Virginia Space Grant Consortium
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Abstracts are listed in alphabetical order by presenter's last name.
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Undergraduate Research Fellows

Room 4:

AN EXPLORATORY LITERATURE REVIEW OF MICROGRAVITY INDUCED PERIPHERAL NERVE DAMAGE AND POTENTIAL NEURPROTECTANTS USING CONCEPTUAL RESEARCH

Naomi Carter, Hampton University

A plethora of research studies have correlated changes in the gravitational vector with neuronal adaptation. Prolonged exposure to microgravity has been shown to induce physiological changes including depolarized afferent and efferent nerves, increased membrane fluidity and reduced nerve conduction velocities, all of which contribute to downstream consequences in the musculoskeletal system. Current methods of astronaut preparation lack sufficient modeling of microgravity and investigating additional treatments that mediate symptoms of microgravity induced peripheral nerve injury (MIPNI) will help astronauts adjust during long duration space missions. A thorough literature review on MIPNI was conducted using the PubMed and Hampton University William R. and Norman B. Harvey Library Databases. The results were indicative of a significant gap in the research literature in regards to the role of immune activation, diet and altered vasculature in MIPNI pathophysiology. Notwithstanding, oxidative stress and decreased membrane viscosity were identified as primary determinants in MIPNI progression. Oral cholesterol and antioxidants are thoroughly discussed as possible treatments which may mediate decreased membrane viscosity and apoptosis associated with MIPNI.

IMAGING THE ELECTRONIC QUENCHING DYNAMICS OF NITRIC OXIDE WITH MOLECULAR COLLISIONAL PARTNERS

David Hood, William & Mary

Nitric oxide (NO) radicals are common reactive intermediates and byproducts of incomplete combustion of fossil fuels, are present in the atmosphere and interstellar medium, and are an important contributor to urban smog. Using high-level theoretical calculations, I investigated the probability that NO would be electronically quenched from its excited state via collisions with H2 and N2. For H2, we found that all interactions were repulsive with no quenching predicted. However, collisions with N2 showed that for nitrogen-first orientations, NO underwent electronic quenching with the lowest barrier to interaction at 111 degrees.

CRATERS AS PASSIVE PROBES OF ICE SHELL STRUCTURE AND TRANSPORT PROCESSES ON OCEAN WORLDS

Mikayla Huffman, William & Mary

Europa is one of the most likely locations in our solar system to house extraterrestrial life. Life is more likely to exist on Europa if a plumbing system allows for the mixing of biologically useful components from the highly irradiated ice shell surface with the more habitable regions in its subsurface ocean. We performed numerical modeling of impact craters on a Europa-like body in iSALE to investigate the morphological effects of embedded low viscosity layers (LVLs) at varying depths and with different viscosities. Our work indicates that both crater radius and crater depth are affected by the depth and viscosity of LVLs. We specifically found that a LVL embedded at a depth of 5 km below the surface yields maximum overlying crater morphology variation based on the alteration of LVL viscosity. These findings have ramifications for the Europa Clipper mission and for the detection of biosignatures in the subsurface seas of icy satellites.

SOLID ROCKET GRAIN MANUFACTURING VIA ADDITIVE MANUFACTURING

Kieran Koch, Virginia Tech

Additive Manufacturing (AM) can be used to create novel propellant grain geometries that are otherwise extremely difficult or impossible to produce with traditional grain casting techniques. Using AM will also significantly decrease the time required to fabricate the propellant grain. The goal of this research project was to demonstrate the capability to reliably print propellant geometries that contain a significant particle loading (50 volume percentage) of glass beads to simulate fuel and oxidizer in the material formulation while maintaining sufficient structural integrity. Ultraviolet-Assisted Direct Ink Write Additive Manufacturing (UV-DIW) was used to polymerize the deposited material and solidify it in place. Through this research project, it is clear that AM is capable of reliably printing solid rocket grains with a significant particle loading percentage of both glass beads and aluminum beads.

MODELING COASTAL WATER CLARITY USING LANDSAT-8 AND SENTINEL-2

Sarah Lang, University of Virginia

Understanding and attributing changes to water quality is essential to the study and management of coastal ecosystems and functions they sustain. However, measuring water clarity, a key aspect of water quality, is challenging because it varies greatly over space and time due to natural and anthropogenic processes. Coupling long-term in situ observations with estimates from satellite algorithms could provide a more complete understanding of coastal water clarity changes and its drivers. We created a remote sensing product by coupling Landsat-8 and Sentinel-2 reflectance data with water clarity measurements at 7 sites over 8 years in a shallow turbid coastal lagoon system in Virginia, USA. Our satellite-based model explained 29% of the variation in in situ water clarity, and an out-of-sample validation showed that the model accurately represented interannual variability. Our product increases the spatiotemporal scope of in situ water clarity data and improves estimates from bio-optical algorithms that overpredicted water clarity. Our results demonstrate the ability of high-resolution satellite imagery to improve

estimates of coastal water clarity and highlight the need to further improve and calibrate ocean color algorithms for complex water bodies.

A BUILT-IN PRIOR PROBABILITIES APPROACH FOR GENE REGULATORY NETWORK INFERENCE

Sean Leonard, Old Dominion University

Biological threats have become relevant in the last year since the onset of COVID19. These threats are addressed by finding the necessary mechanisms of the human body to affect them through external methods: vaccines and drugs, among others. The tools needed to divulge the necessary biological mechanisms are at the forefront of the current study in bioinformatics. Within this broad field, genomics and its effects make up a critical part. Genomics is a field encompassing the studies of an organism's source code, the genome. The genome is a library of all the biological instructions, genes, which make up the form and function of an organism. A core part of genomics is within gene regulatory networks (GRNs). A GRN is a network of genes and the genes or other factors regulating them. Through GRNs, the underlying details of biological mechanisms governed by the genome can be revealed. The underlying details of how that cell operates will be revealed by deriving the GRN of a cell, a biological manufacturing center. GRNs can currently be derived from the information found in cells through machine learning and probabilistic graphical models. The current methods are imperfect and do not factor in supplementary genetic data. Given the addition of the supplementary data, a prior probability can be derived to augment the existing probability of a regulatory link produced by the current machine learning approaches. The proposed work plans to improve upon existing machine learning approaches to derive a closer-to-ground-truth GRN from an arbitrary genetic dataset. With the addition of the supplementary data, we would expect to see a decrease in the number of false positives in a GRN. In addition, the investigation of the existing tools designed to explore the products of these genes will further enable improvements to streamline the analytical pipelines. By pairing both the instructions and their later effects on the human body, we hope to find improvements for current and future responses to biological threats.

SENSING IN COLLABORATIVE ASSEMBLY WITH UNCERTAINTY

Devin McCulley, Virginia Tech

Automation in robotics needs a large amount of data which is gathered by sensors and data acquisition. This project intended to update the Mobile Assembly Robotic Collaborators (MARC) in the FASER lab to incorporate more sensors and a robust user interface. The use and general design of the prototype is described, followed by the execution and results. The design was successful, and most components were tested but only a few were fully integrated into the MARC. Impact from the global pandemic led to slower than expected progress but more emphasis was put on the user interface instead. This leaves a lot of low-level code to be written and tested before there is an autonomous ready MARC.

SUPER-RESOLUTION OF GOES IMAGERY FOR NEAR REAL TIME HIGH RESOLUTION IMAGERY

James Mullen, Virginia Tech

Remote sensing continues to gain relevance in modern society in part due to the development of new image processing methods and imagery platforms. The rise of convolutional neural networks (CNNs) for processing imagery has coincided with an increase in publicly available remote sensing imagery, expanding the envelope of possibility when processing satellite imagery. For many use cases, it is desirable to have remote sensing imagery with high temporal and spatial resolution. The temporal resolution of GOES imagery at 15 minutes is unmatched in other publicly available products, but GOES's spatial resolution of 2 km per pixel is too coarse for many use cases. Conversely, VIIRS-I imagery has the high resolution needed for many applications, but the temporal resolution limits time-sensitive applications. Our contribution combines two disparate areas of research by applying state-of-the-art CNN-based super-resolution techniques to GOES imagery, while utilizing high-resolution VIIRS-I imagery as ground truth, bringing its effective spatial resolution down to sub-kilometer pixels. We attempt this super-resolution using both an autoencoder-based architecture of our own creation and the Very Deep Super-Resolution network \cite{kim2016accurate} (VDSR). Both our model and the VDSR provide an improvement in the peak signal-to-noise ratio over the original imagery of 1.37 and 1.20 dB, respectively.

EFFECT OF MICROGRAVITY ON NEUROMUSCULAR SYSTEMS DURING PERIODS OF CRITICAL DEVELOPMENT

Leah Patek, William & Mary

The ability of the human race to venture beyond our home planet requires many delicate systems to function under extreme conditions, yet perhaps the most delicate system of all is the human body. One of the greatest strains of long-term space travel lies in the absence of gravitational force acting upon the body, which is well known to have consequences specifically on the neuromuscular system. The purpose of our experiment was to identify the consequence of long-term non-use on both the ability of postural muscles to produce a forceful contraction, and the efficiency of the nervous system to achieve muscle contraction via electrochemical stimulation. More specifically, we are investigating whether developing neuromuscular systems face greater consequences of an extended period of muscle unloading compared to fully developed neuromuscular systems. The experimental results confirm that not only does neuromuscular function suffer following long-term periods of non-use, but it confirms that the loss of neuromuscular function is far more prevalent for neuromuscular systems undergoing growth development compared to those that are already developed.

INVESTIGATING MATERIALS PROCESSING CHALLENGES FOR ULTRA-HIGH TEMPERATURE CERAMICS

Dominic Pinnisi, University of Virginia

Ultra-high temperature hypersonic components require complex geometries, but severe limitations are placed on the geometries that can be produced by current ultra-high temperature ceramic (UHTC) processing methods. Colloidal processing (CP) followed

by pressureless sintering has produced near-net shaped UHTC components, but the oxidation behavior of these components has yet to be compared to that of other state-of-the-art UHTC processing methods. This work is focused on providing a comparison between the oxidation behavior of zirconium diboride specimens processed via CP, spark plasma sintering (SPS), and a combination of the two processes. Sintering aids such as carbon black and boron carbide were also incorporated in this study. Sintered samples were oxidized in air at 1500°C for durations of 5 min., 15 min., 30 min., and 60 min. Specific weight gain and oxide thickness were used as metrics for oxidation resistance. The findings of this study show that the combination of CP and pressureless sintering produces specimens with the most favorable oxidation resistance out of the fabrication methods employed.

THE CONSTRUCTION AND DEVELOPMENT OF AN NFT SYSTEM FOR MUSHROOM CULTIVATION IN SPACE: DECREASING VOIDS IN LITERATURE AND DEMONSTRATING TECHNOLOGY

Abigail Re, Virginia Tech

The purpose of this study is to develop and demonstrate the use of a Nutrient Film Technique (NFT) system for use in microgravity related oyster mushroom cultivation research at the Kennedy Space Center. The constructed NFT system was tested against an Ebb/Flow and Commercial Off the Shelf (COTS) mushroom cultivation kit. The Ebb/Flow system produced the highest count of mushrooms, while the NFT system produced the total highest biomass by weight. Given the variety in fruit shape and size, conclusions were based off weight rather than count. These results rejected the hypothesis stating that the Ebb/Flow system would produce more fruit. As predicted however, the NFT system induced the growth of a possibly harmful and unappetizing biofilm. The mushrooms grown in the NFT system also appeared soggy, encouraging a re-run of the tests as well as a redefinition of “edible-biomass.” Given the inconclusive results and need for future research it is difficult to determine which system performed “better”. Still, the results obtained from this study alone support use of the NFT system in the KSC Space Crop Production Laboratory by NASA scientists in microgravity mushroom cultivation ground tests.

BOUNDS ON NUCLEAR MATTER EQUATION OF STATE USING GRAVITATIONAL WAVE AND X-RAY OBSERVATIONS

Josef Zimmerman, University of Virginia

The nuclear equation of state (EoS) remains unknown at present. Properties of neutron stars (NSs) such as radius and tidal deformability are strongly correlated with the EoS, providing an opportunity to study nuclear matter through observations of NSs. We construct a population of EoSs by randomly sampling a multidimensional Taylor expansion, then constructing correlation distributions between the nuclear parameter Ksym, radius R, and tidal deformability Lambda. Using NICER measurements of R from PSR J0030+0451 and LIGO measurements of Λ from GW170817and LIGO measurements of Λ, we develop a statistical method to place bounds on Ksym. Work is ongoing to refine the statistical procedures to produce reliable constraints on the EoS.