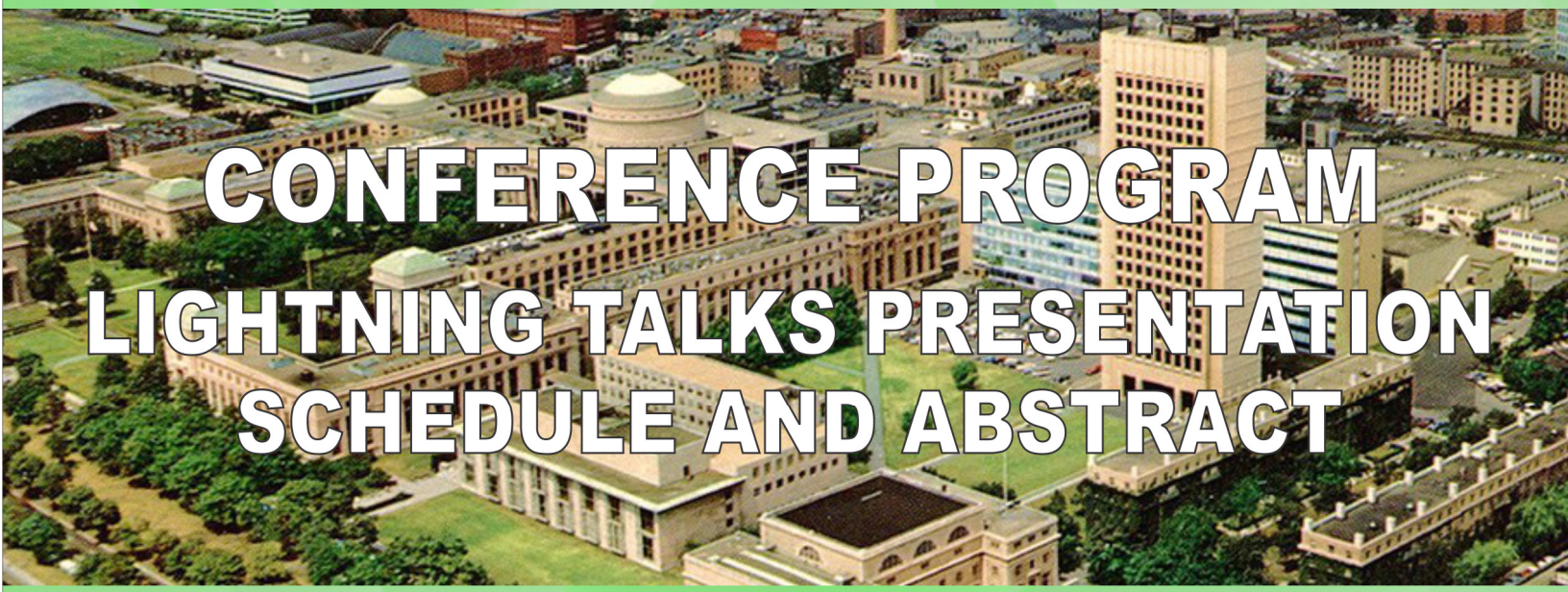
# IEEE MIT URTC 2020

## UNDERGRADUATE RESEARCH TECHNOLOGY CONFERENCE

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

# MEET INNOVATIVE TECHNOLOGY



# CONFERENCE PROGRAM
# LIGHTNING TALKS PRESENTATION SCHEDULE AND ABSTRACT

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## October 11, 2020 (Sunday)

**Lightning Talks Presentation (Main Stage)**

EST 1:30pm - 2:30pm

**Lightning Talks**

Track Chair: Cathy Yung

➢ **1:30pm (TK20-0007)**

**Drover: Drone-Rover Communication for Pathfinding**

Noah Bergam, Justin Li, Samuel Henriques (The Pingry School)

Due to their unique abilities and visual perspectives, integrating an unmanned aerial vehicle (UAV, or drone) and an unmanned ground vehicle (UGV, or rover) into a single autonomous system is an enticing prospect, with applications currently being explored in wildfire tracking, garbage collection, and extraterrestrial reconnaissance. This project, entitled Drover, is concerned with building such a system cheaply and effectively and applying the AirGround protocol for drone-rover communication, developed by (Pace, et al., 2015), to a pathfinding problem in an unknown environment. The great challenge in developing this pathfinding system is making sure that both the drone and rover know where they are relative to each other and their environments, and that they update that information over time. This necessitates the implementation of a multi-robot simultaneous localization and mapping (SLAM) protocol which can integrate the perspectives of the drone and the rover into a global map in real time. This project is currently developing a solution implementing an Extended Kalman Filter SLAM scheme which can function on three sources of information: 3D images captured by a stereo vision setup on the rover, 2D images captured by a downward-facing camera on the drone, and the states of both the drone and rover according to GPS and other sensor readings. Alongside SLAM, the drone and rover vision address problems more specific to pathfinding; the drone draws and dictates paths for the rover, while the rover identifies objects in its path and dodges them. The drone's path planning ability involves turning images into node maps and applying Djikstra's Shortest Path algorithm from a starting point to an end point. It was found that weighting the nodes by color, rather than predetermining the path viability of each pixel on an absolute basis, was more effective for pre-planning paths on roads. Work is currently underway on generating these paths in real time, translating them into motion instructions for the rover, and allowing the rover to alter these instructions based on its closer view of its surroundings.

➢ **1:35pm (TK20-0024)**

**Quadratic Unconstrained Binary Optimization Formulation for Naval Aviation Training Scheduling**

Michael Mizell (Harvard College)

Current scheduling for military aviation training is done sub-optimally because it takes hours, is disrupted by event failures and cancellations, and does poorly accounting for long-term effects when making short-term decisions. Optimization formulations for this problem have been created for several decades, but the recent emergence of low-energy-seeking computer systems ideal for optimization problems normally impracticable on typical computers provides the opportunity for new research in this problem with the hope of making improvements in time-to-solve and scalability. A 2014 paper by Roger S. Jacobs, Optimization of daily flight training schedules, creates a detailed constrained optimization problem of binary decision variables representing the aviation training scheduling problem and, although not explicitly geared towards low-energy-seeking systems, provides a good foundation for a formulation that addresses the new technology. Jacobs' form, however, is just a starting point because low-energy-seeking systems require the optimization problem to be formulated in a format called Ising form, and Jacobs is not in Ising form. In Ising, the objectives and constraints are captured in a single function of linear and quadratic terms, and the variables take values of -1 or 1. An arbitrary conversion of Ising form is Quadratic Unconstrained Binary Optimization (QUBO) form, which only differs in that the variables take values of 0 or 1. It is possible to convert an existing optimization problem into QUBO form, and the conversion of Jacobs' formulation to QUBO form and subsequent implementation computationally to take advantage of the burgeoning field of low-energy systems is the subject of our current work. The general process thus far has been two-step. First, convert the inequalities and equations that represent the problem's constraints into penalty terms that penalize the objective function for invalid solutions; then, rewrite the penalties and original objective function using vectors, matrices, and tensors so that the function can be written out concretely and implementation on a computer is simplified. Writing robust code that uses an appropriate solver to gather data on our formulation is our next step.

➢ **1:40pm (TK20-0025)**

**Fast Mapping onto Census Blocks**

Kaira Samuel (Massachusetts Institute of Technology)

Efficient data mapping tools are more essential than ever. This project was created out of the necessity of COVID-19, as it was intended to provide a quick way for large amounts of meaningful data to be sorted and displayed without highly complicated software or much technical debt. The fast mapping of census data using Google Earth and Microsoft Excel has the potential to give local and federal emergency responders a powerful tool to improve emergency preparedness. For mapping tools to appeal to emergency responders, it is important that the tools are easily accessible and maintainable on a wide range of legacy hardware. Our approach displays relevant census data (total population, population under 15, population over 65, median age) per census block, sorted by county, through a spreadsheet (xls file) and Google Earth (kml file). The spreadsheet interface includes features that allow users to interconvert between different longitude and latitude coordinate units. For the Google Earth files, a variety of absolute and relative colors maps of population density have been explored to provide an intuitive and meaningful interface.

➢ **1:45pm (TK20-0027)**

**Simulation of Microwave-Induced Temperature Fields in SiC Composites**

Kevin Stern (Worcester Polytechnic Institute)

The project is focused on Multiphysics modeling of microwave-induced heating production of SiC composites by chemical vapor infiltration. The resulting composites are expected to be capable of withstanding temperatures beyond 1500 C and are meant to be used in nuclear reactors. The iterative solution of a coupled electromagnetic-thermal problem mimics the time evolution of the temperature field in a SiC preform in a large microwave cavity. Simulation of the heating of tubular samples at different resonant and non-resonant frequencies shows the heating rates and patterns of temperature distribution and generates recommendations for corresponding experiments.

➢ **1:50pm (TK20-0028)**

**Intelligent Diagnostics and Clinical Management: Improving the Detection and Treatment of ADHD Using Machine Learning**

William Das (Icahn School of Medicine at Mount Sinai, Hunter College High School)

This lightning talk will delve into improving the detection of ADHD using oculometric paradigms in conjunction with machine learning based methods â€" current challenges with the clinical diagnosis of ADHD will be addressed, as well as our proposed solution to synthesize data science and machine learning for the analysis of pupillometric features as a novel mechanism to detect ADHD through the development of a tangible web application based interface. Additional opportunities to drive intelligent clinical management/decision-making for the detection and treatment of neurobehavioral disorders using machine learning will also be briefly touched upon as a broader, encompassing theme. Our research on pupillometrics and its associations with the presence of ADHD, which culminated in the creation of a novel diagnostic application to detect ADHD using machine learning, will be briefly presented. Accurate and efficient detection of attention-deficit/hyperactivity disorder (ADHD) is critical to ensure proper treatment for affected individuals. Current clinical examinations, however, are inefficient and prone to misdiagnosis, as they rely on qualitative observations of perceived behavior and are subject to inherent doctor biases. This has perennially resulted in lengthy clinical examinations lasting multiple hours, and a high misdiagnosis rate, estimated in 2010 at 20%. Wait times from initial concern to formal diagnosis can extend beyond 13 months, as the demand for examinations often exceeds the capacity of pediatric clinics, preventing the administration of proper treatment regimens for affected individuals. Preliminary results will be presented as a proof-of-concept for the promising use of pupillometrics as a biomarker to characterize ADHD. Overall, this study is the first to apply machine learning based methods for the detection of ADHD using solely pupillometrics, and highlights its strength as a potential discriminative biomarker to drive clinical management and decision-making, paving the path for the development of novel diagnostic applications to aid in the detection of ADHD using oculometric paradigms and machine learning. As such, towards the end, the lightning talk will briefly touch upon a broader theme of developing novel diagnostic applications for the improved detection and treatment of neurobehavioral disorders using machine learning based methods.

➢ **1:55pm (TK20-0030)**

**Smell-rinkler: A Sprinkler Device for Scents**

Ryan Parekh (Wentworth Institute of Technology)

Humans have different feelings throughout the day. We sometimes feel tired or sad in different situation. According to the study, scent can play an important role to influence how humans feel. Specifically, the ups and downs of estrogen and progesterone make the humans sensitive to scent. We hypothesize that if we can control scent smartly, we can help the humans to control the feelings. In this research, we propose a new system, Smell-rinkler, which consists of a scent dispenser, a 3D-printed robotic finger, a mini-computer and an Android mobile application, to help the humans switch their feelings by smelling different scents controlled by the system. According to Steinemann et. al's work [1], air fragrances pollute the society and affect it one way or another. Although air pollutants in Australia are different from what we have in the U.S., air fragrances exposed to everyday workers cause major disruptions, such as headaches, migraines, and asthma attacks, is the same. Espino-DA-az et al's work [2] goes into the details on the relationship between the fragrances contain and the types of disruptions. The work mainly describes apple taste, but this can apply to the aroma as well. Volatile compounds contained in apple aroma can vary depending on harvesting methods. Rachel S. Herz's work [3] focuses on the concentration levels of fragrances. The concentration of the oil fragrance is a factor in how strong or weak the fragrance smells. A stronger scent will typically last longer while a weaker scent will dissipate shortly. Therefore, we believe controlling fragrances in the air is important for the humans.The design of Smell-rinkler is a user-centered design. It starts from paper prototyping, prototype testing, design, implementation and evaluation. The system takes the user's input from the mobile application and sends it to Raspberry Pi that uses a Python program to determine the time intervals as well as the type of scent to spray. To support the interaction, a 3D-printed robotic finger is built and controlled to spray the scent at different time, such as early morning or sleeping time. The current result shows that the prototype system can use the user's feedback to select different scents to spray. The demonstration of the system has a potential to be integrated into different home- or office-based environment, such as smart home or personal office. The future work of this research includes applying machine learning algorithms to learn from the user's feelings by using physiological signals from different sensors, such as electrocardiogram (ECG), electromyography (EMG) and electrodermal activity (EDA), adding tangible and visible gadgets to support interactions, etc. References: [1] Anne Steinemann. â€œHealth and Societal Effects from Exposure to Fragranced Consumer Products.â€ NCBI, US National Library of Medicine National Institutes of Health, 14 Nov. 2016. [2] Miguel Espino-DA-az, David Roberto Seplveda, Gustavo GonzÃ¡lez-Aguilar and Guadalupe I Olivas. Biochemistry of Apple Aroma: A Review. NCBI, US National Library of Medicine National Institutes of Health, Dec. 2016. [3] Rachel S. Herz. â€œChapter 17 Perfume. NCBI, US National Library of Medicine National Institutes of Health.

➢ **2:00pm (TK20-0035)**

**Utilizing Game Theory and Machine Learning to Play Board Games**

Owen Casciotti (Clarkson University)

Our research uses principles of Game Theory to analyze approaches for playing common two player games. In particular, we used Game Theory inspired algorithms to play Tic-Tac-Toe, Connect Four and Checkers at expert levels. Some of the main ideas of Game Theory we are working with are games, players, strategies, and payoffs. Some of the methods used to control the actions of the players were handcrafted strategies, Minimax based algorithms, and Q-learning. Our initial testing of handcrafted strategies revealed that more complex strategies resulted in better outcomes. This led to the testing of the Minimax algorithm, which searches through all possible moves to a specified depth and chooses the move with the best payoff. Testing this method resulted in nearly perfect gameplay of Tic-Tac-Toe. To get Minimax to work with Connect Four, an evaluation function was needed to determine board quality. The Minimax algorithm with our Connect Four board evaluation function hasn't lost a game. When trying to create an evaluation function for checkers, we discovered that the game was far too complicated to be summarized by a function similar to the one developed for the other two games and instead employed a reinforcement learning algorithm called Q-Learning. We found that this method was not able to perform as well as expected due to the sheer complexity of connect four. We look forward to continuing to use our game play strategies to explore better approaches to more complicated games such as Stratego.

➢ **2:05pm (TK20-0039)**

**Exploring Models of Internet Traffic**

Ashley Luo (Massachusetts Institute of Technology)

In today's world, the Internet is a widely accessed tool that is capable of significantly influencing our society. Therefore, it is necessary that we understand Internet traffic. One way to approach this is to construct a model, in which all traffic can be represented as a matrix A, where each entry corresponds to the number of packets sent from a source to a destination and are entered into A with rows mapping to the source and columns mapping to the destination. After analyzing the largest publicly available streaming data containing 50 billion packets, it was discovered that the two parameter Zipf-Mandelbrot distribution model could accurately depict a range of source/destination statistics computed from matrix A. More recent analysis of larger data sets have revealed another 50 previously unknown scaling relations as function of temporal scale. These results enable the detailed testing of underlying theoretical models of network traffic. This work investigates a variety of traffic topologies such as isolated links, supernode leaves, a supernode and densely connected cores with core leaves. Adjusting the number of nodes and links in the topologies it is possible to create concordance with the observations. By figuring out a model of normal traffic flow, we can determine and distinguish normal patterns of network from abnormal, adversarial patterns and ensure the safety of the Internet.

➢ **2:10pm (TK20-0019)**

**Enhanced developmental defect screening via Deep Learning**

Prateek Kalakuntla (Massachusetts Institute of Technology)

Anomaly detection is an important problem which has seen much attention by researchers in machine learning. Unsupervised learning has proven to be valuable in solving this problem in a variety of contexts. This is primarily because aberrations can occur in variety of manners making it difficult to label each one. At the same time, machine learning models to analyze video data have been growing ever more efficient. Models at the intersection between these fields, those that can analyze anomalies in video data, have been created, but they primarily focus on video data that is "constant" such as surveillance data. In contrast, there is a shortage of work done on anomaly detection models for videos of a changing system. We have focused on video data of developing fruit fly embryos that undergo stereotypic morphological changes. We have created a model that can identify the appearance of a malformation. Our model utilizes transfer learning, PCA, and UMAP to project images into a 2D space. Mutant images are then differentiated from wild type images either by statistical or topological means. Once tuned, the model can consistently distinguish between abnormal and normal images and can even cluster images based on biologically relevant factors such as the underlying mutation. The model does this, while only utilizing spatial data about the images, not temporal data from the videos. Additionally, it only requires dozens of movies. These two factors greatly decrease the amount of compute resources the model requires and the time it takes to run making it a transferable pipeline for diverse contexts. In conclusion, our model demonstrates that machine learning algorithms can be effectively applied to the problem of anomaly detection in evolving systems. This has a variety of potential applications from detecting anomalies in the 3D printing process to detecting anomalies in in-vitro fertilized embryos which could improve our ability to target them before they progress.

➢ **2:15pm (TK20-0037)**

**Finding the Optimal Machine Learning Model for UAV-Led Disaster Response**

Dominic Garrity (Harvard College)

Though the development of artificial intelligence has undoubtedly made many aspects of day-to-day life easier, its applications to disaster response are still limited. Search-and-rescue missions, for example, are still primarily conducted by humans and sometimes result in death. While research has been done on analyzing humans in aerial media, it has primarily focused on action classification, not human detection in rural terrain. In addition, it has not robustly evaluated ways in which unmanned aerial vehicles, which typically lack computing power, can track people with low latency and high accuracy. I review existing literature and use data from the Aerial Semantic Segmentation Drone Dataset and the UCF Aerial Action Dataset to train, validate, and compare machine learning models by standard benchmarks, such as latency, accuracy, and size. I do so with the goal of determining which would be most suitable for drone-based disaster response missions. My findings indicate that extremely large models are not needed for such missions. In fact, especially in conjunction with inference optimizers like NVIDIA's TensorRT, embedded systems are able to detect objects in close to real time. I anticipate that my findings will not only amplify interest in fitting machine learning models on unmanned aerial vehicles, but also lead to more sophisticated research on the applications of artificial intelligence to disaster response.

➢ **2:20pm (TK20-0041)**

**Optimizing the Visualization Pipeline of a 3-D Monitoring and Management System**

Dylan Sequeira (Massachusetts Institute of Technology)

As High-Performance Computing (HPC) environments generate increasingly vast amounts of data, the need for a human-readable data visualization tool becomes clear. This project harnesses the power of the Unity game engine to create an interactive 3D environment where system administrators can gain a better understanding of the system state and quickly identify system failures. With an underlying foundation in the Apache Accumulo database and the d4m.mit.edu data analysis technology, this project combines the scalability and efficiency of traditional data center management tools with the interactivity and visual clarity of a game environment. The focus is on adding informative networking and storage representations to the 3D visualization environment.