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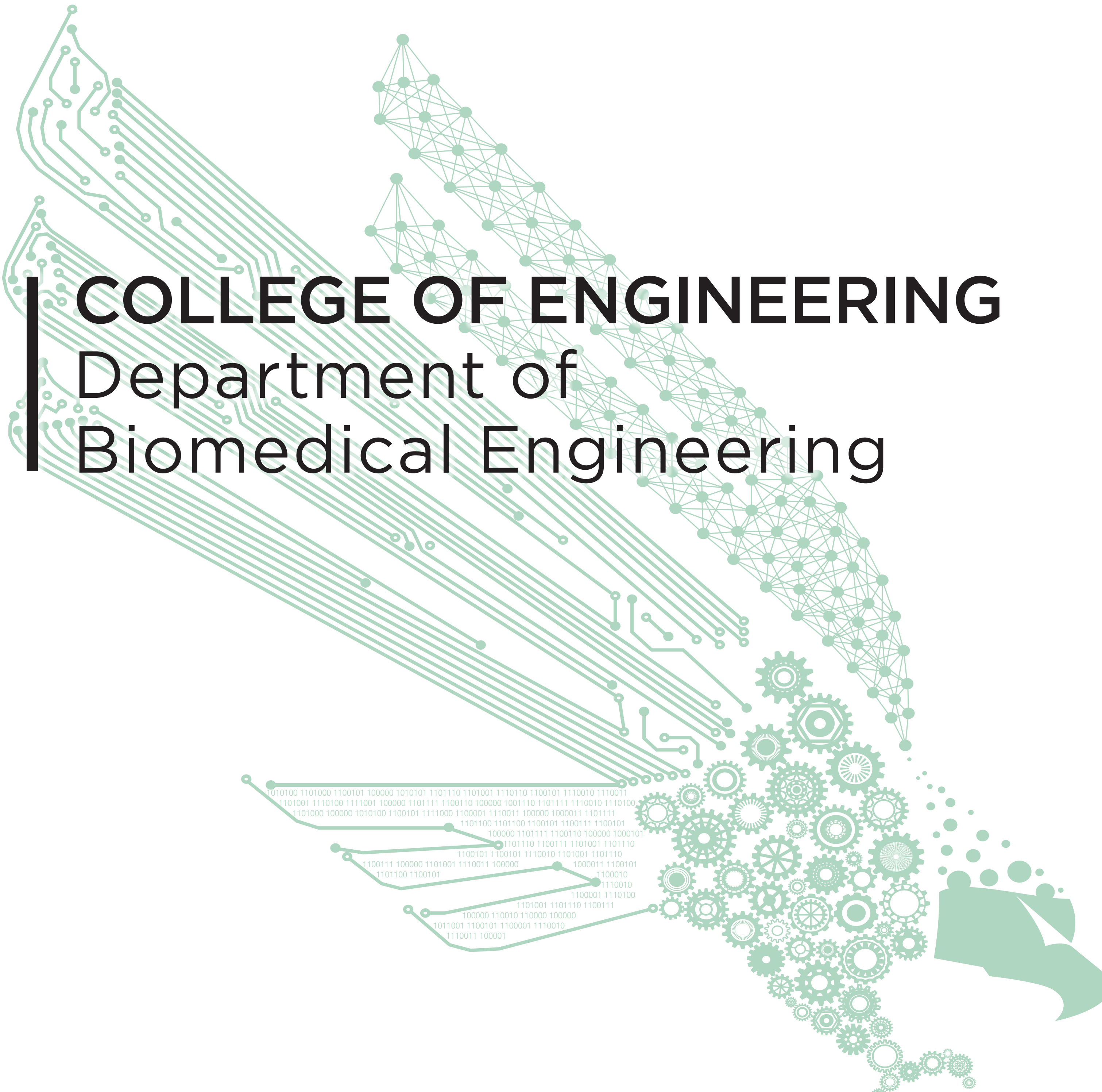

COLLEGE OF ENGINEERING

Department of Biomedical Engineering

Senior Design Abstracts

Spring 2024

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Wireless At-Home Physical Therapy Sensor

DEO SOLUTIONS

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External Sponsors/Mentors

Behavioral Tools
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Abstract

The demand for total knee arthoplasty is rising, while the motivation to get through physical therapy is dropping. DEOS Solutions is aiming to design a device that uses surface electromyography (sEMG) to conduct at-home physical therapy when paired with a smartphone application. The application will feature a game with the goal of motivating the patient, making it more likely that they will finish their physical therapy. Our device uses a simple EMG circuit architecture to capture biosignals from a wide range of sources. Some of its main features include BLE 5.0 and 2.4 GHz Wi-Fi compatability, a rechargeable 3.7V Li-Ion battery, a flexible and reusable electrode pad, and a modular design that aims to be portable, user-friendly, and environmentally conscious. We hope that this device is able to improve the effectiveness of physical therapy for knee replacement surgery patients through our patient-centered design and our motivating therapy games.

Acknowledgements: Dr. Manish Vaidya, Dr. Xiaodan Shi, Nicole Berry, Professor Curtis Chambers, Dr. Neda Habibi, Cass White, Mike Tyndall, Friends & Family.

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VitaCardia: Electrical and mechanical stimulation in millifluidics for cardiac organoid maturation

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Dr. Huaxiao "Adam" Yang (sponsor)
Angello Huerta Gomez (sponsor)
Nicole Berry (mentor)
Vilma Arwood (mentor)
Robert Powell (mentor)

Abstract

Animal models for experimentation in disease modeling, drug testing, and tissue regeneration is still widely used, but the results do not always translate well for human use. Cardiac organoids as the new type of three-dimensional cell culture model consisting of various cardiovascular cells are directly differentiated from human induced pluripotent stem cells (hiPSCs). The hiPSC-derived cardiac organoids have shown potential promises in modeling human heart development and disease as an alternative of animal-based models. We propose to establish an engineering system for housing cardiac organoids combining the use of a millifluidic chip, electric stimulator device, and peristaltic pump to provide electrical and mechanical stimulations needed to promote cardiac maturation and vascularization to create an optimal in vitro human heart model for various biomedical applications.
Keywords: cardiac organoids, culture, hi-PSCs, millifluidic, vascuarization

VitaCardia would like to acknowledge and express our gratitude to Dr. Huaxiao Yang and Angello Huerta Gomez for their support, providing hiPSC-CMs for testing. We would also like to thank Vilma Arwood, Nicole Berry, and Robert Powell for their input and guidance.

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VitalMedProJoints

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Dr. Tsz Yan Clement Chan
Department Of Biomedical Engineering

Abstract

Ultrasound scans are known from prenatal screening, where sound waves are used to create detailed images of a developing baby. However, this technique has surprising versatility, which includes therapeutic ultrasound. Therapeutic ultrasound is a special application that ranges from diagnosis to treatment.

Our project aims to break the boundaries of patient care by developing a revolutionary ultrasound device designed with patient comfort in mind. This innovative device has several key features that put the user experience first. It works like a gentle massage using sound waves and offers a way to treat chronic pain while promoting healing. The therapeutic approach uses low-intensity pulsed ultrasound waves that gently generate heat in target tissues to effectively treat muscle spasms and contractions. By increasing local circulation, the device also promotes significant pain relief and offers a promising alternative for chronic pain. It is completely non-invasive and eliminates the discomfort associated with traditional procedures. In addition, its portable design allows for convenient use at home or in clinical settings, and seamless Bluetooth connectivity facilitates monitoring by healthcare professionals.

We would like to express their sincere gratitude to Dr. Tsz Yan Clement Chan, Nicole Berry and The Department of Biomedical Engineering for their invaluable guidance, support, and insightful contributions throughout the development of this ultrasound device project. We are also grateful to ManaMed for their generous sponsorship and support, which made this project possible.

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Optimizing Interaction Between Cancer and Immune Cells Within a Microfluidic Device

CUMULUS

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Dr. Moo-Yeal Lee
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Abstract

Cancer is a disease that causes uncontrollable cell growth. Due to it causing roughly 10 million deaths worldwide every year, various in-vitro disease modeling methods have been developed by researchers to study different cancer types. Our project combines several of these principles by simulating cancer-immune cell interactions within a recently developed dynamic microfluidic device before analyzing these interactions in-vitro.

We developed a COMSOL simulation that quantifies cancer-immune cell interactions at varying levels of immunocompetence. This model can be applied by researchers to mimic different patient-specific in-vivo conditions, helping them analyze how certain treatments will affect the patient based on their immune system. Our simulation design for disease and drug modeling can revolutionize the field of cancer research, allowing for innovative and novel treatments to emerge.

We would like to express our sincere gratitude to Dr. Moo-Yeal Lee, Dr. Fateme Esmailie, Dr. Sooyeon Kang, Bioprinting Laboratories, and the UNT Biomedical Engineering Department for all of their guidance, resources, and support.

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Makasi:
A Fall Detection and Warning Device

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Abstract

The mortality rate in elderly population directly pertaining to injuries caused by falling makes it a global health concern. This project focuses on the frequent falling issue and the development of a device that monitors the likelihood of a fall and warn of a potential fall. The device, SureStep 3: A Fall Detection and Warning Device, will constantly monitor and warn of potential falls based on the user's posture and muscle activation. The device utilizes both gyroscopes and EMG sensors to monitor the balance and posture of the user along with their muscle activity, respectively. The device will send the gyroscope and EMG data to an app which will identify the fall conditions and warn the user to be cautious of their movement, via Bluetooth headset or notification. This approach allows for the integration of the device with physical and mental exercises during therapy sessions for balance training or everyday use for the elderly population. This device could present a solution in addressing the major public health issue posed by the falls of the elderly population.

We would like to acknowledge & thank Dr. Vijay Viadyanathan for serving as our academic advisor.

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The "Lazy Susan" Cervical Collar

KAVE technology

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Dr. Melanie Ecker

Abstract

Patients that have undergone cervical disk arthroplasty face long recovery periods that often leave them with muscle loss in the neck and a decreased range of motion. To fix this issue, KAVE Technology, sponsored by ManaMed, has designed the “Lazy Susan” cervical collar by allowing for left and right turning movements to accelerate the healing process. The cervical collar facilitates neck turning up to 60-degree at 10-degree intervals and has the ability to resist being broken up to 5 PSI for physical therapy.

The prototype of the cervical collar was first 3D printed using polylactic acid filament (PLA) and then validated by various testing, including turning, locking, and resistance mechanisms, and human fit. The “Lazy Susan” cervical collar, once on the market, will be able to aid in returning patients to normal life faster and help them retain the range of motion and muscle mass that would otherwise have been lost.

We would like to thank Trevor Theriot, Kelly Nolan, and Christopher Cioffi of ManaMed for the opportunity to work with them and our faculty advisor, Dr. Melanie Ecker, for her support and guidance throughout this project.

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MARKS: Silicone Aorta Valve Model for Implementation in Mock Circulation Loops

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The University of North Texas Biomedical Engineering Department
Dr. Fateme Esmailie

Abstract

Cardiovascular research requires a precise platform to replicate human circulatory dynamics accurately. Mock Circulation Loops (MCL) serve this purpose by simulating physiological hemodynamics, aiding both research and professional training. MCL components consist of a pulsatile heart pump, reservoir, heart valve models, control valves, and compliance chambers. The pump replicates heart pulsation, the reservoir compensates for fluid leakage, the compliance chamber maintains pressure, and the control valves regulate pressure through a tube. Flow visualization within the MCL is facilitated by a Particle Image Velocimetry System (PIV), featuring a high-frequency laser and two high-speed cameras.
Our primary focus is on designing and developing a patient-specific aortic valve model. Our objective is to ensure the model's optical and acoustic transparency. Optical characteristics enable effective visualization and dynamics capture within the silicone aortic valve model (SAVM) using the PIV system. Acoustic transparency is vital for investigating ultrasound's role in disrupting blood clotting during transcatheter aortic valve replacements, thereby expanding the product's potential applications. Future plans involve integrating ultrasound with our silicone model to assess acoustic wave impact on vascular blood flow.

Acknowledgements: Dr. Esmailie and The Biomedical Engineering Department

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CRYOCHEM TECHNOLOGY

COGNITO Project: Cold Therapy Gloves for Oncology Generated Neuropathy Inhibition and Treatment Options

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Abstract

Chemotherapy induced peripheral neuropathy (CIPN) is a common side effect of several chemotherapy treatments. This condition most commonly causes a loss of sensory and motor function in the patient's extremities due to the deterioration of nerve endings. Currently, the standard of care to prevent and manage the symptoms of CIPN is to put the patient's extremities into freezable gloves, ice packs, or ice water. These methods are found to be uncomfortable and messy for the individual.

Cryochem Technology proposes a water-circulating chilling glove for the hand featuring multiple layers, including a patient-contact, fluid flow, compression, and insulation layer. The device aims to slow down the blood flow and induce vasoconstriction in localized regions of the hand through the usage of cold temperature and compression. This limits the access of chemotherapy neurotoxins to the capillary beds and reduces the immediate and long term symptoms of CIPN.

The team would like to thank The Realtime Group and the BMEN department for their support!

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B-AMBU

OMEN

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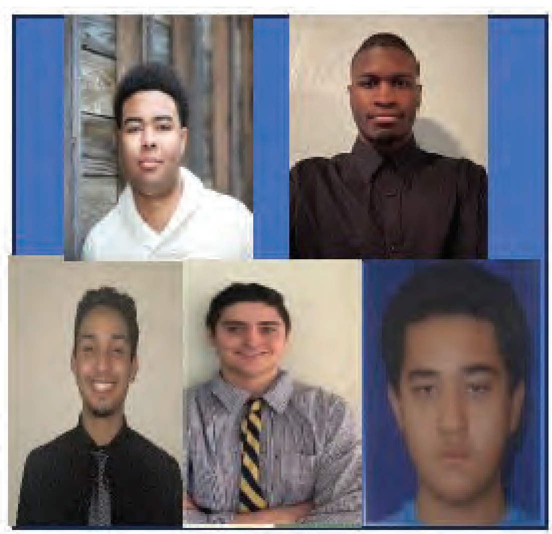
Dr. Fateme Esmailie

Abstract

An automatic blower bag valve mask (BVM) represents a significant advancement in emergency respiratory support, addressing a critical need in medical care. Traditionally, manual BVMs require continuous human effort, leading to fatigue and inconsistent ventilation in prolonged use scenarios. The automatic blower BVM is engineered to alleviate these challenges by providing consistent, automated ventilation. It integrates a compact, battery-operated blower mechanism, ensuring a steady and non-variable amount of air into the patient's lungs. This device is particularly beneficial when healthcare professionals are scarce or when patients require long-term ventilation support during transportation. Its intuitive design includes a single case supplying the necessary ventilation rate and volume, catering to the most patients possible with a single device. Additionally, the device is equipped with a pressure relief valve to help offset the potential for over-pressurizing the patient's lungs. This innovation not only enhances the effectiveness of respiratory support but also reduces the physical burden on healthcare providers, making it a valuable tool in an emergency medical setting.



This group would like to acknowledge Dr. Esmailie for her groundbreaking guidance in the construction of the BAMBU prototype as well as Micronel for supplying the essential Driver and Blower.

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