NAVAL ACADEMY SCIENCE AND ENGINEERING CONFERENCE 2021

On behalf of NASEC 2021 senior staff, I'd like to welcome you to this year's Naval Academy Science and Engineering Conference. We are truly grateful to have you with us and hope you enjoy your time here. As you listen to presentations from distinguished visitors, discuss with fellow delegates during breakout sessions, and tour the world-class facilities here at USNA, I encourage you to take time to interact with our students and faculty and develop new ideas for future research.

Civilian and military delegates alike, we all have a vested interest in understanding the impact of data science in our society. In the next couple of days, we aim to explore both the possibilities that data science affords us, as well as the responsibilities it creates. As such, we trust that the ideas presented will produce a memorable and thought-provoking experience for everyone in attendance.

Sincerely,
Jennifer Jung

Schedule of Events

Sunday, 7 November 2021

1030-1130: Luggage Drop-Off at Conference Hotel

Introduction to NASEC 2021, DoubleTree Hotel by Hilton Annapolis

1200-1215: **Welcome and Discussion of NASEC 2021 Format and Goals**
NASEC Chair: Dr. Cody J. Brownell, Mechanical Engineering Department, USNA
NASEC Midshipmen Coordinator: MIDN 1/C Jennifer Jung, USNA

1215-1245: Icebreaker

Session 1 (S1) DoubleTree Hotel

1300-1340: Lunch

Subject Matter Expert Presentations

1345-1425: **Artificial Intelligence**
Dr. Kyunghyun Cho
New York University

1430-1500: Break and Reception

1500-1540: **Data Analytics**
Dr. Bushra Anjum
Doximity

Session 2 (S2) DoubleTree Hotel

1540-1630: Discussions within Theme Working Groups

1635-1715: **Ethics**
Dr. Jovana Davidovic
University of Iowa
United States Naval Academy Stockdale Center Fellow

1720-1830: Dinner at Doubletree Hotel

1900-2300: Personal Time in Annapolis for NASEC Midshipmen Leaders and Attendees

Monday, 8 November 2021

0630-0745: Complimentary Continental Breakfast at Hotel

0800- 0815: Depart for Naval Academy

Session 1 (M1) Rickover Hall, Room 102

0900-0945: **Keynote Presentation**
Dr. Sethuraman Panchanathan
National Science Foundation

1000-1030: Reception with Dr. Panchanathan

Session 2 (M2) Breakout Rooms, Naval Academy Yard

1015-1140: Discussions within Theme Working Groups in Assigned Breakout Rooms

1150: View Noon Formation

1205-1245 Lunch with Brigade of Midshipmen

Session 3 (M3) Mitscher Auditorium

1300-1345: **Distinguished Speaker:**
Dr. Debra Mathews
Johns Hopkins University

1400-1500: Tour of Naval Academy Yard

Session 4 (M4) Breakout rooms, Naval Academy Yard

1500-1530: Break and Refreshments

1530-1715: Discussions within Theme Working Groups in Assigned Breakout Rooms

Session 5 (M5) Dinner and Forrestal Lecture, Naval Academy Yard

1730-1830: Dinner in the Bo Coppedge Room, Alumni Hall

1845: Assigned Seats in Alumni Hall

1900-2000: **Forrestal Lecture:**
General John W. "Jay" Raymond
United States Space Force

Tuesday, 9 November 2021

0630-0800: Complimentary Continental Breakfast at the Hotel Followed by Check Out

0815: Depart the Hotel for the Naval Academy

0830-0900: Set-up the NASEC Poster Session

Session 1 (T1) USNA Rickover Lobby

0900-1000: **NASEC 2021 Poster Session**

1000-1030: Break and Refreshments

Session 2 (T2) USNA Various Locations

1030-1145: Breakout Group Presentations (Volgenau, Ri102, Ri301) (3 groups)

Session 3 (T3) Rickover Hall, Room 102

1145-1215: Box Lunches, Maneuver Over to Ri102

1215-1230: Closing Remarks

1300: USNA Buses Depart Alumni Hall to Doubletree Hotel for Luggage and POV retrieval. Depart Hotel for BWI Airport and BWI Amtrak station

Abstracts

NASEC 2021.001
Kallee Gallant, Columbia University
Analysis of Hybrid Rocket Combustion Data

Analysis of results is an integral part of the design process. The purpose of this project was to analyze the combustion chamber pressure data from existing hot fire tests in order to provide a better understanding of the effectiveness of changing various design aspects. The considered variables are factors known to affect combustion stability. Python was used to sort, plot and calculate stability metrics from the given datasets. This Python tool will be used to draw conclusions from the Stardust 1.0 data and advise the bluShift team as they work on the next, larger iterations: Starless Rogue and Red Dwarf.

NASEC 2021.002
Jared Jacobowitz, The Cooper Union for the Advancement of Science and Art
Empirical Model for Puncture Energy of Metals

The purpose of this work is to fit a previously developed empirical equation for puncture energy to simulation data. The conservative puncture energy equation could be used to expedite the process of performing calculations in the development of safety measures; avoiding the need to create complex finite element models for specific puncture scenarios. A total of 108 simulations are developed by varying coupon thickness, coupon material, probe shape and probe diameter. The simulations are comprised of a low-velocity probe puncturing the coupons; from which the probe kinetic energy change is calculated. The empirical equation is fit to the dimensions, material properties and energy results using a non-linear least-squares regression method within Python, which determines the two constant parameters for each fit. More statistically significant fit results are achieved by separating the data by probe shape and coupon material.

NASEC 2021.003
Thomas Forzani, Rutgers University
High Speed Training Using Binary Neural Networks

Traditionally, power consumption has been an oft overlooked metric in the training and execution of neural networks, but the paradigm is beginning to shift as large computing systems used in deep learning continue to increase in scale. Integer units take up far less physical chip space than floating point units, and their power consumption is far less as a result. We investigated the use of integers and binary fixed-point number implementations in two neural networks trained on the MNIST-digits and MNIST-fashion datasets to see what effect their use might have on accuracy and training time. Our fixed-point model had a 0% reduction in accuracy from our floating-point model for the MNIST-digits dataset, and a 3% reduction in accuracy for the MNIST-fashion dataset, all while saving power.

NASEC 2021.004
Lucas Mantovani, University of Chicago
Understanding, Modeling and Forecasting Ideology Shifts in Social Groups: Using Recursive Decision Forests to Inform Social Theory

We report the development of a novel computational framework to uncover, represent and leverage hidden dependencies between opinions on contentious social topics in order to ultimately craft a predictive theory of how opinions shift and mature in social groups. Using data from the General Social Survey that curates responses from approximately 40,000 US participants over 4 decades, we show that the ideological divide between the liberal and conservative thought-centers are modulated by economic variables, indicating the possibility of a causal influence from a faltering economy to worsening social polarization. Our data-driven framework, powered by novel learning algorithms, also quantifies the dependencies between key "hot-button topics", and induces a computable yet intrinsically meaningful metric to compare and contrast world-views at the level of individuals, groups and communities across the societal hierarchy. Understanding how opinions shift, and coalesce is key to informing domestic policy, as well as DoD operations in conflict regions.

NASEC 2021.005

Anoop Kiran, University at Buffalo

Numerical simulation of unsteady aerodynamics for a transverse gust encounter

Commercial aircraft are susceptible to gusts induced by large-scale turbulent flow structures in the atmospheric boundary layer. Small and agile autonomous vehicles are also susceptible to gusts that arise from wakes, complex terrains, and urban environments. This study examines the unsteady aerodynamics of an airfoil encountering a transverse gust in two dimensions. The objective of this research is to find optimal maneuvers that the airfoil can execute, such as pitching, plunging, and surging to reduce the sudden impact of the gust. The gust encounter is modeled using Computational Fluid Dynamics (CFD) simulation in the commercially available software COMSOL Multiphysics. The numerical simulation looks for convergent solutions to the Reynolds Averaged Navier-Stokes (RANS) equations, which describe the physics of the flow passing over the wing, including changes in the flow as the airfoil translates and rotates. Measurements of the coefficient of lift and the flow velocity at probe locations are used to validate the simulation by comparison to results from towing tank experiments. Gust encounter simulations are performed for an airfoil surging at a constant rate and from several angles of attack. Results from the simulation and gust mitigation strategies will be discussed in this presentation.

NASEC 2021.006

Dana Lin, University of Chicago

Hyperparameter Optimization of a Conventional Neural Network Model

Machine learning models contain hyperparameters that control the effectiveness of the learning process and must be tuned before training. However, hyperparameter tuning is difficult due to the heterogeneity in the types of hyperparameters, the complex interdependence of hyperparameters and the computational expense to tune hyperparameters [1]. As a result, many machine learning models resort to setting hyperparameter values based on intuition, experience, and experimentation rather than through objectively defensible tuning methods. In the Secure Biosystems Design project a machine learning model, CRISPRAct, has been created to predict the percent fold change in transcript levels for a given gRNA, as a proxy for how well the CRISPR-induced self-destruct mechanism kills bacteria. CRISPRAct has two separate models: the neural network (NN) model, which processes information about the gRNA's positional and physicochemical properties; the natural language processing (NLP) model, which treats each gRNA 2 of 13sequence as a two-sentence sentiment analysis problem. The results of each model are then combined through a polynomial regression to predict the gRNA activity.

However, while both the NN and NLP models are working models, their current hyperparameter values were determined through manual searching. Therefore, a systematic method to tune the hyperparameters is required to optimize the models' performance. To this end, we leverage HyperSpace, a distributed Bayesian optimization approach shown to outperform several other methods[1], to optimize hyperparameters in CRISPRAct. Specifically, we optimize hyperparameters in the NN model. We focus on four hyperparameters: hidden size, dropout rate, learning rate, and the number of epochs. The hidden size controls the number of nodes in each layer of the neural network; the dropout rate controls the number of connections between layers and can prevent overfitting; the learning rate controls how quickly the model learns to find the global minimum; lastly, the number of epochs controls the number of passes of the entire training dataset completed by the algorithm and prevents overfitting. We optimize the first three hyperparameters in a bundle, and optimize the number of epochs by implementing an early stopping algorithm. We were able to successfully implement HyperSpace to tune three hyperparameters in the original NN model and run the script on Lambda. The minimum values obtained from the HyperSpace trials approached the minimum from the original NN model, but did not reach a lower minimum. We identify areas to improve hyperparameter optimization using HyperSpace in future work on this project. Our work will inform future decisions to enhance the NN model, provide an analogous approach for optimizing hyperparameters for the NLP model, and ultimately allow us to better predict the gRNA activity and design more secure biosystems.

NASEC 2021.007

Eric Matt, Colgate University

Enabling Unsupervised Learning in a Josephson Junction Neural Circuit

Neural networks are computing devices designed to mimic the architecture of the biological brain. Most existing implementations rely on supervised learning, where an external algorithm determines the weight of each individual synapse. In large enough networks this becomes computationally expensive. This project offers an alternative approach using superconducting circuitry to maximize biological realism and enable spike timing dependent, unsupervised learning. By using Josephson Junctions to create artificial analogs to the three major neural components: neurons, synapses, and axons, we are able to demonstrate five unique cases of unsupervised learning.

NASEC 2021.008

Fairuz Ishraque, Colgate University

Estimating Tracer Sources with Ensemble Data Assimilation: Tests in an Augmented Lorenz-96 Model with Tracer Advection

Characterizing the source and behavior of airborne contaminants is an important problem in air-quality analysis and fighting air pollution. Identifying the location and strength of the source of a potentially harmful pollutant is often necessary to take appropriate actions for mitigation. At the very least, tracer releases from such sources need to be modeled to predict the damages they might cause. However, given the chaotic nature of atmospheric circulation, modeling airborne tracers with accuracy is a challenging task. To explore this issue, a novel low-order dynamical system is implemented to investigate the capabilities of ensemble data assimilation to estimate tracer concentration and sources.

Our study coupled the low-order Lorenz-96 model with a Semi-Lagrangian scheme to advect model tracers on a one-dimensional periodic domain. We then assimilated high quality synthetic observations of a 'truth' trajectory using the ensemble adjustment Kalman Filter (EAKF) inside the Data Assimilation Research Testbed (DART). We were able to assimilate observations of Lorenz-96 state variables (here serving as a wind) and tracer concentrations. Assimilating only wind observations improved analyses for both wind and tracer concentrations, but more interestingly, assimilating only tracer concentration observations noticeably improved the analyses for wind. Assimilating both wind and tracer concentration observations resulted in the overall best estimates. Assimilation of wind and tracer concentration observations also enabled estimates of tracer source location and strength. We explored the impact of gradually lowering the quality and density of observations on estimates of source location and strength and also the best locations for observations to detect sources at given model grid points.

NASEC 2021.009

Haley Smith, East Carolina University

Woodchip Bioreactors in Saline Environments

There is a hypoxia crisis along the coasts of the United States which is caused by the growth of algal blooms due to excess nitrates from agricultural and industrial operations running off into these waters. Woodchip bioreactors are an ecological engineered technology primarily being used in the Midwest to remediate nitrate from agricultural runoff and drainage. The purpose of this study is to explore how effective woodchip bioreactors are at remediating nitrates from near coastal waters that experience varying levels of salinity to demonstrate their potential viability in reducing the impact that agricultural runoff has on eutrophication and hypoxia. The progression in this study so far has been designing and building a lab-scale experiment and determining how well the woodchip media perform at remediating nitrate from a freshwater source. Feeding the system with a mixture of reverse osmosis water, NO3-N at a concentration of 20 mg/L, and other micronutrients, the reactors achieved an average reduction of 44.7% of nitrate-N at a hydraulic retention time of 8 hours. To prepare for the introduction of salinity to the system, a micro-experiment was conducted to find the quantitative relationship between salinity and specific conductivity for Instant Ocean Sea salt. The equation for this relationship was determined to be salinity, ppt = (0.0007 × specific conductivity, µs/cm) – 1.0936 with an R2 value of 0.9985. The barrier that delayed testing nitrate removal upon introduction of high salinity water was determining an accepted analytical method to test nitrate concentration in high salinity waters; however, this barrier has been overcome and sampling and analysis were initiated on 10/15/2021.

NASEC 2021.010

Julie Nierwinski, Towson University

Differential Privacy of a Randomized Learning Algorithm

Differential privacy is a rapidly developing area of machine learning. Differential privacy is a property of an algorithm where the results derived from datasets that differ by a single sample are almost indistinguishable. Companies and agencies including the Census Bureau, Apple, and Google utilize differential privacy in their algorithms to gain statistical insight into a dataset of users, while preserving the individuals' privacy. I will discuss new connections between two notions of differential privacy.

NASEC 2021.011

Avery Schweitzer, Towson University

Private Machine Learning of Partition Classes

A randomized learning algorithm inputs a set of data samples, produces a probability distribution over a concept class, and selects a concept according to the distribution. The algorithm is differentially private if, for any two data samples differing by at most one element, the algorithm produces two nearly indistinguishable probability distributions. The learning algorithm is Probably Approximately Correct (PAC) if it selects a concept that has low error with high probability. It is known that a concept class admits a differentially privately PAC-learning algorithm if and only if it has finite Littlestone dimension. In our talk, we will compute the Littlestone dimension of the concept class dual to the class of cross-cutting families of equivalence relations on an ambient set. We will also examine the sample complexity of a differentially private PAC-learning algorithm on the dual class.

NASEC 2021.012

Kara Koopman, The University of Virginia

Design of a Diesel Fuel Evaporator

Heavy-duty road vehicles and container shipping vessels are likely to remain diesel fuel dependent for the foreseeable future. With increasing demand on supply chains and the shipping sector, diesel consumption is expected to increase emphasizing the need to minimize the impacts of its use on the environment. The diesel fuel evaporator outlined in this poster will be used to isolate the chemical effects of fuel composition on combustion products by eliminating fuel spray effects including atomization and mixing by constructing a diesel pre-vaporization system. The system will be used for premixed diesel flame studies using in-situ laser-based measurements including coherent anti-Stokes Raman scattering and laser induced incandescence to measure gas temperature, hydrocarbon species, and particulate formation throughout the reaction combustion zone. This poster outlines the design process of the diesel fuel evaporator and includes analysis of its control systems and effectiveness. Evaporator effectiveness was evaluated using distillation and Mie scattering testing. These preliminary tests show the evaporator was able to produce a fully vaporized fuel-air mixture under certain conditions; however, improvements to the control systems will be necessary before further testing.

NASEC 2021.013

Anna Konvicka, The Cooper Union for the Advancement of Science and Art

Standardizing Tumor Mutation Burden for use as a Cancer Biomarker

Tumor mutation burden (TMB) is a useful genomic biomarker for predicting the response of cancer patients to immunotherapy, but it has been shown to be responsive to external factors, in particular tumor tissue sample purity. In this research, we demonstrate through in-silico experiments that this metric corresponds to several other factors (tumor ploidy, sequencing depth, etc.) which are not directly related to mutation count and propose a novel corrective method.

NASEC 2021.014

Rebecca Henion, College of the Holy Cross

Sample Size Determination in Experimental Design

Basic inferential statistics focuses on interval estimates of population parameters and tests of hypotheses. Confidence intervals (CI) are computed from data derived from random sampling. They are mainly functions of the sample estimate of the parameter, an estimate of variability, critical values of the sampling distribution, and sample size (n). Using a CI, one can easily derive the relationship between the error of estimation (EE) and the sample size. For hypothesis tests, a similar relationship may be found between the effect size (ES), i.e., the difference between the null mean and alternate mean, and sample size. In this poster, we illustrate the relationship between EE and n, as well as ES and n. Results for one-sample and two-sample confidence intervals and hypothesis tests will be included under various experimental conditions. A comparison will be made between the standard normal and Student's t-distribution. We also will derive and include the results for a one-way ANOVA, as parameterized by the number of groups being compared.

NASEC 2021.015

Melody Khoriaty, Bowdoin College

How Weight, Frequency, And Speed Interact To Create An Underwater Bouncing Gait In Sea Stars

We have observed that at least five species of sea star have a periodic gait with vertical oscillations in position and horizontal oscillations in speed - a bouncing gait. This is similar to the vertical oscillations seen in walking gaits of legged land (such as people and robots) and underwater (such as crabs and octopi) locomotors. The kinematics of this bounce determines the gait – be it walking, running, or some other gait. This sea star bouncing gait is created through coordinated waves of their feet (podia) and corresponds with an increased speed relative to their slower crawling gait. Here we focus on the relationship between sea star size and the frequency and velocity with which they exhibit this behavior. Three species of sea star (Protoreaster nodosus, Asterias forbesi, Luidia clathrata) were filmed from two directions (bottom and side views) in recirculating seawater flow tanks. Subsequently, position and time data were extracted from these films using Tracker software; these data were processed using Mathematica to produce values of velocity and frequency (and other relevant parameters). We found that L. clathrata had the fastest gait and had the highest bouncing frequency, locomoting over five times faster than P. nodosus, the slowest species studied with the lowest frequency. Velocity was positively correlated with weight for A. forbesi and P. nodosus, but negatively correlated for L. clathrata. For all three species, frequency was negatively correlated with weight. Because speed = frequency * stride length, when frequency decreases with weight but speed does not there must be a compensatory increase in stride length. Both P. nodosus and L. clathrata had frequency scaling coefficients consistent with the inverted pendulum model.

NASEC 2021.016

Jackson Wray, The University of Virginia

On the Varying Tail-Beat Frequency in High-Density Fish School

Fish schooling has been studied thoroughly in order to understand their physical strengths and benefits. It has been proven that schooling creates a hydrodynamic benefit for individual fish in a school as well as providing protection from predators. In this study, numerical simulations utilizing an immersed-boundary-method-based incompressible Navier-Stokes flow solver are used to investigate the impact of undulation frequency on two-dimensional fish-like bodies swimming with carangiform locomotion in a high-density diamond-shaped school. Frequencies were selected to range from 0.46 to 1.11 Hz. This research analyzes the impact on individual fish performance as well as overall school average values by examining thrust coefficient, power coefficient, and propulsive efficiency. As the undulation frequency of the school is increased, the results come to a peak efficiency that the school can operate at. As the frequency continues to increase, the thrust and power consumption significantly increases while the average propulsive efficiency decreases due to the affected downstream momentum and wake structure of the school. The insights revealed from this study will contribute to a better understanding of physical mechanisms used by fish schools as well as providing new information to be used for bio-inspired underwater swarm robots.

NASEC 2021.017

Nelusha Dias, Rutgers University

Real-Time Machine Learning

The Real-Time Machine Learning project was designed with the intent of creating a program for recognizing and identifying people, as well as checking if the person is masked or not. The project involved working with algorithms and a Convolutional Neural Network (CNN) in Pytorch in order to run a facial recognition program on a NVIDIA Jetson Nano. The NVIDIA Jetson Nano enabled the use of a real-time camera feed and display screen. The program itself uses a CNN to differentiate masked and unmasked individuals. This allows the program to determine how to run the facial recognition, which is broken down into three parts. The program has a database of known people, a folder for unknown people, and a folder for masked people. If an unmasked person whose image is in the database appears before the camera, they are recognized, and their name is shown on the display screen near their face. If the person is not in the database, they are shown as unknown, along with the number of times they have appeared before the camera. The unknown person's image is saved with the number of appearances into the folder for unknown people. With masked individuals, regardless of whether they are known or not, their images are saved into the folder for masked people with a short list of names of people that could be under the mask. Using these segments of code, the program came together to determine if a person is masked or not, and who they are or may be.

NASEC 2021.018

MaryClare Martin, College of the Holy Cross

Human Context Recognition: A Controllable GAN Approach

Human activity recognition (HAR) is the use of sensor data to identify activities performed by a user. Due to its usefulness, HAR has received substantial research attention, but obtaining data for HAR is costly and difficult. As such, recent studies have used Generative Adversarial Networks (GANs) to create synthetic HAR data. However, these solutions are unable to generate personalized data that match the behavior of a user, limiting potential HAR applications since previous work has shown that personalized HAR models outperform generalized models. To address this, we propose a novel controllable GAN where user and activity attributes can be explicitly requested for generation under a single model. The GAN can learn these attributes independently and infer context pairs never seen during training, which is impossible for existing methods. We show that while our model is comparable to standard HAR GANs, its ability to consider user differences and generate novel context pairs outperforms these state-of-the-art GANs.

NASEC 2021.019

Marshall Mendoza, The Catholic University of America

Recovering Extreme Sport Safety Through Additive Osseointegration BreakaWAY Connector

With increasing advances in design and use of prosthetic devices, the Osseointegration procedure is providing amputees a more symbiotic relationship with their prosthesis. Osseointegration implants a biocompatible metal rod into the amputee's femur; As the bone heals, the femur grows around the device and the abutment portion of the device protrudes from the remaining portion of the amputee's limb. This process provides the individual with a more natural association to the artificial limb for better stability, functionality, and mobility. While this procedure has great advantages over the typical socket-wear prosthesis, there are limitations relating to connection security for activities outside of daily routine movements. For this reason, our research and proposed design seeks to develop an intermediary device between the osseointegrated rod and the leg prosthesis. The device will allow the amputee to participate in more strenuous activities (I.e. mountain biking, skiing, etc.) with a reduced concern for premature disconnection or a failure to disconnect resulting in structural damage to the remaining portion of the femur. A more responsive safe release device will afford amputees the opportunity to safely return to previous sporting activities.

NASEC 2021.020

Hunter Pigg, East Carolina University

Numerical Analysis of Blue Energy Harvesting Under Extreme Conditions for Ocean Water Desalination

Sea water desalination is a small but growing part of the global water industry. It is a very important process for meeting the increasing demand for freshwater. In the United States, the existing seawater reverse-osmosis (RO) market is at a capacity of 500,000 m3 per day. This translates to $65 million per year in electricity consumption. This process is highly energy intensive, but the use of renewable energy resources will help to eliminate the high cost of the process. Ocean energy is a promising source of renewable energy with an estimated potential of 337 GW worldwide. Reducing the cost of wave energy converters (WECs) is key for advancing the technology. One of the greatest identified cost reductions has been associated with the structure of the WEC. They must be designed to withstand the largest waves experienced during storms of magnitude equal to their design condition. In this research, two- and three-dimensional computational fluid dynamic (CFD) analyses are conducted to study the performance of a bottom-hinged oscillating wave surge converter (OWSC). This type of WEC is selected because its motion is suitable for direct pressurization of water for desalination. The CFD analysis utilizes the finite volume of fluid (VOF) code for unsteady simulations. Different WEC geometries are simulated at both full and experimental scales to allow for validation by experimental results obtained from a wave tank tests.

NASEC 2021.021

Upasana Ghosh, Rutgers University

Comparison of Cardiac Electrophysiological Characteristics with Programmed Electrical Stimulation in Mice

Programmed electrical stimulation (PES) involves pacing the heart via intra-cardiac electrodes to characterize cardiac electrophysiological properties. PES can be used to induce and analyze ventricular arrhythmias which could lead to possible diagnostic and therapeutic interventions to treat ventricular tachycardia (VT) and abnormal sinus rhythm. Several mouse models used in cardiopulmonary toxicology lack any characterization of their baseline cardiac electrophysiology (basic cycle length, pacing threshold, and arrhythmia inducibility) and autonomic modulation (heart rate variability). Thus, to aid in future toxicologic studies, we assessed cardiac conduction and arrhythmia inducibility in two genetic mouse models (and their wild-type controls) with presumed underlying cardiac susceptibility (Kvβ2 KO) and cardiopulmonary protection (ecSOD-TG) experimental groups.

A mini-burst (20 normal stimuli [S1]) PES protocol with 3-10 extra-stimuli (S2-S11) were used to induce ventricular arrhythmias in wild-type mice (C57BL/6J, n=3), pulmonary extracellular superoxide dismutase transgenic mice (eSOD-TG, n=2), voltage-gated potassium β2 wild-type and knockout mice (Kvβ2-WT, n=3; Kvβ2-KO, n=2). Intra-cardiac pacing was achieved by a 1.1F octa-polar catheter, inserted into the right external jugular vein and advanced into the right ventricle, which was connected to an external stimulus generator (STG3004). Surface ECG was recorded using Lead II configuration and data acquired and analyzed using LabChart Pro 8. Each protocol was repeated after isoprenaline (1.0 µg/g i.p.) infusion to assess arrhythmia inducibility under adrenergic activation.

The stimulation protocols were modified with different S1 cycle lengths based on the basic cycle lengths (CL=70-100ms) of each mouse strain. Kvβ2 KO mice differed noticeably in pacing threshold (PT, 30µA) from the three other mouse strains, including its own wild-type control (PT, 150-220µA). The mini-burst protocol to induce VAs increased average heart rate (HR) in all strains of mice concordant with incremental number of extra-stimuli from three to ten. Non-sustained ventricular tachycardia (≤1s) occurred after the PES protocol in all strains. However, the incidence of VT was predominant in ecSOD-TG mice, which also uniquely exhibited atrial flutter. Administration of isoprenaline, a sympathomimetic drug, enhanced susceptibility to ventricular arrhythmia induction as indicated by the occurrence of ventricular premature beats (single and couplets) and VT in all strains.

The mini-burst PES protocol is an effective tool to induce ventricular tachycardia and other forms of ventricular arrhythmias in multiple mouse strains. Contrary to our expectations, the results indicate that pulmonary-specific ecSOD over-expressing mice had a greater susceptibility to arrhythmia induction and the Kvβ2-KO mice required the lowest amplitude for stimulation indicating a better conduction mechanism. Future studies will further investigate the mechanisms underlying enhanced arrhythmia susceptibility and cardiac conduction in ecSOD-TG mice and Kvβ2-KO mice respectively.In this poster, we illustrate the relationship between EE and n, as well as ES and n. Results for one-sample and two-sample confidence intervals and hypothesis tests will be included under various experimental conditions. A comparison will be made between the standard normal and Student's t-distribution. We also will derive and include the results for a one-way ANOVA, as parameterized by the number of groups being compared.

NASEC 2021.022

Alicia Palmerin, Colgate University

OBSCURE: Determining the Likelihood of Exoplanetary System Configurations from Observational Catalogs

Over the past few decades, exoplanetary detections have grown substantially. With instruments like TESS, Kepler, and others, diverse detection methods are leading to more comprehensive discoveries. While these observations provide some glimpses into the environment of the exoplanetary system, some aspects of the system's characterization are left unexplored due to the limitations of detection techniques (such as the true mass and inclination w.r.t the observer). However, these gaps in our knowledge can be partially filled when we utilize our understanding of planetary orbits. For example, Petit et al and others have explored an analytical approach to limiting exoplanetary configurations via the use of a system's Angular Momentum Deficit (AMD). Within the AMD framework, one can include stability requirements quite easily which result in accurately determining the long-term stability of a system without the need for costly simulations. However, analytical approaches cannot fully encompass regions of where other factors cause a theoretically unstable system to become stable. In these regions, full numerical simulations are the only correct way forward. In order to be time efficient, secular approaches are the most efficient and accurate in systems of quasi-stability. For example, Hamers et al. has presented one such method which can take into account passing massive external perturbers as well as sub-orbital effects within his code, SECULARMULTIPLES.

NASEC 2021.023
Eric Dillon, Marshall University
Fine-grained Analysis of Gender Bias in Student Evaluations

The most widely applied method to evaluate a course instructor's performance is by collecting numerical and free-form textual responses from the students who took the course. Published research results from fields including depict biases in the student evaluations of instructors in both their ratings and comments. However, the research so far has not been directed at the fine-grained analysis of gender bias: the opinion (sentiments) of students towards qualitative metrics of their interaction with their instructors. This work-in-progress (WIP) proposes A) a methodology to mine teaching evaluations, and B) an open-source repository where outside researchers can use and investigate the data collected from this study.

NASEC 2021.024
Buduka Ogonor, University of Chicago
Crystal Structure Prediction via Deep Learning in Real Space HAADF STEM Imagestor

It is known that the electronic structure of materials can assist in the prediction of microscopic and macroscopic properties of those materials, and understanding these properties can mediate material discovery. However, solving for material structure from chemical identity and microscopy image is an arduous task involving computationally expensive first principles modeling and combinatorial calculations. As such, the development of a faster, general purpose structure prediction tool with artificial intelligence would be key in the material discovery workflow. This presentation discusses a proof of concept study that demonstrated that a deep neural network pretrained on everyday images (cats, dogs, cars, etc.) could be used to discriminate between the 7 crystal systems (monoclinic, cubic, etc.) in real space electron microscopy images. For model training, we employ the atomagined dataset, which comprises over 200,000 simulated real space high angular dark field scanning transmission electron microscopy images of materials. To investigate the efficacy of our structure classifying tool, we use the grad-CAM method from interpretable AI to identify the regions of image the model uses to its classifications.

NASEC 2021.025
Sreya Vangara, Massachusetts Institute of Technology
Permanent Magnet Mirror

Advances in permanent magnet technology may enable their usage as a simple and accessible option for fusion mirror configurations. Permanent magnets do not require power supplies or cryogenic cooling, and are conveniently adjustable, demountable, and low-cost. Attaining high magnetic field strengths is challenging, though, since the maximum remanent magnetization of the evaluated neodymium boron iron permanent magnets (NdFeB) is 1.4 Tesla. However, by implementing a judicious configuration, we are able to demonstrate a magnetic mirror with field maxima of 4 Tesla. Producing magnetic fields exceeding this strength would begin to demagnetize the permanent magnets at room temperature. The configuration is built from analytic optimized solutions, which can be utilized to generate mirror devices with different geometries and parameters. Possible applications of the theoretical configurations range from plasma confinement in stellarators to medical imaging devices, and will be discussed during the presentation.

NASEC 2021.026
Karter Seitz, College of the Holy Cross
Addressing the student loan crisis and expanding access to higher education

In addition to a traditional loan-based financial aid program, Purdue University offers an alternative form of financial aid called an Income Share Agreement (ISA). Under this alternative program, students receive funding for their college education in exchange for a percentage of their future income. Proponents highlight that this alternative tuition plan can allow students to get a college education without having to take on any debt, which helps in expanding access to higher education to those financially constrained. However, how does one's prior knowledge, or lack of knowledge in this case, impact their likelihood to participate in an ISA? In this project, I seek to answer three specific questions: (i) if an individual is exposed to an ISA across multiple periods and becomes more knowledgeable about the concept, does their gained knowledge change their likelihood to participate in an ISA; (ii) as individuals become more knowledgeable, is there a greater adverse selection problem; and (iii) are ISAs sustainable for colleges and universities? This environmentally toxic output. Wave energy has a high potential for use in desalination systems because of the immense energy potential it has and the associated environmental benefits. A wave energy converter (WEC) converts the motion of waves into usable energy. This project aims to develop a simulation of a WEC that powers both RO and supercritical desalination systems. The waves and their interactions with the WEC geometry are simulated using a boundary element method analysis software called WAMIT to analyze the hydrodynamic response. The resulting hydrodynamic diffraction data is then used to simulate the WEC's response to waves as a function of time for varying sea states and wavelengths using a MATLAB-based program called WEC-Sim. The RO and supercritical desalination systems will be modeled in MATLAB SIMULINK, where they will be coupled to WEC-Sim. This project aims to simulate an entire zero-waste wave to water desalination process to understand how much clean water can be produced through this method without harming the environment.

NASEC 2021.027
Titiksha Singh, University at Buffalo
Silica Aerogel for Energy Efficient Homes

The porous structure of aerogel is a result of how compounds known as surfactants react in water. Another important factor in the porous structure of aerogel is the drying process which allows the aerogel to maintain its structure after the initial reaction is done. This process is called supercritical drying which is very expensive to do on a large scale making it difficult to use in the commercial market. In order to reduce the production cost of aerogel in the lab we are using ambient drying process. We are doing ambient drying in an oven at a constant temperature and pressure. To ensure the thermal conductivity is kept at extremely low levels we examine how surfactants, organic compounds, and acids react in water. These aspects are examined in order to control the pore size of the aerogel. The pore size is vital towards making sure that the aerogel is lightweight and has low conductivity. The effects of these chemical are examined through SEM, TEM imaging. Reducing the cost of aerogel allows for it to be brought into the commercial market by using it as a replacement to drywall used residential homes. In order to do that we have to make sure that the mechanical and thermal properties of aerogel match or surpass drywall. In order to make sure that this aerogel works in high humidity conditions, the aerogel was made hydrophobic to deal with these conditions. Insulating fiber such as fiberglass insulation is being combined with our aerogel in order to improve mechanical and thermal properties of the aerogel. We examine how to combine fiberglass reacts if it used in the reaction in order to see if the fibers bond with the solid matrix during the reaction.

NASEC 2021.028
Lawrence He, Georgia Institute of Technology
Application of Neural Networks for Severity Risk Prediction in COVID-19 Patients

This project is focused on generating a data-driven approach for identifying patients at highest risk for severe COVID-19 complications. The goal is to apply a deep learning approach to generate a severity prediction for patients based on electronic health records (EHR) available at time of diagnosis. Using EHR data from Emory with a variety of significant clinical features ranging from age to medications and vital signs, we aim to train and optimize several state-of-art models for generating severity risk scores for patients diagnosed with COVID-19. We will then test the performance of each model based on available patient data. Our approach is to implement a neural network to generate patient risk scores. We have implemented the baseline classifier and preliminary results show a MCC of 0.44 and area under ROC of 0.865.

NASEC 2021.029
Gabriel Glosson, East Carolina University
Simulating a zero-waste wave to water desalination system

Current methods of producing clean water are not capable of meeting demands. One method of producing clean water is through a desalination process called reverse osmosis (RO), which uses a semi-permeable membrane that separates clean water from pressurized seawater. Traditional desalination systems produce brine which is harmful to the environment. Recent studies have been done on the potential for using supercritical water desalination as a means of using this brine to extract more clean water and eliminate

NASEC 2021.030
Mariam Adegbuyi, Towson University
Modelling Crimes With Stochastic Processes

Self-Exciting Poisson point processes are typically used in earthquake modelling to account for aftershocks, which are triggered from the initial occurrence of an earthquake. Following the work of Reinhart and Mohler, our premise is that the occurrence of crimes can be similarly modelled. That is, the occurrence of crimes can trigger the nearby occurrence of crimes shortly thereafter. We use publicly available crime data from Baltimore City, as well as the Expectation Maximization algorithm, to fit the parameters of a Self-Exciting Poisson point process model. After fitting, we can predict how likely crimes are to occur in a spatial region, and given that a crime occurs, the likelihood of a triggered crime occurring. We can then explore what the model tells us about the crime triggering mechanism on our data. We are actively pursuing ways to use our model beyond simply predicting crimes in Baltimore City. One of the possibilities that we wish to explore includes how the triggering mechanism varies from city to city, and the effect of the pandemic on the triggering of crimes.

NASEC 2021.031
Bryan Holguin Herrera, East Carolina University
Creating Unique Educational Experiences
in Marine Meteorology with Odyssey Extreme Education

Studying changes in the marine environment can be challenging. It requires collecting data over large areas, and over long periods of time, to identify trends. Odyssey Extreme Education seeks to alleviate this issue by providing a useful website that compiles the data collected by buoys launched in different parts of the world, and allowing a user to access all the data from one page. This also has educational applications as it provides a visualization that shows how the travel of a buoy correlates to temperature and pressure changes. Partnering with East Carolina University, Old Dominion University, and NOAA we seek to create a website that will enable collaboration between researchers, teachers, and students and provide unique educational experiences.

NASEC 2021.032
Jack LeGrow, University of Chicago
Clean and Efficient Graphene Stacking for the
Fabrication of Highly Anisotropic Thermal Conductors

Since its discovery in 2004, graphene—a two-dimensional sheet of carbon atoms in a repeating honeycomb lattice—has become an auspicious material for future material design as it distinguishes itself with unparalleled strength, thermal and electric conductivity, spin transport, and gas impermeability. Remarkably, graphene's composition of carbon and atomic slenderness render it biologically compatible and optically transparent, respectively. Despite graphene's desirable properties, however, the material has been notoriously difficult to leverage in application. The field of 2D materials science, concerned with the production and design of molecularly thin sheets such as graphene, has three essential phases in device fabrication: growth, transfer, and patterning. Graphene growth and patterning continues to be perfected in parallel with other atomically-thin materials like transition metal dichalcogenides (TMDs), but effective and reproducible techniques have become commonplace. The remaining limitation bottlenecking graphene from widescale integration in cutting-edge technology is a clean and repeatable method for transferring graphene from its growth copper substrate to a target. We propose a novel technique to stack paraffin-supported graphene while caged at the immiscible interface between an etching solution and fluorohexane. With this technique we hope to demonstrate unparalleled thermal anisotropy in stacked graphene and stacked graphene heterostructures.

NASEC 2021.033
Mel Gonzalez, Rutgers University
Using Computer Vision to Develop Deep Learning
Approaches to Monitor Mouse Motor Behaviors

Neural circuits embedded in the spinal cord modulate motor function. To gain an understanding in modeling the motor system, these spinal cord circuits can be investigated using animal behavior, coupled with computer vision applications. Here, we focus on developing deep learning approaches to monitor mouse motor behaviors during forced locomotion using DeepLabCut, a pose estimation software. Given the inability to use wearable devices to track mouse locomotor activity, DeepLabCut uses deep neural networks to train datasets for analysis, that effectively allow users to track and predict the position of anatomical landmarks from high-speed video recordings. To create a gait analysis profile, we track six positions on the right hindlimb, namely: the iliac crest, hip, knee, ankle, metatarsal phalangeal joint, and the toe. This gait analysis involves leg kinematics such as examining the joint angles during complete step cycles, and separately during the swing and stance phases. Additionally, this deep learning approach is coupled with optogenetic stimulation of spinal cord interneurons to activate and repress the cells of interest. Taken together, this comprehensive approach allows us to effectively monitor mouse motor behaviors and explore how joint angles are altered during activation of cells at different phases of the step cycle.

NASEC 2021.034
Brian Gonzalez Villa, United States Military Academy
Determining and Modeling Pattern-of-Life Using OSINT

Using an open-source social media data set and important dates, what can we determine about an individual's activity and pattern of life based on their online signature? Can we determine an individual's pattern of life for our teammates at home in an automated way? Where are we creating digital exhaust? What techniques could be applied to finding interesting behavior in adversaries? Through the connection of different organizations, their respective patterns-of-life, and their online footprint, we can identify unit behavior and apply modeling techniques to create a predictive system that uses pattern-of-life indicators to assume future movements of units.

NASEC 2021.035
Nick Ashby, United States Military Academy
Determining and Modeling Pattern-of-Life Using OSINT

The United States Army currently uses body mass index (BMI) and body fact percentage to create its height and weight standards. However, these standards may not be indicative of success in the Army's new physical assessment: the Army Combat Fitness Test (ACFT). This exploration offers a different approach, using a Styku 3D body scanner to measure circumferences at multiple locations on the body and unsupervised learning to assign each participant to a body shape cluster. The variance of physical performance within each of these clusters is calculated to determine the effectiveness of this technique.

NASEC 2021.036
Thorin Jean, United States Military Academy
NY State Thruway Wildlife Crossing

This study aims to determine the feasibility of a wildlife overpass or underpass on I-87. Wildlife crossings pass over or under highways to promote habitat connectivity and decrease the number of animal vehicle crashes every year. This promotes animal and driver safety and animal biodiversity. After evaluating the benefits of each structure it was determined that an overpass best met the needs of the client and the environment.

NASEC 2021.037
Deyan Ivanov, Nikola Vaptsarov Naval Academy
LNG as an alternative fuel. The future in clean energy for shipping

With the IMO 's tightening of SOx (sulfur oxides) regulations introduced in January 2020, most ocean-going vessels now use low-sulfur heavy oil. However, the utilization of low sulfur heavy oil doesn't change CO2 emissions, it's clear that the fuel is inadequate in achieving the IMO goal of reducing CO2 emissions by more than 40% in 2030 compared to 2008. For this reason, the introduction of LNG(Liquefied Natural Gas) -fueled vessels which don't use heavy oil is drawing attention in the long term. LNG is said to have a low environmental impact because it removes sulfur in the pre-liquefaction process, so it emits almost no Sulfur.

NASEC 2021.038
Dhyuti Gopalakrishna, United States Military Academy
Radar Image Style Transfer

The purpose of this research is to explore the capabilities of neural networks in order to create a model that enhances Synthetic Aperture Radar (SAR) images through neural style transfer. The model used a Convolutional Neural Network in order to compare two images – a SAR image and an electro-optical (EO) image taken by a satellite.

NASEC 2021.039
Hannah Ball, United States Military Academy
Modeling Laser Propagation

High energy lasers have been a subject of interest for the US military for several decades, posing a solution to many tactical and strategic problems involving engagements with physical targets. Military lasers therefore continue to be a highly researched topic. A wide variety of previous research has considered the propagation of high energy lasers through several media. This research considers the propagation of high energy laser beams with the goal of developing a comprehensive mathematical model for a laser aimed at target material. The underpinning mathematics are based on a combination of Maxwell's equations, the Mie solution, and paraxial approximations to Maxwell's equations as well as previously developed modeling solutions for individual conditions. To account for a wider range of variables and develop a more accurate model, sub-equations are incorporated. Experiments using lasers are performed as a basis for the analysis of beam characteristics and their effects.

NASEC 2021.040
Liz Cheatham, Jeffrey Meyer & John Feliz, United States Coast Guard Academy
The Application of Natural Language Processing on Coast Guard Data Sets

We explore and develop a basic understanding of the field of Natural Language Processing (NLP). We will begin by explaining what NLP is and some of the goals in its implementation, grouping different areas of focus within NLP and how it fits into the realm of Artificial Intelligence. Then we investigate some everyday examples of NLP and some of the basic theories behind some of these implementations and methods. Following this broad overview, we begin to take a closer look at the application of NLP within the Coast Guard. We discuss the data available to the Coast Guard, identify valuable applications, and view specific basic examples of utilizing NLP to gain insight. We will conclude by discussing other ideas for applications of NLP within the Coast Guard.

NASEC 2021.041
Madison McGovern, United States Military Academy
Data Fusion

The volume of raw data being collected is growing at an exponential rate. Humans cannot process and analyze this volume of data in a quick, efficient way for operators to use. Right now, the process of collecting data to create actionable analysis is happening at an extreme delay as data is being collected, sent to a headquarters office where it is analyzed and finally sent back to operators. We plan to devise a plug-in for the ATAK system where data is collected and analyzed in real time so that the delay in collecting data and using data is virtually eliminated. This will allow operators to make informed decisions in a timely manner as they are no longer waiting for data to be processed and analyzed.

NASEC 2021.042
Rasa Kirvelevicius, United States Coast Guard Academy
Ice Accumulation on Mesh Surfaces From The SCANDIES ROSE Incident: A Directed Study

Fishing and crabbing vessel SCANDIES ROSE sank off the coast of Kodiak on December 31, 2019, killing seven crew members. She capsized due to topside icing in a heavy winter storm, whereas vessels operating in the Bearing Sea usually have proper stability calculations to withstand such conditions. It was found that the Code of Federal Regulations lacks guidance for calculating icing on mesh surfaces such as nets and crab pots. Members in this directed study conducted research on marine icing phenomena and related regulations, unpacked the SCANDIES ROSE's icing conditions from analyzing weather and sea conditions leading up to the capsize, followed marine investigation hearings, remodeled the SCANDIES ROSE's hull and outfitting using computer model software, and conducted an icing experiment on constructed model crab pots. Currently, directed study members are digitally modeling the SCANDIES ROSE's sea spray ice accumulation pattern which led to her capsize.

NASEC 2021.043
Anna Vinnedge, United States Military Academy
DNA Data Storage and Cryptography

Recent advances in the fields of chemical engineering, computer science, and mathematics have opened up a new means of data storage using DNA. An important component of data storage and computing is the ability to encrypt and decrypt data using cryptography which will be able to protect and secure the data. Cryptographic algorithms will appear and act differently for data stored on DNA due to the unique structure of the molecule and the differing formats of standard data storage versus DNA storage. In this poster we have reviewed and analyzed different encryption and decryption methods, to include both symmetric and asymmetric ciphers, and how they could be applied to DNA storage. We examine the structure of DNA as it relates to binary and XOR operations as well as how DNA cryptography may be more or less secure using some standard ciphers. We also explore some more complex cryptographic algorithms to determine their potential for developing practical and perfectly secure data.

NASEC 2021.044

Alma Cooper, United States Military Academy

Sensing Explosives with Quantum Dots

A new method has been developed to detect the chemical vapors of explosive compounds by leveraging the electronic and optical properties of quantum dots (QDs). Cadmium selenide (CdSe) QDs were added to polyvinyl chloride (PVC) polymers and electrospun into fibers. The QD-fiber composite was then challenged to the headspace vapors of known explosives such as 2,5-dinitrotoluene (DNT), 1,3,5-trinitro-1,3,5-triazine (RDX), triacetone triperoxide (TATP), and 2,4,6-trinitrotoluene (TNT). Upon exposure to these explosive vapors, fluorescence measurements were observed to change with time of exposure and concentration. Explosives could be detected with a simple UV flashlight or wearable device and thus not require significant training or expensive and bulky testing equipment. This technology is primarily applicable to first responders, military and homeland security professionals, and for passive detection devices in high traffic areas such as airports. Further applications of this technology could be applied to nerve agents, illicit drugs, or any volatile chemical of interest upon characterization of the distinct chemical functional groups. Testing conditions and repeated experiments have thus far demonstrated this application to be robust and suitable for field-operable conditions where low limits of detection are necessary.

NASEC 2021.045

Alyssa Burns, United States Coast Guard Academy

The First Steps in Developing a Publicly Available Geospatial Database of U.S. Aids to Navigation

The Geospatial Data Act was implemented in 2018 to facilitate sharing geospatial data across federal agencies and with the public. To comply, the U.S. Coast Guard is exploring the feasibility of designing and managing a publicly available Geospatial database containing all Aids to Navigation (ATON). ATON provide for the safe navigation of waterways, and they are dynamic in many aspects. For example, geographic position of aids may change over time, some are seasonal, others are permanent, or some may be removed altogether, to list a few. The Coast Guard services ATON frequently and regularly updates the information in the Integrated Aids to Navigation Information System. The information is provided annually to mariners in the Light List and weekly in a Local Notice to Mariners, both of which are pdf/text format and not easily integrated into GIS. A publicly available geospatial dataset would be a more useful way to publish the data so that mariners can visualize ATON on shipboard displays along with current Light List data, enhancing navigational safety in coastal waterways. This study explores the first steps in developing such a geospatial database from Coast Guard datasets and comparing it to pre-existing, published data from the National Oceanic and Atmospheric Administration (NOAA). The two datasets, which should be identical, contained systematic discrepancies in naming and geographic position which pose challenges for end users. This project works to understand the scope of the discrepancies, identify potential sources of error, and classify the ones which require remedy. This project focuses on ATON in the Chesapeake Bay, but the methodology will be repeatable for all Coast Guard areas of responsibility.

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