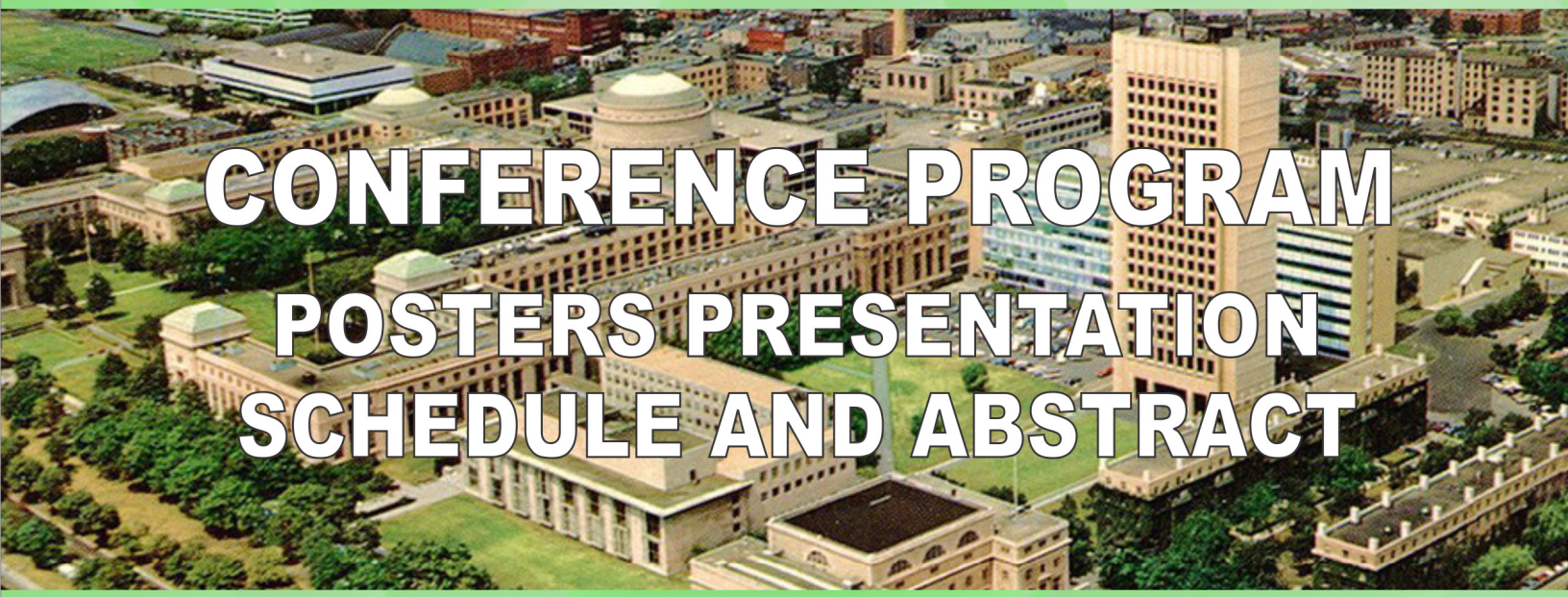
IEEE MIT URTC 2020

UNDERGRADUATE RESEARCH TECHNOLOGY CONFERENCE

October 09 - 11, 2020 | Cambridge, Massachusetts, USA (Virtual)

MEET INNOVATIVE TECHNOLOGY



CONFERENCE PROGRAM
POSTERS PRESENTATION
SCHEDULE AND ABSTRACT

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October 11, 2020 (Sunday)

Technical Poster Presentation (Session #1 Room A)

EST 8:00am - 10:00am

Innovative Technologies Track

Track Chair: Chelsea Chen

➢ **8:10am (PO20-0006)**

Analysis of Power Systems Abnormalities, A Case Study Approach

Kai Shraiberg (Wentworth Institute of technology)

In this work we demonstrate case studies to discuss the use of certain power metrics for detecting abnormalities under steady state or fault conditions in 3-phase power systems. Indicators that capture the change in performance are necessary in maintaining the health of the power system and in developing processes for protections purposes. We use symmetrical components and time-frequency plots to determine trends of abnormalities in power systems' performance. We would like to ultimately develop indicators that are used for fault classification and forecasting. We illustrate our points on a few synthetic as well as real-world examples. Additionally, we explain development of a corresponding Graphical User Interface (GUI) that allows for the classification of abnormalities in a 3-phase system.

➢ **8:20am (PO20-0014)**

Harnessing the Power of Comparative Functional Genetics: How the Medically Important Enzyme Na+, K+-ATPase Can Advance the Treatment of Cardiovascular Diseases

Yi Xie (Massachusetts Institute of Technology)

Cardiovascular Diseases (CVD) are the number one cause of death worldwide according to the World Health Organization. Cardiac glycosides (CGs), a Na+, K+-ATPase inhibitor, are used extensively to treat CVD and can also be used to treat neurological disorders. However, a variety of toxicity symptoms are associated with their administration. The medically important enzyme Na+K+-ATPase can reduce the detrimental side-effects resulting from the steroid treatment of CVD. Using comparative functional genetics, I studied the genetic basis of insensitivity to steroid inhibitors by assaying survivorship upon exposure to toxic CGs in a large number of Drosophila melanogaster strains. After, I performed a genetic association study between the single nucleotide polymorphisms (SNPs) of these strains mapping to the ATPalpha gene which encodes the catalytic subunits and adult survivorship upon CG-exposure. From a total of 256 high-quality SNPs, I found four intronic SNPs within two introns that are significantly associated with adult survivorship (p-value < 0.01). CGs have been recognized as the next revolution of CVD treatment. Understanding how populations respond to selection pressures requires identifying both the genetic basis of adaptations and the factors that limit their evolution. My results demonstrate CG-insensitivity varies within the same species, and that these differences have a genetic basis. The identification of the genetic basis for CG insensitivity yields insights that can be used in the development of drugs to treat a number of Na+K+-ATPase associated diseases such as CVD.

➢ **8:30am (PO20-0015)**

Harnessing the Power of Comparative Functional Genetics: How the Medically Important Enzyme Na+, K+-ATPase Can Advance the Treatment of Cardiovascular Diseases

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➢ **8:40am (PO20-0018)**

Cane Companion: Leveraging Modern Hardware Tools and Utilizing Deep Learning Methods to Create an Assistance Method for Individuals with Visual Disorders

Neeraj Rattehalli, Ishan Jain (Menlo Atherton High School)

Machine learning has become a staple in computer vision. With more robust model architectures and a substantial datasets, computational object detection can be leveraged in commercial level applications. Globally, there are an estimated 289 million individuals who are visually impaired and 39 million who are legally blind. In hopes of mitigating the deficits caused by visual impairments, we leverage computer vision tools, deep learning models, and modern hardware technologies to construct a smart cane. Composed of Raspberry Pi, photoelectric object detection sensor, camera packet, collapsible button, and audio output, Cane Companion can navigate the visually impaired. The photoelectric sensor detects sudden changes in motion, cueing the camera packet to start recording live footage. The video stream is sent through gRPC protocols to the Raspberry Pi, which utilizes a pretrained YoloV3 model for object detection. Once a prediction has been made, the inbuilt speaker or the connected audio output(headphones, bone conduction glasses, etc) broadcasts the object's identity. If the user is stationary, for example at a supermarket, and is looking for groceries, the cane collapses into a wand through a button click. Utilizing both OCR and YoloV3, the wand can be waved around to detect the various items present in the store. Ultimately, through the use of Cane Companion, users are able to more successfully self navigate their surrounding and can get some insight into the world around them.

➢ **8:50am (PO20-0021)**

Optimization of the Temporal Profile of DBS Therapy for Parkinson's Disease

Aidan Riley (University of Connecticut)

Introduction: Deep brain stimulation (DBS) of the subthalamic nucleus (STN) is an established therapy to treat motor symptoms of Parkinson's disease (PD) but is inefficient and hard to customize. In recent years, closed-loop strategies have been developed to personalize DBS and reduce the amount of stimulation delivered to the STN. These strategies require continuous monitoring of PD biomarkers to adjust the stimulation and result in higher consumption of power than traditional open-loop DBS. Also, since both recording and stimulation capabilities are needed, more sophisticated neurostimulation devices are necessary. To avoid these limitations, we investigate open-loop DBS protocols with optimized amplitude profiles and show in simulation that such optimal protocols can modulate PD biomarkers in the same way as traditional DBS while significantly reducing the amount of stimulation delivered to the brain and the power consumption. Methods: We considered DBS pulse trains at constant frequency (i.e., 130 Hz, similar to therapeutic DBS) and varied the envelope of the DBS pulses over time. We developed a genetic algorithm to find the envelope shape that optimizes the trade-off between power consumption and attenuation of PD-specific 7-35-Hz neural oscillations in the globus pallidus (GPi), which is the output structure of the basal ganglia, and we paired the algorithm with a computational model of the basal ganglia under PD conditions and STN DBS. Then, we simulated open-loop DBS with the optimal envelope on a large-scale computer model of the basal ganglia (over 1,000 conductance-based neurons) and assessed the performance of optimal DBS versus traditional DBS. Results: We found two optimal envelope profiles, i.e., a Gaussian profile (GAUSS) and a triangular profile (TRIAN), which modulated the pulse amplitudes up to 10% (GAUSS) and 15% (TRIAN) of the nominal value used in traditional DBS, respectively, and were both repeated every 100ms (i.e., envelope frequency: 10 Hz). Applied to 3 instances of the basal ganglia model under PD conditions, both profiles significantly lowered the power spectrum of the GPi spike trains in the 7-35-Hz range from the value at rest (ANOVA test with Tukey-Kramer post-hoc test, P-value $P<0.05$), which is a biomarker of PD, and the reduction under optimal DBS was similar to the reduction under traditional DBS (GAUSS: -17.1Â±4.4%; TRIAN: -12.5Â±1.6%; traditional: -26.6±2.9%, respectively, mean± S.D.; ANOVA test, $P<0.05$). Optimal DBS resulted in lower power consumption than traditional DBS (GAUSS: -7.5%; TRIAN: -14.9%). Furthermore, optimal TRIAN DBS increased the power spectrum of the GPi spike trains in the 0-7-Hz range to 49.2±1.5% of the normal value (TRIAN) when applied at a frequency of 10hz and 49.9±1.7% when applied at a frequency of 2hz, both of which were significantly higher than the value under traditional DBS (43.0±3.0%, mean± S.D., ANOVA test, $P<0.05$). Conclusions: This study shows in simulation that an optimized envelope of DBS pulses may result in significant therapeutic outcomes and increased physiological restoration of the GPi activity at low frequencies while saving up to 15% of battery power.

➢ 9:10am (PO20-0057)

A Novel Approach to Assisting Gene Therapy of Hearing and Balance Loss Using Artificial Intelligence

Connie Jiang, Michelle Chen (Palo Alto High School, Crystal Springs Uplands School)

This project utilizes the algorithms of artificial intelligence to enhance the efficiency of the manual cell counting process, a tedious process that has been commonly delegated to experienced interns. In recent gene-regulated studies, scientists used biomarkers like LGR5 to record the process of hair cell regeneration. To gather datasets, all 3D images of cells that are produced by high-tech microscopes are thoroughly analyzed and counted. Although programs currently exist to aid this process, scientists still rely on manual counting, which, in addition to being extremely time consuming, also significantly delays their research. After discovering the View5D plugin for the image processing program ImageJ, we extended the existing code to accommodate three-dimensional tools for visualizing, segmenting, and counting cells. View5D provides three orthogonally cross-sectional views of the 3D image, but it only supports one region of interest (ROI) at a time. We introduced a module that manages a list of ROIs and a mechanism that outlines the 2D cross-sectional areas of the ROIs and displays them on the orthogonal views. We further developed a rule-based AI classification algorithm that automatically detects the cell's type. This algorithm creates a channel vector for each cell and handles information across the four color channels(RGB-Grey). This program also identifies bio-tagged cells, which track the effectiveness of treatment. Furthermore, the ROIs segmented using this tool form a training dataset, which can be applied to train an advanced learning model as machine learning is implemented for completely automated cell counting.

➢ 9:20am (PO20-0062)

High Dimensional Quantum Sampling and Entropic Uncertainty

Keegan Yao (University of Connecticut)

Entropy plays a crucial role in quantum information and cryptography, quantifying the amount of secure information that can be extracted from a quantum state. Maximizing the amount of secure information that can be extracted from signals is a fundamental problem in information theory and cryptography. Quantum sampling provides a means of predicting, with high probability, the amount of secure information that can be extracted from a full quantum system through the behavior of a smaller quantum system. In [2], a d-dimensional quantum entropic uncertainty relation is proposed, which bounds the conditional smooth quantum min entropy using the measurement result of a two outcome positive-operator valued measure (POVM) and the failure probability of a classical sampling strategy [1]. We look to improve upon this bound by tightening post measurement behavior of a quantum system. Our modifications and improved quantum entropic uncertainty relation follow from a new sampling strategy on classical strings and more rigorous analysis of the post measurement state. This new result shows theoretically promising improvements in asymptotic generation rates compared against other high dimensional quantum random number generator protocols [2, 4, 5]. Asymptotic improvement over the originally proposed quantum entropic uncertain relation [2] is proved using a novel result comparing the d-ary entropy and Shannon entropy. Moreover, our new result can be used towards an alternative proof of the standard Maassen and Uffink quantum entropic uncertainty relation for arbitrary dimension d [3].

References: [1] Niek J bouman and Serge Fehr. "Sampling in a quantum population, and applications". In Annual Cryptology Conference, pages 724-741. Springer, 2010. [2] Walter O Krawec. "A new high-dimensional quantum entropic uncertainty relation with applications". To appear: Proc. IEEE International Symposium on Information Theory. arXiv preprint arXiv:2005.04773, 2020. [3] Hans Maassen and Jos BM Uffink. "Generalized entropic uncertainty relations". Physical Review Letters, 60(12):1103, 1988. [4] Giuseppe Vallone, Davide G Marangon, Marco Tomasin, and Paolo Villoresi. "Quantum randomness certified by the uncertainty principle". Physical Review A, 90(5):052327, 2014. [5] Feihu Xu, Jeffrey H Shapiro, and Franco NC Wong. "Experimental fast quantum random number generation using high-dimensional entanglement with entropy monitoring. Optica, 3(11):1266 1269, 2016.

➢ 9:30am (PO20-0063)

Evaluating the Impact of Data Offloading in Dense Wireless Networks with Optical Communication

Myles Toole (University of Massachusetts, Boston)

Global networks went from processing 100 GB per day to 100 GB per second between 1992 and 2002. Device mobility has expanded in the nearly two decades since and there are now approximately 5.1 billion mobile users with a predicted growth to 5.7 billion devices by 2023. Since 2002, the introduction of wireless applications like the smartphones, video calling, Internet of Things, and augmented/virtual reality have continued to increase the device density and data demand within the wireless ecosystem. Wireless networks have typically addressed this demand by deploying more access points with smaller individual coverage. These smaller range cells offer better spatial reuse qualities and, accordingly, higher area spectral efficiency. Offloading to smaller cells also removes congestion from larger networks and improves system capacity. This trend of offloading to smaller cells has continued into the visible spectrum with highly directional optical wireless cells. Previous research into heterogeneous RF and visible light communications (VLC) networks has shown excellent potential to improve performance on individual networks. We aim to report the broader impact of offloading to optical cells, considering the performance impact on neighboring WiFi cells as well. In an effort to understand the impact of offloading in an environment with nearby co-channel wireless network deployments, UCaN Lab has developed a testbed that emulates network traffic using distributed Raspberry Pi microprocessors. The testbed can be implemented to produce a multitude of experiments designed to observe how certain variables impact network performance. The primary goal of each experiment is to report the effect of neighboring network performance as devices are removed from a primary RF network. Data is collected by simultaneously running the iPerf performance measurement tool on a configurable set of the Raspberry Pis. Results of the distributed test are then aggregated on a central host computer for data analysis.