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UNDERGRADUATE RESEARCH TECHNOLOGY CONFERENCE

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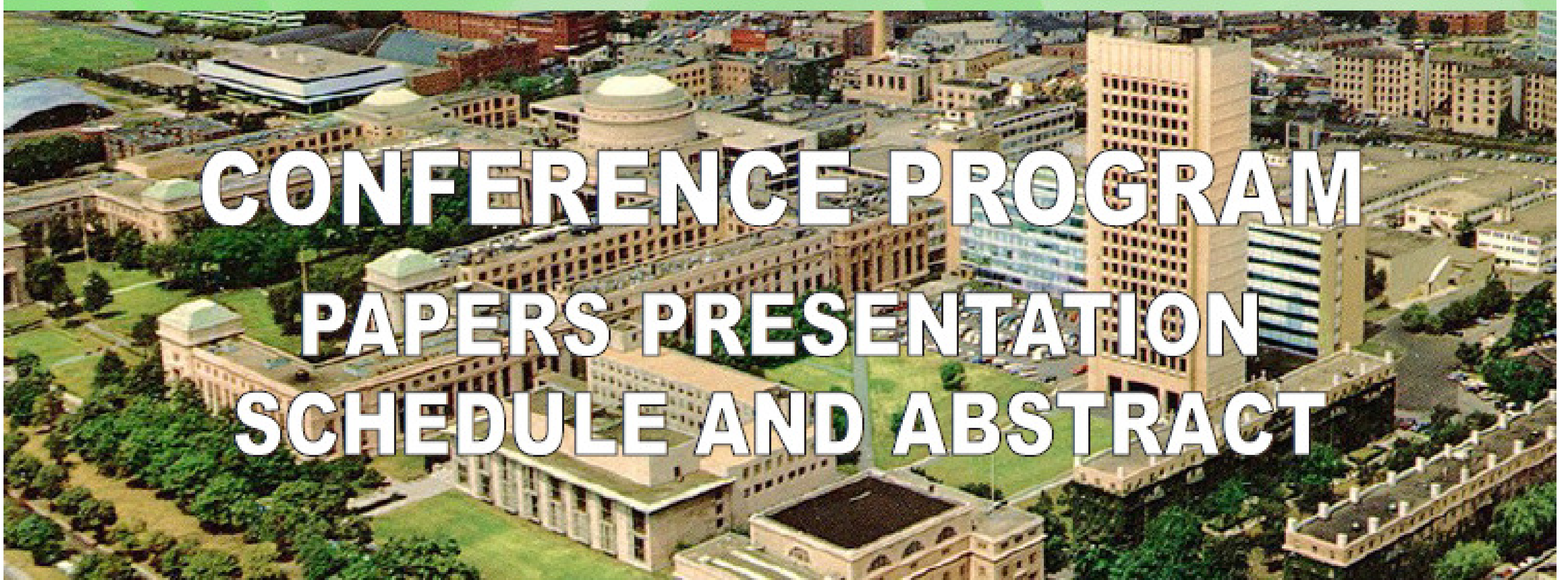
MEET INNOVATIVE TECHNOLOGY



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October 10, 2020 (Saturday)

Technical Paper Oral Presentation (AM Track #3)

EST 8:00am - 10:00am HOPIN Session Room C

Biological and Biomedical Engineering and Technology (BioEECS) Track, Innovative Technologies Track

Track Chair: Penny Tan

- **8:00am (PA20-0016)**

A Novel Controller Architecture for Intelligent Artificial Pancreas

Eric Costa Pimentel (University of Illinois - Chicago)

According to the ADA (American Diabetes Association), in 2018, over 34.2 million Americans were reported to have diabetes. This need fostered the research and development of infusion devices and controllers capable of precise and regulated insulin delivery, also known as the Artificial Pancreas (AP). The extensive amount of research conducted in the past decades has led to the development of safe and reliable APs. However, there are still several challenges hindering successful fully automated insulin delivery such as maintaining Time-In-Range (TIR) above 90% throughout treatment and continuously administering exogenous insulin to patients with severe insulin resistance. The traditional strategy has been to implement an algorithm capable of handling the complexity of the insulin-glucose physiology (IGP) while keeping BG within the desired TIR. This paper proposes a novel architecture that adopts independent agents specialized in the control of each critical compartment of the IGP and a decision engine that coordinates the agents to achieve near-optimal performance. The approach allows for the development of treatments tailored to patient-specific physiology through custom system tuning based on patient-specific metabolic parameters. The preliminary results of this study led to superior TIR, predictive CHO-insulin behavior, and greater system robustness.

- **8:10am (PA20-0058)**

An Analog Front-End For A Noninvasive Core Body Temperature Sensor

Eric Baccei, Eric Macorri (Worcester Polytechnic Institute)

Core body temperature falls under the list of vitals that must be closely monitored in many settings, such as a patient going through surgery or a soldier in the battlefield. Although the importance is major, there isn't an abundance of devices that can do this remotely and in a noninvasive manner. This paper presents the design of an integrated analog front-end for noninvasive monitoring of core body temperature. This analog front-end was designed in the TSMC 0.18 mm 3.3V and 1.8 V CMOS process. The overall system consists of a voltage regulator, a constant current source, bias circuits, an operational amplifier, and a filter. Specifications achieved include an amplifier with open-loop gain of 84.4 dB, a filter with a cut off frequency of 0.4 Hz, and a total power consumption of 181.2 mW. This was achieved with a total layout area of 0.027mm^2.

- **8:20am (PA20-0063)**

Decoding Emotions from Brain Signals Using Recurrent Neural Networks

Eva Zhang, Jos Parayil, Aaliyah Sayed, Jonathan Yao, Raphaelle Hoang (Rutgers University)

Despite playing a crucial role in human interactions and decisions, emotions are not well understood. These emotions can appear as electrical signals through electroencephalography (EEG). This paper uses data from the Dataset of Emotional Analysis Using Physiological Signals (DEAP), which recorded the EEG signals of participants as they watched videos that were specifically chosen to elicit strong emotions and rated their emotions on quantitative scales. A Long Short-Term Memory (LSTM) recurrent neural network was trained to find correlations between EEG data and self-reported emotional scores. The purpose of this study was to create an accurate and efficient method of decoding electrical activity into quantitative emotional values. It was found that valence scores, measures of the degree of happiness, predicted by the neural network matched somewhat closely with the actual valence scores given by the participants. The trained LSTM neural network achieved a reasonable accuracy in predicting valence scores given EEG signals.

- **8:30am (PA20-0071)**

Classifying EEG of Propofol-Induced Unconsciousness in the Presence of Burst Suppression

Willian De Faria (University of Notre Dame)

Anesthesia delivery yields dynamic electroencephalogram (EEG) signatures during moments of consciousness and unconsciousness. Consequently, real-time analysis of EEG signals during anesthesia administration is a promising technique to monitor patient states. Moreover, EEG has the potential to be the prime brain-monitoring technique for the creation of a closed-loop anesthesia delivery (CLAD) system. Machine learning (ML) software that can classify EEG time samples as conscious or unconscious is necessary for further CLAD system development. Burst suppression, a common metabolic phenomenon in deeply unconscious patients, presents a unique challenge to engineering an effective classifier. In this project, a previously engineered EEG classifier was replicated using band wise power (BWP) and principal component analysis (PCA) as features in a logistic regression classifier. The classifier performed well on the training data (BWP AUC = 0.94428, PCA AUC = 0.96096) and validation sets (BWP Mean AUC = 0.94426, SEM = 0.0010468, PCA Mean AUC = 0.96099, SEM = 0.0010535) but performed poorly when burst suppression samples were isolated for performance (BWP Hit rate = 0.4062, PCA Hit rate = 0.4330). Two new supervised ML approaches, support vector machines (SVM) and single-layer artificial neural networks (ANN), were utilized to improve classifier performance on burst suppression samples. As a result, the best performing classifier, PCA trained SVM, generated a burst suppression hit rate of 0.9598 on the training set and 0.8660 on the testing set while maintaining an AUC of 0.94714. While this project demonstrates that a classifier utilizing PCA with SVM is a promising avenue for robustly characterizing EEG signals in the presence of burst suppression, we conclude that dynamic preprocessing normalization techniques need to be implemented for optimal performance without overfitting.

- **8:40am (PA20-0096)**

A Photoplethysmography Wearable with Long-term Heart Rate Variability Detection Algorithm

Fivos Kavassalis (Worcester Polytechnic Institute)

This paper presents a wearable device that extracts and utilizes a photoplethysmogram waveform to measure and estimate various vital signs via custom-designed algorithms running on a mobile application. These vital signs include peripheral oxygen saturation, heart rate, respiratory rate, and short/long term heart rate variability. The device wirelessly transmits accumulated data to a mobile phone and a personal computer over Bluetooth Low Energy. Moreover, this paper explores the proposed device as an emerging technology with the contemporary concerns of the Coronavirus Disease 19 (COVID-19) pandemic. The measurement of peripheral oxygen saturation would give an early indicator of degrading respiratory health before the apparent manifestation of symptoms. The convenient use of the device in a mobile setting is especially relevant to current isolation precautions in place and its critical role in improving the care of at-risk patients.

- **8:50am (PA20-0103)**

Improving Prosthetics by Using Silicone as an Artificial Skin

Lasya Balachandran (High Technology High School)

Artificial skins that reproduce the sensation of touch are extremely valuable when designing prosthetic limbs. This natural sensation is critical for amputees who employ a prosthetic hand for everyday tasks such as holding or gripping objects. The use of silicone as an artificial skin covering on the fingertips of a prosthetic hand has the potential to significantly decrease the amount of force necessary to hold an object since silicone can increase sensitivity and the ability to mimic the sensation of touch. An experiment was conducted with a 3D-printed prosthetic hand to measure the force required to hold a common object such as a water bottle. Trials were conducted for both an uncovered prosthetic hand and the prosthetic hand covered with silicone skin, and the force was measured using an Arduino UNO microcontroller board in conjunction with a force sensitive resistor (FSR). The results of this experiment supported that the use of silicone skin on the fingertips of the prosthetic hand resulted in a significant decrease in the amount of force necessary to hold an object, likely due to its frictional properties. This work provides new insights into the design of artificial skins and the calibration of force feedback for prosthetic hands.

- **9:00am (PA20-0124)**

Detecting Differential Transcription Factor Binding Based on DNA Accessibility

John Lin (Boston Latin School)

Common genetic diseases - systemic diseases that are caused by thousands of mutations - affect millions of people around the world. Many of these mutations fall within regulatory regions. While the mutations associated with these diseases are widely known, the link between these mutations and their role in disease pathogenicity has largely gone undiscovered. This study harnesses single cell ATAC-seq data to differentiate bound and unbound sites in regulatory regions, serving as a first step to understanding these diseases. By computing observed and expected cuts for footprint regions, the study finds that regions with lower observed cuts than expected cuts conferred to protection from sequencing enzymes, indicating the presence of a bound transcription factor. In contrast, regions with higher observed cuts than expected indicate the absence of protection from sequencing enzymes, suggesting an absence of a bound transcription factor. In distinguishing between bound and unbound transcription factors, the study paves the way for using single cell ATAC-seq to understand common diseases by identifying the cell types and changes in transcription factor binding caused by mutations.

➢ **9:10am (PA20-0013)**

3D Depth Imaging for Assistive Guidance

Manuel Ackattupathil, Eli Levenshus (Bergen Community College)

The standard white cane is the most widely used mobility tool in the blind community. However, traditional cane travel can be difficult, as standard canes are unable to detect fluctuations in terrain. To bolster the capabilities of cane travel, a novel "smart cane" has been developed, which implements real-time depth detection mechanisms to help improve the safety and efficiency of cane travel. This system consists of a 3D depth detecting camera, a single-board computer, and a haptic feedback device to locate objects and alert the user by triggering a vibration in real-time. With the use of a 5V 3A portable charger, the system is completely self-operating and can last up to five hours of usage before recharging. The combination of these tools will warn users of obstructions up to 1.5 meters away from them. This direct feedback mechanism can help the visually impaired navigate with confidence and ease.

➢ **9:20am (PA20-0051)**

Probabilistic Analysis of Confocally Imaged Synaptic Calcium Activity (PACISCA)

Grace Tang, Shreya Kochar (Massachusetts Institute of Technology, Wellesley College)

Calcium imaging is widely used in neuroscience to analyze neuronal activity patterns in neural networks to correlate animal behavior with neural activity. Confocal microscopy has been brought up as an option for synaptic imaging in the past (as compared to 2-photon microscopy). However, one of its main drawbacks is the lack of options for processing, particularly in the context of synaptic imaging. Most existing pipelines, such as CaImAn, EZCalcium, etc. are designed for one/two photon microscopy and detect/analyze neuronal regions of interest (ROIs). Quantitative tools to analyze synaptic calcium imaging collected by confocal microscopy in an automated manner are lacking due to the nanoscopic organization of synapses. To address this technical challenge, we developed a novel pipeline that analyzes synaptic ROIs to map the probability of synaptic transmission at the resolution of individual active zones: PACISCA. The pipeline has four main components: synapse annotation/image motion correction, flash identification, fluorescence tracing, and probability mapping. Our work provides an efficient computational framework to analyze synaptic calcium imaging signals from neuroscience experiments studying synaptic function. Improving the reliability of our analytic tool on larger datasets will be the next steps of this work.

➢ **9:30am (PA20-0052)**

Designing and Simulating a Smart Air Purifier to Combat HVAC-induced COVID-19 Transmission

Noah Bergam, Sakshi Lende, Skyler Snow, Julianna Zhang, Lily Chen (Rutgers University)

Although heating, ventilation, and air conditioning (HVAC) systems serve the important function of providing fresh air changes for indoor spaces, they have been shown to distribute aerosolized severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) across such spaces and potentially exacerbate the risk of coronavirus disease 2019 (COVID-19) transmission. This paper proposes a solution to this issue in the form of a distributed network of small, compact air purifier modules, stationed on tables, which could be implemented alongside an HVAC system. Each module would use a high efficiency particulate air filter to capture SARS-CoV-2 and an ultraviolet C light-emitting diode (UVC LED) to routinely sterilize said filter. This moduleâ€™s structure is outlined using Computer Aided Design, its Internet of Things networking capabilities are mapped out using microcontrollers and a mobile application, and its potential impacts are modeled using computational fluid dynamics (CFD) simulations. The module could capture at least 99.97% of SARS-CoV-2 particles it encounters, fully decontaminate its filter with 108.4s of UVC exposure, and as demonstrated through CFD, manipulate airflow in order to treat potentially contaminated air before an HVAC system pushes such air to others.

➢ **9:40am (PA20-0061)**

A Hybrid Approach to Noise-Reduced Pods in Urban Areas

Lasya Balachandran, Arjun Agarwal, Hannah Cherry, John Kellaher, Ethne Laude (Rutgers University)

Urban environments generate noise, oftentimes creating distractions and health concerns for city inhabitants. To address the concerns created by short-term exposure to acute noise pollution, this project proposes a noise-reduced pod. The pod integrates passive and active noise cancellation technology to effectively reduce high and low frequency signals, respectively. For the passive approach, the pod was modeled with highly noise absorbent and reflective materials and was structured to most effectively attenuate sound waves. For the active approach, electronic components were utilized to collect and output signals, and a Filtered-x Least Mean Square (LMS) Finite Impulse Response (FIR) adaptive filter was created to process the input noise and produce the anti-noise. It was determined that polyurethane foam and double-glazed plexiglass are the best materials for sound absorption, rounded edges are the best structure for sound reflection, and an LMS step size of 0.008 provides the best trade-off for adaptive filtering. The technology, which achieved a significant noise reduction, was incorporated in a novel pod design for single person use in smart cities.