable Lower Leg Prosthetic with Shock Absorbing Capabilities

Mossab Asiri, Mason Buseman, Allison Schmidli & Jonathan Talos - SBHSE

Mentor(s): Dr. Jeffery LaBelle - SBHSE

Next Level Prosthetics is focusing on the revamping of current lower limb prosthetics available on the market. Through the team's market research, the current issues identified with current lower leg prosthetics involves prosthetic interface design, shock/force interface and cost to the consumer. The proposed solution to the customization issue is to design a method of engineering the structure of the prosthetic using 3D-printed, interlocking pieces developed from a 3D-model of the patient's limb. This is to result in a more cost-effective and customized prosthetic design, effectively resolving another of the identified issues: cost to the consumer. With technological advancements in 3D-printing technology, this manufacturing method will be a cheaper and faster option over current methods. The final customer need, prosthetic/ prosthetic interface impact absorbance, will be resolved by the integration of an adjustable-height suspension into the lower shank interface. An additional benefit of this design is that it increases the customizability of the prosthetic in a way that lowers the cost to the consumer. An adjustable-height suspension would enable individuals still growing to simply increase the height of the device, instead of purchasing a new prosthetic as often as with current methods. With the proposed design solidified, the team's plan for Phase II is to begin the 3D-modeling of potential prosthesis compositions, as well as potential methods of attaching our adjustable suspension system. According to The Amputee Coalition of America, there are an estimated two-million lower limb amputees in the United States alone. Next Level Prosthetics' new lower leg prosthetic will provide these individuals with a more customizable, comfortable, and cost-effective option.

20: Navajo Neurohepatopathy Molecular Biosensor

Sydney Connor, Ishitha Jagadish & Jordan Todd - SBHSE

Mentor(s): Dr. Michael Caplan - SBHSE | Dr. David Carpentieri - Phoenix Children's Hospital

Navajo neurohepatopathy (NNH) is a fatal, metabolic disease that impacts 1 in 1600 children in the Navajo Nation each year. This disease is caused by a missense mutation in the MPV17 gene, for which whole genome sequencing is the standard of care at Phoenix Children's Hospital (PCH) for diagnosis. However, this diagnostic process is neither time- nor cost-efficient when a patient requires immediate intervention. Several diagnostic tools are currently available in the research lab, but are not currently validated for clinical use. Through compliance with Clinical Laboratory Improvement Amendments (CLIA) validation requirements and pertinent International Standards Organization (ISO) standards, these technologies can be implemented in a clinical setting such as PCH. SNPsCorp, Inc. is a molecular diagnostic biosensor (NNH Molecular Biosensor) that rivals the sensitivity and specificity (>95%) of the current standard of care at 100x. Specifically, SNPsCorp, Inc. will design, validate, and implement the NNH Molecular Biosensor to improve diagnostic turnaround at PCH. Molecular biosensors that meet requirements for specificity and sensitivity can be designed through open-sourced tools. The molecular biosensor will be less invasive, requiring blood and/or saliva rather than a liver biopsy, and time efficient, yielding results in approximately 24 hours. In addition, this technology will cost less than 20% of the current standard of care ($700). The goal of the NNH Molecular Biosensor is to yield product specifications that rival that of sequencing when time is just as valuable as the cost itself. Through collaborations with clinicians at PCH, the necessary technical equipment and financial resources make this project feasible. The proposed product will utilize manufacturing practices, such as synthesis of molecular tools, used by current state of the arts in molecular diagnosis.

21: Transcranial Direct Current Stimulation for Migraine Relief

Cynthia Crockett, Kasun Daundasekara, Antonio Lopez & Joseline Valenzuela - SBHSE

Mentor(s): Dr. Stephen Helms Tillery - SBHSE | Dr. Jitendran Muthuswamy - SBHSE

JACKMed Innovation's mission statement is to provide an effective and alternative method for migraine therapy by using Transcranial Direct Current Stimulation (tDCS) as a form of treatment. Approximately 10-12% of the worldwide population experiences migraines which can be a costly burden to treat. Current treatment methods involve relieving symptoms by taking high dose medication at high frequencies. This may lead to potential side effects which includes liver damage and an increase of headache occurrences. Since medication is the most readily available solution, people often do nothing to treat their symptoms. Alternative methods in the market currently have a very high price tag, which reduces the accessibility for many people and forces them to continue taking drug medications.

Our design provides an effective treatment method that prevents unwanted side effects and is available to patients at a reasonable price. As such, the device provides an alternative to migraine therapy that is high quality, non-invasive, and safe to use. An electrical current is delivered through the use of electrodes to the trigeminal nerve to provide stimulation near the ear to relax the nerve and provide pain relief. To maximize comfort in providing treatment the device design incorporates ergonomic fit. Incorporating an ergonomic fit ensures that the device is comfortable during treatment. Future direction of the device includes analyzing the various specifications to ensure maximum efficacy. JACKmed Innovations is evaluating these parameters through the use simulation software such as SimVascular and SimHrm-5. The next steps involved building a prototype, gaining customer input on the device design, and modifications to ensure customer needs are sufficiently met.

22: Responsi-Pill: An Automated Prescription Sorting and Dispersion System

Elizabeth Delgado, Jesus Escobedo & Austin Morgan - SBHSE

Mentor(s): Dr. Barbara Smith - SBHSE

Medication non-adherence is said to cost as much as a $300 billion burden on the United States healthcare system in avoidable costs every year. Non-adherent patients may experience worsening of their condition, increased risk of hospitalization, or physical harm and episodic symptoms. Despite the widespread prevalence and cost, it still undetected and undertreated in a significant proportion of adults across care settings. Traditional methods of intervention include reminder pill boxes and alarms, which must be solely maintained either by the user or caretaker. However, this entails a cumbersome process with hours of medication sorting and still relies on the accuracy of the organization and the user's ability to maintain their regimen. Responsi-Pill will curtail this hardship by taking the pressure of remembering dosage times and completely out of the hands of the patient and automating the process of organization. Our device will be able to remind the users when to take their medication through timed dispensing, assist in the refill of the medication containers, and calculate the percentage of times medication is taken on time and report findings to the doctor or healthcare professional. Responsi-Pill will revolutionize the way medication is administered and tracked by healthcare professionals and caregivers. The device will cater to the elderly with cognitive disorders but will also aid patients with complex regimens. The goal for Apex Technologies is to reduce the strain on the US healthcare system by saving carers invaluable time, reducing unnecessary financial burden, and assisting doctors in selecting and maintaining the best treatment method for the patient.

23: Transcatheter Vessel Occluder for High Flow Arteriovenous Shunts in Infants

Kyle Durrant, Kyle Hull, Devin Lillegaard, Patrick Panattoni & Nick Whitley - SBHSE

Mentor(s): Dr. Todd Abzugio - Phoenix Children's Hospital | Dr. Brent Vernon - SBHSE

Vein of Galen Malformations are a rare but serious condition in which an arteriovenous shunt is formed within the brain of an infant. Current treatment involves occluding the vessel with a cyanoacrylate glue that is opacified with tantalum powder DL. This is a dangerous procedure that presents many challenges including getting the glue to anchor/set in the correct location as well as posing the risk of inducing a stroke in the patient. Similar malformations use coils as an occluder but then proper sizing becomes an issue and multiple coils may need to be used. Balloon occluders have also been used. The proposed solution to this problem, as tasked by
Acute upper gastrointestinal bleeding (UGIB) is one of the most common medical emergencies treated by gastroenterologists. UGIB accounts for more than 250,000 hospitalizations annually in the United States with 85% of patients receiving endoscopic treatment. Between 1989 and 2009, the median length of hospitalization for upper gastrointestinal bleeding has decreased from 4.5 days to 2.8 days while the median hospital charges increased from $9,049 to $20,970. This has driven the direct in-hospital economic burden on a national level from $2.2 billion in 1989 to $7.6 billion per year as of 2009 and is expected to continue to increase. Additionally, in 2010, the 30-day readmission rate for patients with another gastrointestinal bleed was 5.1%, where readmission rates are significantly higher in patients with recurrent UGIB. The current standards of treatment include a variety of retrieval devices, suction devices, and irrigation. Normally, gastroenterologists must create impromptu solutions during endoscopy procedures to avoid having to proceed to interventional radiology or surgery where the mortality risk greatly increases. GI Endoscopic Solution's obstruction removal device will provide gastroenterologists with the ability to effectively remove a wide range of blood clots and obstructions. Obstruction removal is comprised of an external suction channel that attaches to the endoscope, providing greater suction capacity than the endoscope's suction channel. The degree of suction can be controlled by an external valve to reduce the risk of damage to the mucosa and the lumen of the gastrointestinal system. The principal target specifications of this product include effective removal of varying degrees of blood clots, reduction of procedure time below 30 minutes, and minimalization of the occurrences of complications. The obstruction removal will be marketed to interventional gastroenterology departments with gastroenterologists and technicians being the primary customers.
Prolonged air leak (PAL) is a common complication that occurs five days after lung surgery caused by Bronchopleural fistula (BPF), pneumothorax, chest trauma, cystic pulmonary infections, fisture dissection, or lung biopsies typically seen using a bronchoscope. The incidence of any air leak after lung resection is around 50% of patients, and the mortality rate is reported to be between 1-10%. Our project aims to create a biocompatible hydrogel sealant and a compatible delivery system. The hydrogel sealant does not clot inside the delivery system but polymerizes only once it reaches the desired site and is biocompatible, flexible, nontoxic, biodegradable, and has hemostatic properties. It should also have a low inflammatory host response and fast in vivo degradation allowing for adequate wound healing. Current methods to treat PAL include sutures, stitches, wires, and chest tubes, all of which are not ideal. There exists the need for better sealing. Current techniques require invasive processes such as re-operation which is not an ideal solution as not all patients are in a medically appropriate condition for operations, which are also costly. The use of the device aims to reduce the duration of hospital stay and to improve patient lives. PAL, if left untreated, can cause collapsed lung and significant morbidity. Through experimental testing in phase II of Capstone, this project aims to analyze the characteristics of the material in order to deliver best results. SealUNG will be designed to be minimally invasive and to be a better solution. SealUNG will be a significant improvement in the treatment of the complications caused by pulmonary air leaks that are an aftermath of surgery.

30: A Low-Cost, Stable, and Mobile Chair to Provide Ergonomic Support During Robotic Surgery

Amar Joshi, Brody Kilgore, Bryce Richards & Zach Humphreys - SBHSE

Mentor(s): Dr. Paul Del Prado - Maricopa Integrated Health System | Dr. Thurmon Lockhart - SBHSE

The purpose of this project involves designing a low-cost, stable, and mobile chair to provide ergonomic support for surgeons during robotic surgery. Robotic surgery is performed through a console wherein the surgeon is seated in a conventional rolling chair at an isometric position for long periods of time. These conventional chairs offer poor lumbar support rather than the forward trunk flex that current position flexes the trunk and requires the head of the surgeon to be in the console, while the elbows rest on either side. Due to this unnatural position, the surgeon’s muscles are in isometric contraction which makes them more susceptible to muscle deformation. This deformation over long periods of time leads to pain in the lumbar, is an exhausting factor, and the lower back pain.

If surgeons feel pain during a long surgery, they will not be able to have their undivided attention focused on the surgery itself and this discomfort can affect the success of the surgery. The customer requirements are that the prototype chair shall provide trunk support with flexion, allow for mobility, be adjustable, be stable in order to ensure there is no unnecessary movement, and provide adequate upper body support. The chair shall have a designed lumbar support that ensures the correct lumbar lordosis, which is essential for maintaining correct posture and avoiding discomfort. The goal for Phase II of Capstone Design is to create a working beta prototype.

31: CosmoMark Void-Filling Breast biopsy Marker

Kyra Temple, Nick Keiper - SBHSE & Zach Willis - SEMTE

Mentor(s): Tyson Anderson - Becton Dickinson | Dr. Brent Vernon - SBHSE

Every year, as many as 17 million patients undergo a breast biopsy procedure to determine the malignancy of masses discovered via mammography or self-examination. Many patients that present with suspicious lesions in a breast undergo a vacuum assisted biopsy procedure using a gauge size as small as a 14G but potentially as large as a 7G. Repeated sampling using these devices can cause discomfort can affect the success of the surgery. The customer requirements are that the prototype chair shall provide trunk support with flexion, allow for mobility, be adjustable, be stable in order to ensure there is no unnecessary movement, and provide adequate upper body support. The chair shall have a designed lumbar support that ensures the correct lumbar lordosis, which is essential for maintaining correct posture and avoiding discomfort. The goal for Phase II of Capstone Design is to create a working beta prototype.

32: StimuLate: A Non-Invasive Electrical Neurostimulation Device for Obstructive Sleep Apnea

Stephen Lane, Cami Rowan, Alamei Sira & Kendra Starkel - SBHSE

Mentor(s): Dr. James Abbas - SBHSE | Dr. William Tyler - SBHSE

Obstructive sleep apnea (OSA) is a common sleep disorder characterized by upper airway obstruction that affects over 12 million people in the US and costs an estimated $150 billion in damages each year (e.g. motor vehicle and workplace accidents, lost productivity, and healthcare expenditures). While there are many available treatments for OSA, adherence rates for these treatment options fall below 50% after one year. State-of-the-art devices such as the CPAP are effective, but undesirable due to their bulky design, prevalence of user error, and uncomfortable apparatus. A more up-and-coming treatment is Inspire’s invasive upper airway stimulation (UAS) device, but patients lose interest due to the surgery required. A more approachable treatment solution will address the pressing problem that OSA poses to patients by providing a non-invasive stimulation therapy, therefore influencing user outcomes and adherence drastically. The StimuLate device will deliver non-invasive electrical neurostimulation to the motor neurons of the genioglossus muscle in the tongue. This stimulation will elicit the tongue, adequately eliminating the blockage and improving normal oxygen flow for the patient. The device will be paired with a respiratory sensor to deliver stimulation only during apnea episodes, reducing the total amount of stimulation time per night to an estimated 1-4 minutes for mild to severe obstructive sleep apnea cases.

33: Parallel Stent Graft Simulator

Casey Silva, Luis Novelo & Tyler Lent - SBHSE

Mentor(s): Dr. Victor Davila - Mayo Clinic | Dr. Michael VanAuker - SBHSE

Aortic abdominal aneurysms (AAA) are a life-threatening condition that require invasive intervention to repair. The American College of Surgeons National Surgical Quality Improvement Program reports that 10,026 patients underwent elective aortic abdominal aneurysm repair between the years of 2011 and 2015. Currently, vascular surgeons rely on three-dimensional models reconstructed from computerized tomography (CT) scans in order to better visualize the patient’s pathology and conduct pre-operative planning procedures. In order to better inform the decisions of vascular surgeons with data driven analytics, our team has begun engineering a simulator program that can effectively model how aortic blood flow will be affected by various stent configurations within unique patient anatomies. This program is designed for use with a guided workflow. We have a modular design as a modular design will be a new requirement. The goal for Phase II of Capstone Design is to create a working beta prototype.
clot prevention management. The cheapest option currently on the market is compression stockings, but they do not account for swelling of the lower extremities, leading to decreased patient compliance. Lymphedema machines are another option that applies compression via air pressure, but they limit patients to their homes and restrict movement during treatment. These machines also cost over $1000 per setup, which is too expensive for most patients, and are generally not covered by insurance. Finally, surgery and laser therapies are another expensive option with each procedure costing between $500-$3000. These procedures also tend to not have permanent effects, resulting in patients requiring multiple procedures during their lifetime. To meet this need, our goal is to give patients the compression they need and allow them to perform their daily activities, including travel, avoiding the need for their own muscles to pump blood against gravity will better improve symptoms and pain than a passive treatment. To achieve this goal, our device will be a fabric compression wrap that incorporates a series of airbags which can be filled to meet the desired amount of pressure on the leg. The device will be powered using a standard cell phone portable charger for easy charging while traveling. Overall, we want to allow patients to get back on their feet and live their lives as they would without venous insufficiency symptoms.

35: Digit-Bots Orthotics: An Orthotic Device to Enable Finger Flexion and Extension
Tanner Levi & Derek Vielhauer - SBHSE
Mentor(s): Dr. James Abbas - SBHSE | Anirudh Nayak - The MORE Foundation

Finger flexion and extension defects originate from various complications due to stroke, meningioma, and other motor neuron diseases. Patients with such diseases have difficulties using their fingers for daily tasks and in some cases do not have any function in their fingers. Current solutions include wearables for movement assistance, devices for supporting gripping functions for rehabilitation, and myoelectric hand assisting with finger motion; all of which extend the hand to then be fixed. In some cases, the individual does not have the capacity to flex the hand to be rehabilitated. Our device is aimed at closing the gap and providing opportunities for finger extension and flexion utilizing other muscle input to output finger motion. Customers for this device will be patients with motor neuron disease as well as physical therapists, neurosurgeons, and other clinicians. The rehabilitation market size is expected to reach $1.1 billion by 2021, and our device is aimed at accounting for 5% of that market since rehabilitation of the hand accounts for 5% of the economic output for this market. By interviewing various people either with a motor neuron disease or a neuromuscular one discoveries were made as to what would be needed with the device: slim-fitting, universal, adjustable, durable, flexible, and longevity are a few of those decisions. The choice for the design of the device has been determined to include wires that connect to the base of the fingertips running down the fingers to the palm, then wraps around the hand to the back and down to the wrist. The plan for phase II would be to construct different prototypes to meet and exceed the specifications mentioned before and even more and exceed future specifications that may be discovered or constructed.

36: Tooth Band: A Post Tooth Extraction Covering for Bone Regeneration, Wound Healing, Anti-Inflammation and Antibiotic
Hamida Ismail, Nivenka Mahesh, Shawn Striker & Tudor Sasanar - SBHSE
Mentor(s): Dr. Olivia Burnsed - SBHSE

In dental care, and specifically with tooth extraction, many patients deal with pain and infection. The typical treatment for pain is a bandage. Current solutions include wearables for movement assistance, devices for supporting gripping functions for rehabilitation, and myoelectric hand assisting with finger motion; all of which extend the hand to then be fixed. In some cases, the individual does not have the capacity to flex the hand to be rehabilitated. Our device is aimed at closing the gap and providing opportunities for finger extension and flexion utilizing other muscle input to output finger motion. Customers for this device will be patients with motor neuron disease as well as physical therapists, neurosurgeons, and other clinicians. The rehabilitation market size is expected to reach $1.1 billion by 2021, and our device is aimed at accounting for 5% of that market since rehabilitation of the hand accounts for 5% of the economic output for this market. By interviewing various people either with a motor neuron disease or a neuromuscular one discoveries were made as to what would be needed with the device: slim-fitting, universal, adjustable, durable, flexible, and longevity are a few of those decisions. The choice for the design of the device has been determined to include wires that connect to the base of the fingertips running down the fingers to the palm, then wraps around the hand to the back and down to the wrist. The plan for phase II would be to construct different prototypes to meet and exceed the specifications mentioned before and even more and exceed future specifications that may be discovered or constructed.

37: Thermostasis: Active Thermoregulation Inside Prosthetic Sockets
Andrew Nelson, Corey Soto & Taylor Underwood - SBHSE
Mentor(s): Dr. Jeffrey LaBelle - SBHSE

Transplant amputees commonly experience temperature discomfort while wearing their prosthetic and this discomfort is often cited as the number one reason why users are unable to wear their prosthetic throughout the day. Conventional passive methods of temperature regulation have been tried multiple times with little customer satisfaction. The transatlantic amputation population is currently 2 million people in the United States with 185,000 new cases every year. Dysvascular complications related to diabetes projects the transatlantic amputation population to double by 2050, encapsulating a projected market share of $12 billion annually. The quality of life of an amputee post-surgery relies on the functionality of the prosthetic and the ability for daily use. Temperature comfort includes the residual limb being too hot or too cold, and overheating is most prevalent with 53% of users reporting decreased wear time, skin blistering, infections, and odor because of sweating. Dysvascular patients have also reported their residual limb being too cold as a result of poor thermoregulation in the extremities. Thermostasis seeks to address both hot and cold discomfort with active temperature management facilitated by Peltier cooling modules activated by real time temperature feedback. This device will be designed as an add-on component replacing existing prosthetic sock and liner combinations allowing the user to retain their current fitted prosthetic setup. The thermoregulation module will be attached to the prosthetic leg post and can be concealed using an artificial cail housing. Water running from this module will flow up to the residual limb heat transfer layer to heat or cool the limb. Thermostasis hopes to provide transatlantic prosthetic users with increased wear time to keep them comfortable, active, and independent throughout the day.

38: Upper Extremity Orthotic for Dynamic Movement
Ahnah Rahman, Jagan Pandari, Nick Pederson & Andrew Polson - SBHSE
Mentor(s): Dr. Stephen Helms Tillery - SBHSE | Dr. Shafeeqa Ladha - Barrow Neurological Institute

Muscular dystrophy is a group of genetic diseases caused by mutations or abnormal genes that progressively results in weakness to muscle degradation and loss of muscle mass. Due to the debilitating nature of these diseases, individuals have difficulty completing everyday tasks or hobbies such as trying to put on clothing or attempting to play a musical instrument. Currently, there is no cure for muscular dystrophy, but medications and therapy can help manage symptoms or slow down muscle degradation. This creates a need to explore and manufacture novel solutions to address everyday problems that patients with muscular dystrophy experience. Our mission at B.A.S.S. is to create an orthotic to allow those with muscular dystrophy to achieve a greater degree of movement by individuals with muscular debilitating diseases, we can help them live their dreams and fulfill their passions. Current orthotics do provide a higher quality of life for a fair price and it is rare that a patient can afford the significant costs. The market size consists of approximately 52.6 million patients requiring assistance with some form of muscular degradation. Currently, the concept that the team is proposing is the use of bands which will utilize elastic forces to assist patients’ movements in an attempt to meet customer needs purely mechanically. Our device allows for a higher quality of life and greater freedom for those patients seeking an affordable and practical orthotic.

39: HexFlex: Improved Force Distribution in Passively Cooled Transatlantic Socket
Andrew Smith, Nolan Ross & Patrick Hogan - SBHSE
Mentor(s): Dr. Jeffrey LaBelle - SBHSE | Don LoGuerico - DonJoy/OrthoSport Arizona
Michael Pack - Artificial Limb Specialists | Dr. David Vowels - Medsource Prosthetics and Orthotics

There are currently an estimated 1.46 million lower limb amputees in the US with an estimated 185,000 new amputations annually, with only a 70-75% satisfaction rate with current solutions. The majority of these amputees are Class I and II, with low to moderate levels of mobility. The most common lower limb sockets are pin-lock and suction-based design which utilize solid, custom formed outer shell, and exhibit the highest level of force distribution over the residual limb. These sockets allow little airflow, heat dissipation, moisture wicking, and volume adjustment which creates a stressful environment for the tissue of the residual limb. Current passively cooled sockets utilize large open areas between radially constricting solid struts lined with pads to achieve volume adjustability, fit, and overall comfort. These design of these sockets reduce the area that contacts and constrains around the residual limb increasing the pressure exerted on small portions of the limb from the downward force of locomotion, which can cause pain and tissue damage. In addition to these issues, current passively cooled sockets are very expensive and are generally design for Class III and IV amputees, who desire sockets for high stress activities and are prone to pay more out-of-pocket for such. The proposed HexFlex design provides a modular and mechanically passively cooled ‘everyday walker’ socket structure allowing for mass production in generalized sizes, and improved force distribution with end user volume adjustment to provide the maximum level of comfort for Class I and II amputees, without increasing price. The easily customizable, ‘off-the-shelf size’ design of HexFlex will improve the overall environment of the residual limb, at a price that undercuts the current market competition. This design will improve the overall user experience and quality of life for amputees who suffer from the shortcomings of current solutions.
40: Visual Voice: A System for Aiding Communication in Patients with Locked-In Syndrome (LIS) Using Electro-oculography (EOG)
Andrea Hnatievych, Amy Polaneczi, Jose Galaviz Garcia & Maxwell Sakai - SBHSE
Mentor(s): Dr. Bradley Greger - SBHSE | Dr. Jitendran Multhuswamy - SBHSE

Human-machine interfaces have become a hot topic with the rise of the technology in the medical world, particularly in relation to aiding those with severe physical impairments. These physical impairments can arise from injury, physical disorders, or even brain damage. Among these is a Locked-In Syndrome, a rare neurological disorder that is caused by damage to the brainstem, a region which contains crucial nerve fibers involved in relaying information. This neurological damage leaves patients experiencing paralysis of all voluntary muscle movement, but still conscious and awake, only able to move their eyes in many cases. The range of movement of eye movement is cataloged in the medical world and can be used to communicate information to the patient. For this reason, OBOK Medical has developed the Visual Voice device with hopes to improve the quality of life for these patients. On the topic of specificities, the device involves a connection to an IV system that measures real-time eye movements and possibly muscle activity, electrophysiology (EOG). Functionally, the EEG signal will be obtained between two electrodes that will gather the electrical potential between the retina and corneal region of the patient’s eye. This system will utilize the higher signal as the patient looks up and the negative signal range as they look down in a predetermined pattern. The software will be configured with threshold intervals to output specific responses to these patterns. Along with this, the system will be customizable to the needs of a given patient, able to track the amount of communication restored and relieve stress for both caretakers and patients. Moving forward, the team will continue to practice due diligence in fine-tuning product specifications aimed towards the patient’s specific parameters.

41: Development of a Positional and Electromyographic Biosensor Sensor System for Locomotive Characterization
Max Fisco, Joshua Hsu, Laura Roa & Yassine Yousfii - SBHSE
Mentor(s): Andrew Clary - FROGS Physical Therapy Institute | Dr. William Tyler - SBHSE

In the United States, there are over 30 million student athletes. Among them, 3.4 million students suffer from sports-related injuries that result in musculoskeletal imbalances. Current treatments consist of a combination of prescription drugs, physical therapy, and rehabilitation. Currently, physical therapy is a qualitative industry, using the discretion of the primary care provider to evaluate patient status. Attempts to refine best practices in the industry have led to the creation of various analog tools such as dynamometers and PT specific inclinometers. Nonetheless, these tools only measure specific biomarkers and do not provide the primary care providers with a holistic analysis on patient progress due to the discrete nature of data collection. Our device will tackle this problem by developing a fabric-based sensor suite that can be integrated seamlessly into the patient treatment plan. Our design is a system of bands worn on the patient’s body to continuously monitor muscle activity and motion. Using machine learning, we plan on developing a data analytics platform for physical therapists to curate biometric information and help them refine treatment plans for their patients. The device’s user interface will be a mobile application that is cross-platform compatible and communicates with the sensor system over a network connection. Our customer will be the primary care provider and the end user can either be the physical therapists themselves or the patients. The physical therapy market segment is valued at 36 billion USD and is experiencing a growth rate of 2.2% per annum. We plan on initiating the implementation of our device by partnering with various universities around the nation and cater to the needs of student athletes. This will allow us to develop our technology and address the entire market segment in the future.

42: IVConcentrate: A Non-Invasive, Handheld, And Portable IV Concentration Detection System
Enock Boakye, Jaycob Proffitt & Sarah Soaf - SBHSE
Mentor(s): Dr. Antonio Garcia - SBHSE | Dr. William Tyler - SBHSE

IVConcentrate will allow for ensuring safe and efficient patient care when dealing with IV systems. Incorrect saline concentrations is an issue that can cause negative health effects and death at an unacceptable rate. Cancer patients and those dealing with infections may not be getting the proper dosage of chemotherapy drugs and antibiotics necessary. By ensuring proper dosing of not only the bag but additives as well, it removes unnecessary risk from the patient and truly allows the healthcare professionals to have nothing to worry about delivering effective care. Currently, there is no way for a nurse or other healthcare professional attaching a patient to an IV to confirm the correct contents of an IV bag. This shows a need for the development of a tool that can be used to evaluate these concentrations in health-care settings. Looking at the use of either Raman spectroscopy, FTIR, NMR, refractometry or electrical conductivity testing to allow evaluation of concentration within the bag without contact to the device. The device will be a non-invasive, handheld, lightweight, durable, portable, rechargeable, accurate, easy-to-use, and readable system. The development of such technology opens a new way for characterization of a given analyte in a liquid medium while being contained within a barrier separate from the detection system. This will allow healthcare settings to increase efficiency rating while maximizing maximizing Medicare payout and overall safety of patients. This tool characterizes an IV bag concentration thus optimally lead to a method of optimization of drug treatments as a whole, minimizing adverse effects, increasing efficiency and could eventually be adapted to a technology that allows real-time drug concentration monitoring within the human body non-invasively.

Masters Applied Projects

1: Scaffold to Facilitate Burn Wound Repair
Aaron Blank
Mentor(s): Dr. Brent Vernon - SBHSE | Dr. David Brafman - SBHSE | Dr. Michael VanAuker - SBHSE

This project is on a polymeric based scaffold that is used to facilitate healing in severe burn wounds. In the United States alone, there are over 400,000 incidences of severe burn wounds every year. This scaffold will provide a medium to regenerate tissue while delivering antibiotics to the wound site. This device consists of two major components, a silk fibron based porous scaffold and a hydroyropyll methylcellulose solid to gel transitioning layer. These materials combined will address problems found with the current state of the art treatment, skin grafts, such as high incidence of infection, graft rejection, and lack of mechanical stability. For this project, the target disease state and treatments have been evaluated along with the market share for severe burn wound treatment. The device has also been prototyped, where a method to create the scaffold has been designed along with evaluating drug release profiles.

2: Development of an Electrochemical Continuous Insulin Sensor with a Biodegradable Coating
Tiffany Gong
Mentor(s): Dr. Jeffrey La Belle – SBHSE | Dr. Vincent Pizziconi – SBHSE | Dr. Matthew Green - SEMTE

According to the World Health Organization, there are 422 million people in the world with diabetes mellitus as of 2014. The current standard of care for diabetic patients is frequent monitoring of blood glucose (BG) levels. These BG levels help determine insulin dosages for insulin-dependent diabetics. However, monitoring both glucose and insulin could provide valuable information regarding the overall health of the patient. Insulin monitoring could allow for better glycemic control, improved insulin dosing, and improved A1C levels. The gold standard for insulin measurement is an ELISA, which is costly and time-consuming. The goal of creating a continuous insulin sensor is to allow patients to obtain real-time measurements to monitor their diabetes regimen. Using previously published La Belle lab immobilization protocol, the fully functionalized electrode was dipped in collagen gelatin, which degrade to expose additional binding sites and allow for continuous detection of insulin to become a reality. Physiologically, control of insulin was tested electrochemically to provide proof of concept for patient use, and signal analysis was done to separate degradation activity from binding activity.

3: Robotic Balance Training Based on the Characterization of Ankle Mechanics Improves Paretic Ankle Motor Control
Lindsey Hennington
Mentor(s): Dr. Hyunglake Lee – SEMTE | Dr. Claire Honeycutt – SBHSE | Dr. Thurman Lockhart - SBHSE

Individuals with hemiparetic stroke often have mobility issues related to impaired neuromuscular control of their affected side. Lack of proper ankle control during locomotion can increase the likelihood of trips and falls after hemiparetic stroke. Ankle robots to improve paretic ankle control have been developed for the sitting position, but there is a need for strategies that would involve balance control during an ankle movement task to better relate to gait improvement. The purpose of this study was to determine if robotic balance training for stroke patients would improve paretic ankle motor control and increase gait control. We hypothesize that balance training using a visually guided, compliance-controlled ankle robot would improve paretic ankle motor control and gait control. Two subjects post stroke with right-sided weakness were recruited for this study to perform a task involving standing balance and ankle
motor control with a haptic motorized platform that deflects based on a subject’s force. Data was collected while the subject was in-structed to move their impaired ankle to reach a visually-guided target for dorsiflexion, plantarflexion, inversion, and eversion. We found that paretic ankle control was improved, seen as increased target success as well as faster and smoother movements. Our results are indicative that including a standing balance aspect to robotic ankle rehabilitation techniques is a desirable therapeutic target for increased ankle control in stroke survivors.

4: Generation of Realistic Tissue Structure Library for Simulations and MR Fingerprinting

Etham Mathew

Mentor(s): Dr. Chad Quarles – BNI | Dr. Vikram Kodigbaskar – SBHSE | Natenael Semminine - BNI

MRI imaging has long been used for brain cancer diagnoses as well as the monitoring of hemodynamic and vascular features. There has recently been a push to incorporate machine learning with MRI technology in order to expand the range of biological and structural information that can be extracted. MRI based vascular fingerprinting has been shown to be able to extract the gradi-ent and spin echo decay MRI data, collected across multiple echo times, to a library of signal decays simulated across a range of microvascular tissue structures recapitulating that found in human tissue. In order for MR fingerprinting to be successful, a thor-ough database of tissue structures to compare against needs to be created. This project aimed to devise a computer program to generate models of healthy tissue structures quickly and stably so that they may be used in hemodynamic simulations and even-tually used to develop a MR fingerprinting database. The characteristics of the vascular structures (i.e. the number of branch-es, sizes) and the resolution were designed to be easily modified by the user so that structures for different purposes could be cre-ated. The program yields a volume occupancy of the vasculature (the fraction of the generated structure that actually consists of vessels) between 2% and 10% and was optimized using GPU computing so that a large number structures could be created ef-ficiently. Additionally, hemodynamic properties were to be included in the structures, but accurate implementation of computational fluid dynamics could not be completed for the project at this time. Future work for this project consists of adding hemodynamics to the tissue structures and expanding the range of vasculature structures to reflect cortical and cancer microvascular architecture.

5: A Novel Approach for the Detection of Insulin Aggregation

Blake Morrow

Mentor(s): Dr. Jeffrey La Belle – SBHSE | Dr. Vincent Pizziconi – SBHSE | Dr. Curtiss Cook - The Mayo Clinic

Recent studies have found that prescription insulin is not at its labeled activity when it reaches the patient. The decrease in activity is due to aggregation which is suspected to be caused by mishandling in the supply chain logistics from the manufacturer to the pharma-cy. Here we have proposed a sensor that is capable of measuring the aggregation of insulin via electrochemical impedance spec-troscopy (EIS). The human insulin antibody was immobilized onto a gold screen printed electrode in order to assess the aggregation. By using an ELISA to determine the activity of the sample as well as dynamic light scattering to assess the size of the aggregates, the sensor was calibrated. This sensor will allow insulin dependent patients to test their insulin prior to consumption. Additionally, this sensor can be used in manufacturing and research to ensure insulin samples remain active as expected.

6: Analysis of Bioinformatics Data of Gait Impaired Stroke Patients Following the use of an Inflatable Exosuit.

Alvaro Rascon

Mentor(s): Dr. Panagiots Polyeurogenis – TPS | Dr. Christopher Plaisier – SBHSE | Dr. Vincent Pizziconi - SBHSE

According to Mayo Clinic, stroke is a condition that can eventually lead people to experience complications such as loss of muscle movement, and pain. The aim of this project is to determine whether a post-stroke patient that has such aforementioned functional limitations is able to improve and restore their gait cycle to a healthier level with the use of a soft, knee exosuit. My role in this project allows the analysis of bioinformatics data such as knee angles, circulation, step length and step time that are associated with the human gait cycle. Using JMPI I found significance in the data by conducting an unpaired T-test. This test was chosen because the data was considered to be independent of one another allowing the patients’ data before use of the exosuit to be used as a control or the results after exosuit use. During the gait cycle, I looked to see if the exosuit assistance would help reduce the angle the knee makes during heel strike at the end of each step, thus matching the knee angle profile of a healthy individual. Circumduction was also analyzed by comparing the distance the foot reaches away from the body before and after use of the exosuit. Other bioinformatics data was compared similarly to ensure the significance could be compared to the profiles of healthy individuals. Effect size was also calculated to show that significance found when comparing the patients before and after results could be explained by the use of the soft exosuit.

7: Tattoo Removal via Microneedle Electrochemistry

Adam Redleaf

Mentor(s): Dr. Jeffrey Labelle – SBHSE | Dr. Vincent Pizziconi – SBHSE | Dr. Jit Muthuswamy – SBHSE

The original intent of this project was to develop a new method of tattoo removal involving microneedles with an electric field applied through them, generating a current to pull the ink out of the body. Laser tattoo removal works differently, it breaks down the pigment particles via light which is selectively absorbed by the pigment and is relatively harmless to the skin. When the pigment particles are smaller the immune system carries them away over a few weeks. Recent research indicates that melanophages tend to pick up and hold the pigment particles in position in tattoos and have a more or less continuous replacement cycle so even when the cells current-ly holding pigments are killed off and the pigments are broken down by the laser, a fresh set of melanophages will replace them and start collecting pigment fragments, the immune system will not carry away any fragments that melanophages get to first. I hope that by pulling the inks/pigments directly out of the body and into the microneedles, either in addition to or instead of laser therapy, this technology could make tattoo removal faster, more effective, and potentially less painful.

8: Controlled Oscillating Ultrasound Experimental Set-up

Travis Tibbs

Mentor(s): Dr. Inder Makin - A.T. Still University | Dr. Bruce Towe – SBHSE | Dr. Jitendar Muthuswamy – SBHSE

Ultrasound elastography is an important ultrasonic imaging method that can measure the mechanical properties of tissue. Mechanical measurements of tissue, such as stiffness, can provide insights in diagnostic efforts. Most, if not all, major ultrasound machine man-ufacturers have built-in elastography imaging settings. Machines that employ elastography capabilities require manual tissue com-pres-sion of the transducer to produce adequate motion, allowing the transducer to compress and relax. This motion can be detected and used to determine the tissue’s mechanical properties. The programmable inputs to the system includes the distance the transduc-er displaces, which affects the force applied to the tissue, and the velocity by which the transducer moves. M-mode imaging on the ultrasound machine was used to track the type of motion being produced. The final prototype produces continuous, controlled, and force constant motion that will be useful for future ultrasound elastography research.

9: Development and Standardization of a Functional Reaching Test (FrEt)

Luc Tieu

Mentor(s): Dr. Sydney Schaefer – SBHSE | Dr. James Abbas – SBHSE | Dr. Visar Berisha - Department of Speech and Hearing Sciences

Upper extremity motor problems are common in a number of conditions, including Parkinson’s disease, Alzheimer’s disease, stroke, and even normal aging. Most motor assessments do not capture complex movement patterns that are involved in activities of daily living. Thus, we have been developing a testing apparatus to better mimic real world actions — in this case, using a box to transport small objects (beans) from one location to another. This testing apparatus has four equally sized cups, with three arranged at the same radial distance from the fourth. This is based on classic motor control paradigms involving center-out reaching. The fourth cup is filled with 30 beans and the participant uses a spoon to move two beans at a time to the other three cups until all the beans are distributed. An accelerometer embedded into the spoon tracks the spoon’s acceleration in XYZ coordinates and records the time required to complete the experiment. A handmade, single prototype apparatus is currently being used in Dr. Schaefer’s Motor Reha-bilitation and Learning Lab, but a 3D printed apparatus was designed in this applied project to standardize this testing procedure for use across multiple operators. To demonstrate that there are no differences between both testing setups, 10 participants performed the experiment on both setups with their right and left hand. The trial times and average acceleration was compared using bivariate linear regression, and validity was determined using the Pearson Product Moment Correlation coefficient (r).
Thank you

On behalf of the SBHSE Program, we sincerely thank our BME alumni, industry and clinical partners, and all the mentors for your continued support of our Senior Biomedical Engineering Capstone Design Students and Masters Applied Project Graduates. Please be sure to join us again at our upcoming BME Spring Symposium and see how far the SBHSE Capstone Class of 2019 was able to develop their exciting technologies and what new innovations the Masters Applied Project students are working on in health care.