Oklahoma State University
Mechanical and Aerospace Engineering

5th Annual OSU MAE
Graduate Research Symposium

Where: Student Union

When: March 24, 2023
7:45 AM to 5:00 PM
(Come and go event)

- **Graduate student talks**
- **Graduate student posters**
- **Undergraduate student posters**

Symposium Schedule

@GSC_MAE

MAE GSC OKSTATE

ORGANIZERS

MAE Graduate Activities Committee

Dr. Arvind Santhanakrishnan (Chair)

Dr. Rushikesh Kamalapurkar

Dr. Christian Bach

Dr. Craig Bradshaw

Dr. James Manimala

MAE Graduate Student Council

Amjid Khan
(President)

Rohit Vuppala
(Vice President)

Kevin Bhar
(Secretary)

Leila Rezaei
(Treasurer)

MAE Staff

Dr. Charlotte Fore

Holly Scott

Event Schedule

7:30 - 8:00	Attendee Check-in & Breakfast (room 265 – Ballroom)
7:50 – 8:00	Welcome Remarks by Chair of MAE Graduate Activities Committee (GAC), Prof. Arvind Santhanakrishnan (room 265 – Ballroom)
8:00 - 8:45	**Plenary Lecture** (room 265 – Ballroom) *Breaking boundaries: Why interdisciplinary research is key for tackling grand challenges* **Dr. Romit Maulik** Assistant Professor, Department of Information Science & Technology Pennsylvania State University
9:00 - 10:30	**Graduate Student Talks: Session 1** *Room: 270 – French Lounge*
9:00 - 9:15	**Md Asif Arefeen**, *Optimal Control of Powered Knee Exoskeleton to Assist Human Lifting*
9:15 - 9:30	**Md Arif Billah**, *Implicit Information Transfer via Streaker Bees in a Bio-Inspired Visual Feedback Swarm Framework*
9:30 - 9:45	**Mitchell Ford**, *Scalability of bio-propulsion using metachronal paddling*
9:45 - 10:00	**Sandra Vinnikova**, *Mechanics of nanomeshes for flexible and stretchable bio-sensors*
10:00 - 10:15	**Zach Yap**, *Solar balloons for Stratospheric observations*
10:15 - 10:30	**Asma Tabassum**, *Towards Wind Aware Navigation and Control for Safe Urban Operation of Small Unmanned Aircraft System: Autonomous and Human-Centric Approach*
9:00 - 10:30	**Graduate Student Talks: Session 2** *Room: 280 – Sequoyah Room*
9:00 - 9:15	**Ishriak Ahmed**, *High speed experimental and system identification tools for understanding swarming insect flight*
9:15 - 9:30	**Leila Rezaei**, *Modeling Nematic Liquid Crystal Elastomers in Compression*
9:30 - 9:45	**Kerrick Ray**, *Experimental Observations of the Boundary Layer and Movement in Varying Topography with Unmanned Systems*

9:45 - 10:00	**Muzaffar Qureshi**, *Fast Trajectory Optimization: A Comparative Study*
10:00 - 10:15	**Chris Scott**, *Holographic diagnostics for scramjet engine fuel injection*
10:15 - 10:30	**Joel Quarnstrom**, *Design of a Novel Bio-Inspired Inchworm Robot using Helical Actuators*

10:30-12:00 **Graduate Student Posters: Session 1 & Coffee Break**
Room 265 – Ballroom

Tanner Price, *Hybrid Rocket Test Stand Design and Evaluation of Nozzle Sizes on Hybrid Rocket Engine Performance*

Nissrine Aziz, *Rheological and viscoelastic properties of liquid crystal elastomers during UV curing*

Shahbaz P. Qadri Syed, *Parameterized input inference for approximate stochastic optimal control*

Daniel Gassen, *This Sucks!: Advancement in Noninvasive Hormone Monitoring of Dolphins Using UAS Sample Collection Device*

Ashraf Kassem, *Physics-Guided Multi-fidelity Learning for Characterization of Blunt-Body Dynamic Stability*

Mehdi Yadipour, *Insect-inspired Visually-guided Decentralized Swarming*

Soumya Mandal, *Fabrication of multimetallic NiCoCr nanoparticles via pulsed laser-induced dewetting of alloyed thin films*

Masoud S. Sakha, *Optimal Control of Multi-Mode Switched System*

Nicholas Nowak, *Yarn Pull-Out as a Mechanism of Ballistic Performance Enhancement in Silica Nanoparticle-Treated Kevlar (SNK) Fabric*

Zachary Morrison, *Dynamic Mode Decomposition of Discrete-time Dynamical Systems under Feedback Control using Discrete-time Control Liouville Operators*

Pouria Moghimi, *Modelling of Underground Thermal Energy Storage Tanks for HVAC Applications*

Abby Haddox, *A Smart Skin to Treat and Prevent Pressure Ulcers*

	Erick Pepek, *Recyclable Polymers to improve Sustainability of Additive Manufacturing*
12:00 - 13:00	**Lunch** (*room 265 – Ballroom*)
13:00 - 14:30	**Graduate Student Talks: Session 3** *Room: 270 – French Lounge*
13:00 - 13:15	**Sanzida Hossain**, *Cooperative driving between human-driven and autonomous vehicles considering stochasticity in human driving behavior*
13:15 - 13:30	**Furkan Oz**, *Quantum PDE Solver with Chebyshev Points*
13:30 - 13:45	**Michael Sallaz**, *The Efficacy of Utilizing SolidWorks Finite Element Analysis for Design of Composite I-Beam Wing Spars in UAVs*
13:45 - 14:00	**Jared Town**, *Nonuniqueness and Convergence to Equivalent Solutions in Observer-based Inverse Reinforcement Learning*
14:00 - 14:15	**Jacqueline Esimike**, *Interaction of cough-generated exhalation flow with gasper jets in airliner cabins*
14:15 - 14:30	**Ujjval Patel**, *PLUS - PowerLine Unmanned Surfer: Dynamic and Tracking*
13:00 - 14:30	**Graduate Student Talks: Session 4** *Room: 280 – Sequoyah Room*
13:00 - 13:15	**Joshua Melvin**, *Integration of a Turboprop Replacement for a Piston Engine Driven General-Aviation Aircraft for Ground Turboelectric Research*
13:15 - 13:30	**Achyuth Thumbalam Guthai**, *Use of Full-Field Strain Measurements to Determine Mechanical Properties of Shale Under Repeated Cyclic Loading*
13:30 - 13:45	**Moad Abudia**, *System Identification Using Operator Theory With Eigenfunction Validation*
13:45 - 14:00	**Nastaran Arzamani**, *Stories that Have Not Been Heard: Using Text Mining to Analyze Aviation Accident Reports*
14:00 - 14:15	**Emalee Hough**, *High altitude observations with solar balloons*
14:15 - 14:30	**Abhishek Tikar**, *Spark Plasma Sintering of Al0.5CoCrFeNi2 High Entropy Super Alloy and Composite*

14:30-16:00

Graduate Student Posters: Session 2 & Coffee Break
Room 265 – Ballroom

Khaled I. Alghamdi, *Feasibility Study for a Residential A/C System Integrating Thermal Energy Storage for Load Shifting Using a Novel Three-Fluid Heat Exchange*

Braydon Revard, *Experimentation and Validation of UAS Based Wind Sensors for Urban Applications*

Md Raqibul Hasan Prince, *Binary Variables based Weight Minimization of Lightweight Manufacturable Composite Laminated Structures*

Bipin Kafle, *Gravitational effects on the wettability of microporous hydrophobic tubular surfaces*

Kevin Bhar, *Asynchronous Local Computation in Decentralized Bayesian Learning*

Nahid Uzzaman, *Predicting dynamic covariances of the label even when the inputs are uncertain using variational Wishart processes*

Tochukwu Elijah Ogri, *Joint State-Parameter Estimation for Adaptive Optimal Trajectory Tracking in Nonlinear Systems*

Bryce Randall, *Stability and control analysis using CFD for low aspect ratio low Reynolds number aircraft*

Shafi Al Salman Romeo, *Machine Learning Applications on Predicting Turbulence Closure Term*

Peter Ramsdale, *The Development of Testing Criteria and Methods for the Evaluation of a Counter Unmanned Aerial System Platform as a Viable System*

Patrick Williams, *Orbital Debris Encounters Analysis about ISS Orbit*

Mohammed Abir Mahdi, *Experimental and numerical analysis of lattice structures using homogenization approaches*

Rohit K. S. S. Vuppala, *Machine Learning based Reduced Order Modeling for wind-field prediction in urban spaces for Unmanned Aerial Systems*

16:00 - 16:45	**Undergraduate Student Posters** *Room 265 – Ballroom* **Sam Glenn**, *Morphological characterization of wing shapes of tiny insects* **Tuyen Nguyen**, *Dynamic Stability Analysis of the Orion Capsule at Transonic Speed* **Austin Rouser**, *An experimental evaluation of leading-edge surface roughness effects on propeller performance* **Mason Biliske**, *Aluminum-Infused PLA for Hybrid Rocket Fuel* **Peyton Pierson**, *Blunt re-entry vehicle Reinforcement Learning Model with adaptive mesh refinement to reduce computational load*

PLENARY LECTURE

Dr. Romit Maulik

Assistant Professor, Department of Information Science & Technology

Pennsylvania State University

Breaking boundaries: Why interdisciplinary research is key for tackling grand challenges

Student Union Ballroom (room 265), 8:00 AM – 8:45 AM

Abstract: In today's hyper-connected research landscape, a regular exchange of technical expertise across domains is crucial for rapid development of solutions to grand challenges. This talk will expand on this philosophy by recapping the speaker's journey as an apprentice through different departments (Aerospace Engineering, Leadership Computing, Mathematics and Computer Science), ultimately culminating in how this approach was instrumental in constructing an independent research program. We will also discuss the importance of "grand challenge" questions as compasses to direct the long-term efforts of a research program and how asking the right question is frequently the most difficult, and valuable part, of a new project.

Biography: Dr. Romit Maulik is an incoming Assistant Professor in the Department of Information Science and Technology at Pennsylvania State University. In addition, he is, and will continue to remain, a Staff Scientist at Argonne National Laboratory in the Mathematics and Computer Science Division. He was previously the Margaret Butler Postdoctoral Fellow at Argonne, after obtaining a PhD in Mechanical and Aerospace Engineering at Oklahoma State University with Dr. Omer San. His research interests lie at the intersection of data science, applied mathematics, and high-performance computing. Learn more at: https://romit-maulik.github.io/.

Graduate Student Talks: Session 1

Md. Asif Arefeen

Advisor: Dr. Yujiang Xiang

Optimal Control of Powered Knee Exoskeleton to Assist Human Lifting

Room 270 – French Lounge, 9:00 AM – 9:15 AM

Abstract: Exoskeletons are incredible devices for improving human strength, reducing fatigue, and restoring impaired mobility. The control of powered exoskeletons, on the other hand, is still a challenge. This study uses a two-dimensional (2D) human skeletal model with powered knee exoskeletons to predict the optimal lifting motion and assistive torque using an inverse dynamics optimization formulation. In addition, the electromechanical dynamics of the exoskeleton DC motor are modeled in the lifting optimization formulation. The design variables are human joint angle profiles and exoskeleton motor current profiles. Furthermore, the optimal exoskeleton torque is implemented through a two-phase control strategy in real time to provide optimal assistance in lifting. Experimental validations of the optimal control with 6 Nm and 16 Nm maximum assistive torque are presented. It is observed that the 16 Nm maximum optimal assistance of the exoskeletons helps to reduce knee extensor and flexor muscle, and spine muscle activations significantly compared to lifting without the exoskeletons. Overall, the experimental results demonstrate that the proposed lifting optimization formulation and the control strategy are promising for powered knee exoskeletons to reduce human injury for lifting tasks.

Md. Arif Billah

Advisor: Dr. Imraan Faruque

Implicit Information Transfer via Streaker Bees in a Bio-Inspired Visual Feedback Swarm Framework

Room 270 – French Lounge, 9:15 AM – 9:30 AM

Abstract: Engineering models of in-flight sensing and feedback mechanisms of insects in multi-agent flight do not always include a mechanism to direct the swarm. One biologically motivated hypothesis for aerial swarm direction information transfer is the presence of high speed, informed bees termed “streaker" bees, whose role has been recorded guiding other uninformed bees to new nesting sites. This paper implements a bio-inspired multi-agent visual feedback system based on an engineering model of optic flow response and studies the response of a swarm to a minority of streaker agents on fixed trajectories. The performance of the system is evaluated in a multi-agent kinematic simulation. The agents are initialized to random initial configurations and the asymptotic swarm heading is found with and without streaker bees. The results indicate the streaker agents can successfully change the trajectories of the swarm agents towards the streaker agents' trajectories, as quantified by average group orientation shown to change significantly in presence of the streaker agents. These results suggest that bio-inspired feedback models such as wide field integration can incorporate the biological effect of streaker bees in guiding the swarm towards a desired direction and in swarm cohesion.

Mitchell Ford

Advisor: Dr. Arvind Santhanakrishnan

Scalability of bio-propulsion using metachronal paddling

Room 270 – French Lounge, 9:30 AM – 9:45 AM

Abstract: Metachronal paddling is a form of drag-based locomotion used by many aquatic organisms of sizes varying on the orders of 0.01 mm to 100 mm. Multiple appendages are sequentially stroked starting from the back and progressing to the front of the animal, generating a metachronal wave in the same direction as the animal motion. Despite wide variation in the Reynolds number (Re) based on appendage length and mean tip velocity (ReA) on the orders of 0.01 to 1,000, the metachronal rhythm used by the organisms remains similar. We examined the effect of varying ReA on metachronal paddling flow characteristics and swimming performance using particle image velocimetry on a metachronal paddling robot capable of self-propulsion. Stroke frequency and kinematic viscosity were varied to examine ReA ranging from 23 to 54,700. Both Re based on swimming speed and Re based on tip vortex circulation showed strong linear dependence with ReA (R^2>0.99; p-value<0.0002). The Strouhal number of the paddling wake, indicative of momentum transferred to the wake, was found to remain nearly constant (approximately 0.26) for the majority of ReA tested (50 < ReA <= 54,700). Together, these results indicate that metachronal paddling is a robust locomotion strategy that can function across a wide range of scales.

Sandra Vinnikova

Advisor: Dr. Shuodao Wang

Mechanics of Nano meshes for flexible and stretchable bio-sensors

Room 270 – French Lounge, 9:45 AM – 10:00 AM

Abstract: Next-generation flexible electronics require highly stretchable and transparent electrodes. The applications of conventional electronics are restricted due to their rigid and brittle nature, but stretchable and flexible electrodes are a promising solution to this problem. The requirements for future electronics and bioinspired devices are: high mechanical compliance, transparency and electrical conductivity. Human body is soft, flexible and curve, therefore electronics that can be easily deformed into complex shapes is desirable. Such electronics should demonstrate fully elastic responses to large mechanical strain and high optical transparency. The purpose of this study is to develop a transparent, stretchable, and flexible microelectrode to overcome the limitations currently known in this field. In this study, effects of in-plane patterns and geometry on the stretchability of nanomesh structures were investigated. Stretching of the nanomeshes with uniform patterned geometries to a certain strain was modeled and mechanics analysis of the unit cells for every pattern was performed. The effect of serpentine interconnects on stretchability of the nanomeshes was studied as well. Finite element analysis and experiments were performed to validate the theoretical calculations.

Zach Yap

Co-authors: Emalee Hough, Daniel Bowman

Advisor: Dr. Jamey Jacob

Solar balloons for Stratospheric observations

Room 270 – French Lounge, 10:00 AM – 10:15 AM

Abstract: With emerging high-altitude markets that include high-altitude balloons or stratospheric pseudo-satellites, there is a need for more measurements and observations of the stratosphere in order to better forecast and predict the environment that these new vehicles will operate in. Current methods of measuring events in the stratosphere are either costly or have a low special temporal resolution. The introduction of solar balloons offers a low-cost alternative to traditional helium balloons; because of this, multiple solar balloons can be launched in place of a single helium balloon. Another advantage to this is the ability to add minor trajectory control to solar balloons with very little increase in the overall cost. This ability to control the trajectory gives solar balloons the ability to operate in a swarm configuration for multipoint observations. This poster presents the challenges of launching a solar balloon swarm and how they fit in to the current methods of stratospheric observation as well as show current balloon operations and observations as well as highlight future solar balloon campaigns.

Asma Tabassum

Co-authors: Max DeSantis

Advisor: Dr. He Bai

Towards Wind Aware Navigation and Control for Safe Urban Operation of Small Unmanned Aircraft System: Autonomous and Human-Centric Approach

Room 270 – French Lounge, 10:15 AM – 10:30 AM

Abstract: The global endeavor to increase public confidence and comfort in the integration of passenger and cargo aerial transportation in urban, suburban, rural, and regional areas has posed a challenge to the guidance, navigation, and control research community. Low-altitude missions create a different operational challenge due to the high-density structural environment and atmospheric phenomena. In an effort to complement Urban Air Mobility, we aim to address the rising operational and navigational challenges due to turbulence and investigate controller design concepts for both autonomous and human-centric operations. The reformulation of general quadcopter dynamics to include turbulent dynamics and the solution of optimal control are the focus of our current work. To create a quadcopter-turbulent wind augmented lifted state-space model, we used Koopman Operator-based data-driven modeling and model predictive control to minimize the effect of wind. For human-centric control, we developed wind-aware small, unmanned aircraft system (sUAS) human-in-the-loop (HITL) simulator to study human-computer interaction during operation in a turbulent environment. We have obtained IRB approval to conduct human experiment in spring 2023.

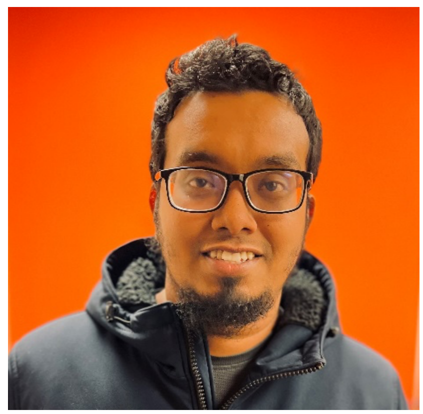
Graduate Student Talks: Session II

Ishriak Ahmed

Advisor: Dr. Imraan Faruque

High speed experimental and system identification tools for understanding swarming insect flight

Room 280 – Sequoyah Room, 9:00 AM – 9:15 AM



Abstract: Insect swarming behavior is significant to the field of multi-agent systems as it provides insights on decentralized decision-making, coordination, and collective problem-solving. This work develops High Speed Visual Insect Swarm Tracker (Hi-VISTA), a tool for simultaneous measurements of multiple insects' wing and body motions using high speed (9000 fps) videography techniques. The measurement system allows us to study the effects of confinement and ethanol exposure on honeybees. The results indicate that body pitch angle, heading rate, flapping frequency, and vertical speed (heave) are each affected by confinement and ethanol exposure leads to decreased maximal body heading and pitch rates and affected roll rate at high concentrations (5%). Finally, system identification tools for detecting emergence and developing reduced order models of coordinated motion experiments are developed. Together, these findings serve as a baseline for understanding swarming behavior and distinguishing the impacts of neighbors, environmental, and chemical factors.

Leila Rezaei

Co-Authors: Abby Haddox, Nissrine Aziz, Adrien Fau, Giulia Scalet, Michael Peigney

Advisor: Dr. Aurelie Azoug

Modeling Nematic Liquid Crystal Elastomers in Compression

Room 280 – Sequoyah Room, 9:15 AM – 9:30 AM

Abstract: Liquid crystal elastomers (LCEs) exhibit unusual mechanical behavior, such as large energy dissipations and soft elasticity. LCEs are composed of mesogens linked by a network of polymer chains. In the polydomain phase, the mesogen microscopic domains are randomly oriented. Under uniaxial tensile loading, the mesogens of the polydomain LCE orient in a single direction leading to a monodomain LCE through the polydomain-monodomain (PM) transition. The PM transition is accompanied by soft elasticity, characterized by an increase in strain at constant stress. The combination of mesogen rotation and polymer viscoelasticity leads to a nonlinear viscoelastic soft elastic behavior. LCEs also exhibit mesogen rotation in compression, which has not been extensively studied. Further, the dissipation associated with mesogen rotation and its influence on the viscoelasticity of the polymer network remains unclear. We measured the viscoelastic behavior of LCEs in compression under small and large strains, at various frequencies and strain rates. In compression, mesogens orient planarly rather than uniaxially, which is not necessarily associated with soft elasticity. Following these observations, we are developing a constitutive model to predict the compressive viscoelastic behavior of LCEs.

Kerrick Ray

Co-Authors: Victoria Natalie

Advisor: Dr. Jamey Jacob

Experimental Observations of the Boundary Layer and Movement in Varying Topography with Unmanned Systems

Room 280 – Sequoyah Room, 9:30 AM – 9:45 AM

Abstract: Desert dunes offer unique geophysical interactions, and these eolian dominant interactions occur over a significant portion of earth surfaces. There are multiple factors that determine the direction and shape of these dunes, which include sand availability and primary wind modes throughout the year. Trying to replicate these interactions in common water or wind tunnels can be difficult as the size of the dune creates a high Reynolds Number that was proven difficult to replicate with sized down models. This project endeavored to apply unmanned aerial systems (UAS) capabilities to track the sub boundary layer propagation by attaching an anemometer and flying vertical profiles while comparing the data with grounded anemometers during controlled test flights. In addition, this research pursued tracking the movement of desert dunes using images capture by unmanned aerial systems (UAS) to create a structure-from-motion to assist when shape modeling. This volatile landscape makes an ideal setup for tracking imagery combined with its effect of atmospheric data.

Muzaffar Qureshi

Advisor: Dr. Rushikesh Kamalapurkar

Fast Trajectory Optimization: A Comparative Study

Room 280 – Sequoyah Room, 9:45 AM – 10:00 AM

Abstract: Unknown and nonlinear dynamics of the environment often pose a great challenge for trajectory planning in small unmanned aerial vehicles. Several numerical optimization techniques are used to optimize the objectives such as time minimization and endurance maximization, but these typically do not guarantee convergence to an optimal solution due to the non-convex nature of the problems. Recently, Lossless and Successive Convexification techniques have been developed to convert non-convex problems into convex ones. The convexified problems have similar solutions, but are guaranteed to converge, which makes them ideal for on-board trajectory generation. In this project, the Mars powered descent and guidance problem was solved using convexification and three traditional nonlinear optimal control methods. Direct and indirect shooting method resulted in satisfactory results with moderate fuel cost but required large computation time. Using the Linear-Quadratic-Gaussian approach computation time was reduced, but global optimality could not be achieved. The convexified problem was found to be the fastest and most fuel efficient among all. Future work is aimed at extending these convexification techniques, to solve trajectory optimization problem in dynamic and unknown environments.

Chris Scott

Advisor: Dr. Khaled Sallam

Holographic diagnostics for scramjet engine fuel injection

Room 280 – Sequoyah Room, 10:00 AM – 10:15 AM

Abstract: In this research, the use of holographic imaging is examined for studying fuel injection in scramjet engines, with a focus on its potential application to hypersonic air breathing vehicles. The specific study presented here aims to investigate the shock-spray interaction and spray structure in the vicinity of the injector within the supersonic combustor. The measurements include the plume's penetration height and droplet size distribution. A novel aspect of the experimental methods is the use of holographic reconstructed imaging planes, which are combined into a stack based on specific statistical criteria to avoid missing any droplets. This approach allows for the capture of the interaction between the shock wave and the spray droplets, unlike other imaging techniques such as shadowgraph, which only provide an average position and rely on arbitrary criteria to define the spray boundary. The use of holographic diagnostics can provide more accurate penetration height measurements compared to other methods, making it more suitable for comparison with numerical studies. The ability to measure the true location of droplets with holography could be the key to advancing the understanding and implementation of hypersonic technology.

Joel Quarnstrom

Advisor: Dr. Yujiang Xiang

Design of a Novel Bio-Inspired Inchworm Robot using Helical Actuators

Room 280 – Sequoyah Room, 10:15 AM – 10:30 AM

Abstract: Bio-inspired robots provide solutions in many applications. Robots that can traverse and transport materials through confined areas are useful in disaster response, mining, mapping, and tunneling. The proposed robot is an inchworm-inspired robot that contracts and expands its body segments to move. It has spiky feet that are angled to only allow each foot to slide forward. It has a small frontal area compared to its length, and this allows it to travel under low hanging obstacles and through gaps between obstacles on the floor. Each segment uses two helical actuators as prismatic linkages to drive both forward movement and turning movement. These helical actuators transform the rotation of stepper motors into linear motion.

Graduate Student Posters: Session 1

Tanner Price

Co-Authors: Chris Rathman

Advisor: Dr. Kurt Rouser

Hybrid Rocket Test Stand Design and Evaluation of Nozzle Sizes on Hybrid Rocket Engine Performance

Room 265 – Ballroom, 10:30 AM – 12:00 PM

Abstract: This paper presents the design and evaluation of a small, portable hybrid rocket test stand; and an evaluation of hybrid rocket engine (HRE) performance using varying nozzle sizes. The primary goal of this study is to determine the most effective way to build a hybrid rocket test stand. Various design ideas were considered; however, the final stand design is oriented horizontally with the use of 3 flat aluminum plates mounted to linear bearings on t-slot framing. The linear bearings allow the most forward aluminum plate to contact and press against the load cell while maintaining minimal friction. A LabVIEW VI was created to control the opening of a solenoid valve, the ignition process, and thrust measurement. Another goal of this study is to determine HRE performance measures while varying nozzle size. Performance evaluations of the HRE were conducted on a 38 mm diameter solid fuel grain over #13, #16, and #19 nozzle throat sizes. All solid fuel grains were composed of 3D printed PLA and had Bates grain geometry with a 0.65 inch core size. The constructed test stand was clearly able to detect differences in thrust and specific impulse; showing the test stand is viable. Additionally, preliminary tests show decreasing the nozzle size has a positive influence on HRE performance.

Nissrine Aziz

Advisor: Dr. Aurelie Azoug

Rheological and viscoelastic properties of liquid crystal elastomers during UV curing

Room 265 – Ballroom, 10:30 AM – 12:00 PM

Abstract: Liquid crystal elastomers (LCEs) offer tremendous opportunities as lightweight smart materials exhibiting a reversible large shape change with temperature changes. The objective of this study is to determine the curing kinetics of a liquid crystal polymer ink formulated to 3D-print LCEs via direct ink writing. First, we characterize the curing kinetics during exposure and assessed the susceptibility of the system to dark curing. Ink specimens are exposed to UV light of various intensity and for various amount of time. Their thermal behavior is then measured via DSC to assess the evolution of the conversion degree according to curing conditions and then compared to results of photo-rheology at different UV intensities and modeled with an autocatalytic model. The thermal behavior of the ink after exposure times of 2, 4, and 8 seconds shows a small change in glass transition temperatures and large variations in nematic-isotropic transition temperatures. The nematic-isotropic transition temperature is a measure of the molecular mobility of the system, and hence the conversion degree. After waiting 30 minutes after exposure to perform the measurement led to variations in both glass transition and nematic-isotropic transition temperatures, indicating the system undergoes dark curing.

Shahbaz P Qadri Syed

Advisor: Dr. He Bai

Parameterized input inference for approximate stochastic optimal control

Room 265 – Ballroom, 10:30 AM – 12:00 PM

Abstract: Probabilistic inference approaches to stochastic optimal control have attracted significant interests from researchers in the past decade. All of the currently known inference approaches are limited to linear controllers in a finite-horizon model-based setting. Since nonlinear systems typically admit nonlinear optimal controllers, linear controllers may yield sub-optimal trajectories when applied to nonlinear systems. In this paper, we propose a new Expectation-Maximization (EM) based inference algorithm for stochastic optimal control. The algorithm employs nonlinear basis functions to infer nonlinear controllers. We formulate the optimal input estimation problem as a parameter inference problem. We further show that a slight modification to the formulation allows us to infer structured controllers for networked systems. We demonstrate the effectiveness of the algorithm on a simulated nonlinear oscillator system for nonlinear control and a linear thermal system for structured control.

Daniel Gassen

Co-Authors: Jason Bruck

Advisor: Dr. Jamey Jacob

This Sucks!: Advancement in Noninvasive Hormone Monitoring of Dolphins Using UAS Sample Collection Device

Room 265 – Ballroom, 10:30 AM – 12:00 PM

Abstract: Marine biologists can monitor the stress of cetaceans by collecting and analyzing the hormone cortisol contained in mucus that is produced from their blowhole during exhalation. To collect mucus samples, a developed collection mechanism attached to an Uncrewed Aircraft System (UAS) will be deployed from land or watercraft, travel to a specimen of interest, collect a sample, and keep it intact while delivering the sample back to researchers. This approach is less invasive compared to existing methods that require the capture of wild cetaceans. Current UAS being used for this mission are usually quadcopters with Petri dishes fixed to their frame. To improve upon this design a VTOL, fixed wing UAS is used for improved endurance, with a collection system capable of active sampling. The collection system can either be used passively by utilizing a fine mesh at the nose of the plane to catch the sample as the aircraft passes through the blow field, or actively using an Electric Ducted Fan to pull samples into the mesh. Results from flight tests over a dolphin chuff simulator were used to validate the new system's capability for sample collection in the field, followed by field tests on live dolphins at Dolphin Quest Bermuda to determine the system's effectiveness.

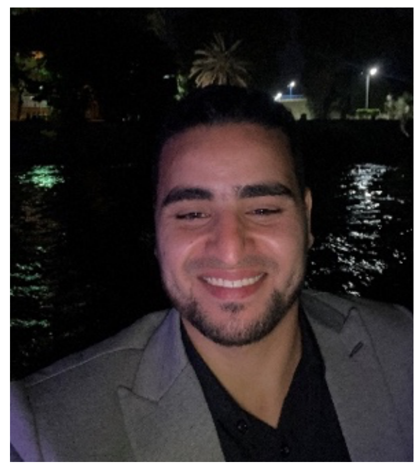
Ashraf Kassem

Co-Authors: Kursat Kara, Furkan Oz, Shafi Romeo

Advisor: Dr. Omer San

Physics-Guided Multi-fidelity Learning for Characterization of Blunt-Body Dynamic Stability

Room 265 – Ballroom, 10:30 AM – 12:00 PM



Abstract: This proposed research aims to develop a statistical inference and modeling framework for characterizing the dynamic stability and performance of blunt-body systems. the research is divided into three phases. first is the Unification and synchronization of existing experimental and computational data stacks along with execution of new high-fidelity CFD runs. Efforts will be made to run steady and unsteady flow simulations of NASA-relevant atmospheric entry vehicle geometries at supersonic and transonic Mach numbers. The second phase is analyzing and modelling the data by applying machine learning techniques. The proposed framework is called physics guided multi-fidelity learning (PGML) approaches. While standard ML solvers and neural network agents are common in deep RL routines, they are limited in cases in more heterogeneous settings in scientific applications. On the other hand, PGML approach is a significant generalization of a number of multi-fidelity approaches, including PI San's physics-guided machine learning approach. The third phase is called evaluation of performance indicators. To validate the problem, computer simulations for canonical examples and relevant prototype will be presented.

Mehdi Yadipour

Advisor: Dr. Imraan A. Faruque

Insect-inspired Visually guided Decentralized Swarming

Room 265 – Ballroom, 10:30 AM – 12:00 PM

Abstract: This research addresses the need for theoretic constructions enabling fast, lightweight algorithms that provide vision guided swarming on maneuverable air vehicles having limited computational tools and no explicit communication network or position source. The study begins by developing a framework for sensing optic flow in a multi-agent environment. It then integrates an idealized inter-agent velocity and distance structure describing distributed feedback under perfect information with optic flow perception to create an analogous visually guided feedback path. We use the seminal Cucker-Smale flocking model as an example to develop a vision-guided update law with rigorous asymptotic convergence guarantees, under ignorance of agent size. No explicit position reference or communication network is required. Under additional assumptions, a mapping of tolerance to additive measurement noise is available. Simulations are presented to illustrate the resulting outcomes, including the behavior's nonlinearity as characterized by an increasing oscillation period and equivalent damping ratio, insensitivity to agent size, and sensitivity to coupling strength and orientation gain.

Soumya Mandal

Co-Authors: Ashish Gupta, Nozomo Shirato

Advisor: Dr. Ritesh Sachan

Fabrication of multimetallic NiCoCr nanoparticles via pulsed laser-induced dewetting of alloyed thin films

Room 265 – Ballroom, 10:30 AM – 12:00 PM

Abstract: This work presents a detailed study on the fabrication of self-assembled NiCoCr nanoparticles by adopting a non-equilibrium route of pulsed laser-induced dewetting of alloyed thin films. In this ultrafast process, nanoparticles are formed by breaking the energetically unstable alloyed thin films in a melt state under pulsed laser irradiation. The strong intermolecular force between the atoms in their liquid state initiates instability, resulting in morphological evolution and eventually leading to the formation of nanoparticles. The evolution of dewetting morphologies with continued laser pulses is explained based on the dewetting timescale and liquid lifetime of NiCoCr. Upon laser irradiation, the morphological evolution toward the formation of NiCoCr nanoparticles is systematically investigated employing electron microscopy. An in-depth analysis of the elemental and compositional distribution of the constituent elements in the NiCoCr nanoparticles reveals that they are well-distributed in the nanoparticles without any sign of segregation and in good agreement with the average atomic percentages of the parent thin films. This study presents a non-equilibrium laser-assisted pathway that enables the fabrication of nanoparticles useful in the fields of catalysis and energy storage.

Masoud S. Sakha
Advisor: Dr. Rushikesh Kamalapurkar

Optimal Control of Multi-Mode Switched System

Room 265 – Ballroom, 10:30 AM – 12:00 PM

Abstract: Switched systems are systems that have two or more distinct modes of operation. Switched optimal control problems (SOCPs) are difficult since they require simultaneous optimization of the mode sequence and the control laws within each mode. Traditional optimal control methods (OCMs) rely on continuity of decision variables and thus cannot be used to optimize discrete mode sequences. In this work, an embedded optimal control problem (EOCP) is defined by replacing the discrete modes with continuous embedded variables that can take intermediate values between the discrete modes. While embedding enables traditional OCMs, optimal solutions of EOCPs often involve nonexistent modes, and thus may not be feasible for the SOCP. Bang-bang solutions of the EOCP, where the embedded signal only requires one mode to be active at a time, are feasible for the SOCP. In our previous work, we showed that the addition of a suitable auxiliary concave function to the cost function enforces the EOCP to have a bang-bang optimal solution. However, the previous work was restricted to systems with two modes. In this work, we present an innovative design of an auxiliary function to facilitate optimal control of switched systems with finite but arbitrary number of modes of operation.

Nicholas Nowak

Co-Authors: Muhammad Bablu

Advisor: Dr. James Manimala

Yarn Pull-Out as a Mechanism of Ballistic Performance Enhancement in Silica Nanoparticle-Treated Kevlar (SNK) Fabric

Room 265 – Ballroom, 10:30 AM – 12:00 PM

Abstract: Silica nanoparticle-treated Kevlar (SNK) fabrics provide the same level of ballistic protection as neat Kevlar while remaining ~17% lighter. It is well-known that treatment of aramid fabrics with silica nanoparticles significantly enhances shear rigidity indicating that an increase in inter-yarn friction plays a key role in energy dissipation. Therefore, investigation of yarn pull-out in SNK fabrics could yield insights into performance enhancement mechanisms vis-à-vis nanoparticle and woven fabric specifications. In this study, customized rigs and procedures were developed for quasi-static and dynamic yarn pull-out tests on neat and SNK samples. Parameters such as loading rate, transverse tension, and yarn direction were also examined. In each case, critical features were extracted from the load-displacement response. Using piecewise definitions for various pull-out regimes, coefficients for quadratic and exponential fitting functions were calibrated and can be utilized to model yarn friction as a function of SNK specifications. It is envisioned that armors enabled by SNK optimization would not just enhance ballistic protection, but also be amenable for integration with multifunctional capabilities such as for wearable electronics, wound coagulation, or smart camouflage.

Zachary Morrison

Advisor: Dr. Rushikesh Kamalapurkar

Dynamic Mode Decomposition of Discrete-time Dynamical Systems under Feedback Control using Discrete-time Control Liouville Operators

Room 265 – Ballroom, 10:30 AM – 12:00 PM

Abstract: Dynamic mode decomposition aims to develop a systematic way to model or predict the trajectory of dynamical systems - with potentially unknown dynamics - using previous observations. While DMD methods for continuous time control-affine dynamical systems under feedback control have recently appeared in the literature, such techniques are not available for discrete-time controlaffine dynamical systems (DTCADS). In this project, a DTCADS is modeled by collecting snapshots of its trajectories in response to open-loop control signals. The data are then embedded into an infinite dimensional feature space using kernel functions. In the feature space, the relationship between the data is modeled in terms of linear operators. A new DMD-like method is then developed to generate a predictive model of the DTCADS under a known feedback controller. Validation of the developed method in simulation is ongoing.

Pouria Moghimi

Advisor: Dr. Christian Bach

Modelling of Underground Thermal Energy Storage Tanks for HVAC Applications

Room 265 – Ballroom, 10:30 AM – 12:00 PM

Abstract: Buildings account for almost more than one third of global energy consumption and GHG emissions. Integration of renewables and energy efficiency can reduce their indirect GHG emissions. Renewables have an intermittent nature, and their electricity production profile does not match the heating or cooling loads of the building. We can convert renewable electricity, when available, to end-use thermal form and move it to a Thermal Energy Storage (TES) tank for later use. Using the TES tank reduces electricity supply and thermal building demand mismatch. In our research group, we aim to investigate the economic and technical feasibility of TES tank integration in buildings. We consider that TES tank will be buried in the ground, hence tank's thermal interaction with the ground should be studied. In this research, we will focus on TES tank's thermal modeling in the ground. Since TES's performance for whole building energy simulation in the long run is important, efficiency of the model in terms of both accuracy and simulation resources plays a vital role here. We are working to develop computationally cheap models by either developing a numerical model or an analytical solution using the concept of g-functions. The g-function method is interesting, for it is widely and successfully us

Abby Haddox

Co-Authors: Jeremy Perez, Leila Rezaei, Jerome Hausselle

Advisor: Dr. Aurelie Azoug

A Smart Skin to Treat and Prevent Pressure Ulcers

Room 265 – Ballroom, 10:30 AM – 12:00 PM

Abstract: Pressure Ulcers (PUs) are injuries of the skin and underlying tissue resulting from prolonged applied pressure on a bony prominence. One strategy to mitigate the risk of PUs is to reduce the peak pressure on the skin. Our goal is to design a smart skin that redistributes pressure on the skin, using the nonlinear properties of Liquid Crystal Elastomers (LCEs). The objective of this study is to measure the effectiveness of LCE smart skin by quantifying the decrease in peak pressure under human subjects' heels due to the smart skin during static and dynamic conditions. We recruited 30 healthy subjects (15 males and 15 females, ages:18-25 years old, BMI<28). Each subject was asked to lay flat on their back on a testing surface while we measured the pressure under their heels with and without the smart skin in static and dynamic conditions. Recovery of the smart skin was also measured through weight shifting and a longevity test. The peak pressure decreased when the smart skin was applied, and recovery was based on the relaxation behavior of LCEs. In the future, these results will be compared to a simulation of a heel on an LCE support, currently under development in the lab, to identify the actual pressure on the subject's skin.

Erick Pepek

Advisor: Dr. Jay Hanan

Recyclable Polymers to improve Sustainability of Additive Manufacturing

Room 265 – Ballroom, 10:30 AM – 12:00 PM

Abstract: The FDM additive manufacturing market has evolved to prefer ABS, PLA, Nylon, PC, and PETG polymers. These materials have become favorable since their melting temperatures are similar allowing for wide deployment in manufacturing as well as having a relatively low cost per kilogram. However, these polymers are not commonly recycled, but are listed in category "7" (other). In contrast to PETG, PET is listed as number "1" and is commonly recycled. However, PET is less commonly used in additive manufacturing. Processing methods and mechanical properties for both filament and printed parts were collected and compared. The same equipment was, with some added complexity, able to produce PET filament that produced PLA and PETG filaments. In addition, the same 3D printer was able to make parts from all the aforementioned materials. The results show, even before optimization, satisfactory performance for PET in applications also suited to these resins and opens the door to more sustainable options for 3D printing.

Graduate Student Talks: Session 3

Sanzida Hossain

Advisor: Dr. He Bai

Cooperative driving between human-driven and autonomous vehicles considering stochasticity in human driving behavior

Room: 270 – French Lounge, 1:00 PM – 1:15 PM

Abstract: In this research, we investigate how an autonomous vehicle (AV) and an intelligent human vehicle (IHV) can work together to merge onto a two-lane road. An IHV is equipped with an automated system with advisory directives to the human driver to optimize its maneuver while communicating and collaborating with other vehicles. Modeling and taking into account the human driver's actions' stochasticity in the IHV is crucial for the best coordination of the two vehicles. We present a cooperative driving technique that takes into account a variety of stochastic human characteristics in the IHV, such as human intent and input transitions. We also model the system to take into consideration calculation delays and the ability of the driver to adhere to advisory instructions. Stochastic model predictive control (sMPC) is used to formulate the coordination for the AV and IHV. Using simulations, we show that the model that considers the stochastic effects of a human driver's actions performs better and can mitigate the effect of the driver's inattentiveness while merging.

Furkan Oz

Advisor: Dr. Kursat Kara

Quantum PDE Solver with Chebyshev Points

Room: 270 – French Lounge, 1:15 PM – 1:30 PM

Abstract: Quantum computing is a promising technology for solving complex multiphysics problems that cannot be solved using classical computers. Although the utilization of quantum computing is extraordinarily challenging because of the difficulties in measurement and control, there is a significant investment in quantum computing due to its potential. The recent developments showed that a clear path exists toward demonstrating the advantages of quantum computing over existing high-performance computing for some engineering problems. One solver recently developed for quantum computers is the quantum partial differential equation (PDE) solver, which utilizes the quantum amplitude estimation algorithm (QAEA). This presentation proposes a new and efficient implementation of the quantum amplitude estimation algorithm for a quantum PDE solver with Chebyshev points. A generic ordinary differential equation (ODE), heat equation, and convection-diffusion equation are solved with the proposed implementation, and the results are compared with the existing data.

Michael Sallaz

Advisor: Dr. Andy Arena

The Efficacy of Utilizing SolidWorks Finite Element Analysis for Design of Composite I-Beam Wing Spars in UAVs

Room: 270 – French Lounge, 1:30 PM – 1:45 PM

Abstract: Labs in which unmanned composite aircraft are produced by Oklahoma State University currently lack the capability to adequately analyze wing structural designs computationally. This is especially true regarding the design of the main composite spar. Within these labs, utilization of SolidWorks for modeling and CFD analysis of designs to be built is commonplace. It would be advantageous to capitalize on this familiarity with SolidWorks to extend pre-prototype analysis capabilities by utilizing the SolidWorks FEA package to analyze wing spars designed for both graduate level and undergraduate capstone projects. Proof of good correlation between experimental 3-Point Bending testing and FEA results for these composite spars would allow for further pre-prototype structural refinement, thus reducing the man hours and material costs associated with the prototyping phase. Baseline testing of isotropic aluminum beams indicates SolidWorks FEA performs better than Beam Theory. Despite this, it consistently underpredicts deflection and bending stress by ~16% and ~8% on average, respectively, while shear stress predictions are typically off by ~13%. Given the orthotropic nature of carbon fiber and balsa wood, this trend is expected to persist and perhaps worsen for the composite I-beam spars.

Jared Town

Co-Authors: Zachary Morrison

Advisor: Dr. Rushikesh Kamalapurkar

Nonuniqueness and Convergence to Equivalent Solutions in Observer-based Inverse Reinforcement Learning

Room: 270 – French Lounge, 1:45 PM – 2:00 PM

Abstract: A variety of tasks, performed by humans or automatic controllers, can be realized by taking actions that minimize the integral of a cost function over a given time. The objective of inverse reinforcement learning is to identify the cost function that realizes a given task by observing the control inputs and system response of an agent performing that task. A key challenge in cost function estimation is that a given set of control inputs and system responses can be optimal with respect to multiple cost functions. As a result, only a suitably defined 'equivalent' cost function can be identified from data. While offline algorithms that result in convergence to equivalent cost functions have been developed in the literature, online, real-time techniques that address equivalent cost functions are not available. In this work, a novel real-time algorithm is developed, along with new data-richness conditions, to facilitate provably convergent cost function estimation. The developed algorithm is then applied to model an autopilot as a controller that is trying to optimize an unknown quadratic cost function. Simulation results indicate that the developed method can successfully identify an equivalent cost function for the autopilot using position and orientation measurements.

Jacqueline Esimike

Co-Authors: Mitchell Ford

Advisor: Dr. Arvind Santhanakrishnan

Interaction of cough-generated exhalation flow with gasper jets in airliner cabins

Room: 270 – French Lounge, 2:00 PM – 2:15 PM

Abstract: Airborne transmission of virus-laden aerosols, including SARS-CoV-2 that causes COVID-19, is of concern in airliner cabins due to the close-seating of passengers inside a confined region. The interaction of exhaled air flow from passengers with ambient flow has not been experimentally examined. We conducted particle image velocimetry measurements within the OSU MD-80 cabin to examine how the jet exhaled by a coughing passenger interacts with jets originating from overhead vents (gaspers). Exhalation flow similar to human coughing was generated using a respiratory flow phantom fitted in a human dummy. This exhalation flow-generating dummy was seated in the middle seat of the middle row (3 seats/row) of 3 consecutive front-to-back rows (starboard side only). Passive human dummies were placed in the remaining 8 seats. Gasper jets produced a noticeable impact on the trajectory of the coughing jet, deflecting the jet downward in the range of 10-34 degrees relative to the horizontal. Larger deflection angles can potentially minimize aerosol dispersal within the cabin and direct aerosols toward the exhaust vents located near the floor. These findings can potentially inform the design of ventilation strategies to improve air quality and reduce the risk of airborne virus transmission.

Ujjval Patel

Advisor: Dr. Imraan A. Faruque

PLUS - PowerLine Unmanned Surfer: Dynamic and Tracking

Room: 270 – French Lounge, 2:15 PM – 2:30 PM

Abstract: Significant energetic challenges remain for long range, small unmanned aerial systems (UAS), and the potential to recover powerline energy would significantly increase range. This study investigates a long-range fixed wing UAS that uses morphing aerodynamics to enable near proximity powerline flight. A bilinear flight dynamics model is developed incorporating generalized aerodynamic morphing, and a frequency-correspondence established to a characteristic powerline with use of ToF sensor. The resulting feedforward control architecture is tested in simulation using a camber-actuated RQ-11 airframe, showing that the control approach results in several seconds of powerline contact and a required morphing range (11-13 % camber) within aerostructural feasibility expectations.

Graduate Student Talks: Session 4

Joshua Melvin

Advisor: Dr. Kurt Rouser

Integration of a Turboprop Replacement for a Piston Engine Driven General-Aviation Aircraft for Ground Turboelectric Research

Room: 280 – Sequoyah Room, 1:00 PM – 1:15 PM

Abstract: This study presents the analyses, methods, and considerations needed to adapt a 160-hp piston engine driven four seat aircraft for a 240-hp turboprop main engine replacement. This is needed to conduct hybrid propulsion integration research to inform safety standards for the growing hybrid aircraft segment. The analyses used were structural, vibrational, aircraft center of gravity, and fuel delivery through use of pipe frictional losses. Methods employed were standard mechanical design elements such as dimensioning, tolerancing, factor of safeties, and access to external engine elements for maintenance. Other methods used were basic aircraft mechanic theory for installing the components, verifying safe installations, and attention to sensitive equipment for vibration and corrosion. Finally, steps needed to fully install and run the turboprop are covered. These include physically installing the engine mount and engine, installing propeller assembly, providing adequate oil cooling, developing a fuel delivery system, installing electrical systems, and installation of engine controls. Successfully running the engine was used as a benchmark to verify proper installation of all components and lastly a leak inspection was conducted to verify that all fluid lines did not leak.

Achyuth Thumbalam Guthai

Co- Authors: Ali Fahem

Advisor: Dr. Raman Singh

Use of Full-Field Strain Measurements to Determine Mechanical Properties of Shale Under Repeated Cyclic Loading

Room: 280 – Sequoyah Room, 1:15 PM – 1:30 PM

Abstract: Stimulation of unconventional hydrocarbon reservoirs in the form of shale deposits through hydraulic fracturing is a considerable resource to produce oil and gas. Consequently, it is important to understand the properties of shale, especially when subjected to repeated cyclic loading. This is because during drilling and hydraulic fracturing construction, surrounding rocks are exposed to cyclic stresses which encompass micro cracks, and their behavior affects mechanical response and failure, which in turn influence the hydraulic fracture process. In this study, Woodford shale materials obtained from Anadarko basin in Oklahoma are tested to determine the mechanical properties, post-failure behavior, and the failure strength of shale. These properties are quantified under cyclic loading conditions using full-field strain measurements from digital image correlation (DIC) in conjunction with analytical expressions of the stress fields. Tests are carried out by loading perpendicular to the bedding planes. It is found that shale materials display significant anisotropy in material response and are also influenced by tensile or compressive loading conditions. This has important implication on the use of shale properties to predict fracking parameters that will lead to optimum yield.

Moad Abudia

Advisor: Dr. Rushikesh Kamalapurkar

System Identification Using Operator Theory With Eigenfunction Validation

Room: 280 – Sequoyah Room, 1:30 PM – 1:45 PM

Abstract: In order to make predictions into the future of a particular system, such as the weather system, financial system, etc. a model of the system is need. If the system in question is simple and well understood, then first principles can be used to develop the model. Otherwise, a system identification method must be used to develop the model. The method in this project is designed to identify nonlinear systems using a set of trajectories that are generated by the system. Once a model is Identified, the model can be used to predict future trajectories of the system. The system is modeled using identified eigenfunctions in a method termed Liouville dynamic mode decomposition, or Liouville DMD. However, the use of this method results in the generation of as many eigenfunctions as there are trajectories in the dataset. In some cases, many of the generated eigenfunctions are spurious, which only introduce errors that add up as the trajectory is predicted further into the future. To remedy this problem, an eigenfunction validation routine is used on the generated eigenfunctions to discard the spurious ones, which results in a more accurate prediction of the trajectory further into the future. The results are demonstrated in simulation using a Duffing oscillator.

Nastaran Arzamani

Advisor: Dr. Nicoletta Fala

Stories that Have Not Been Heard: Using Text Mining to Analyze Aviation Accident Reports

Room: 280 – Sequoyah Room, 1:45 PM – 2:00 PM

Abstract: Aviation safety has traditionally made strides through lessons learned from prior accidents. In more recent times, access to the databases of accident reports has evolved our approach from a reactive to a proactive and predictive approach to analyzing trends. While accident investigators provide a written narrative of the events surrounding an accident, most studies use coded information in their analyses. Only a few studies analyze text data from the reports, which may lead to missing out on important information. Analyzing trends behind all available data reveals findings and insights that would be impossible without the narrative of the reports. Text mining is a powerful technique for analyzing qualitative data. In this project, we used the Natural Language Processing technique and the TF-IDF method to analyze aviation accident reports and narratives to identify significant factors leading to aviation disasters. By doing so, we can discover contributing, hazard-leading factors and trends that were previously invisible without using the textual data, and, therefore, develop strategies to improve aviation safety by preventing similar adverse conditions from recurring.

Emalee Hough

Co-Authors: Zach Yap, Daniel Bowman

Advisor: Dr. Jamey Jacob

High altitude observations with solar balloons

Room: 280 – Sequoyah Room, 2:00 PM – 2:15 PM

Abstract: To study weather and atmospheric phenomena there are many platforms used, most commonly super pressure helium balloons. These platforms only examine a slice of the atmosphere because of the short flight profile. Solar Balloons on the other hand, a relatively newer lighter-than-air system, can achieve multi-hour flight within the lower stratosphere buoyed aloft by solar heating. A key part of planning a solar balloon launch is verifying that the balloons will fly over a targeted location. To do this a trajectory prediction algorithm is used. The two most common ways of predicting the solar balloon flight paths are a heat transfer model and a geometric model. Once the balloon vertical flight profile has been generated, it can be integrated with a forecasted wind field, such as the National Oceanic and Atmospheric Administration Global Forecast System to produce the predicted flight trajectories. While predicted trajectories are highly dependent on the accuracy of the weather forecast, they generally give a good approximation of the anticipated landing zone. The longer flights can provide more insight to these trajectory predictions. This presentation will discuss the development of solar balloon trajectory models and results from nearly 100 launches performed over 2021-today

Abhishek Tikar

Advisor: Dr. Sandip Harimkar

Spark Plasma Sintering of Al0.5CoCrFeNi2 High Entropy Super Alloy and Composite

Room: 280 – Sequoyah Room, 2:15 PM – 2:30 PM

Abstract: Al0.5CoCrFeNi2 high entropy super alloy (HESA) was spark plasma sintered in temperature range of 800℃ to 1050℃. As the porosity decreased with sintering temperature, density and average grain size exhibits an increasing trend. Complete densification is achieved at 1000℃ and above. Irrespective of sintering temperature, a stable FCC phase persist throughout. All the sintered specimen showcase primarily adhesive wear with signs of delamination and oxidation assisted abrasive wear. The exceptional stability of FCC phase in Al0.5CoCrFeNi2 over a wide range of temperature make if good contender to be used as reinforcement in Aluminum Matric Composite (AMC). AMCs with 5vol% HESA were sintered at 525℃ for 10min, 15min, 20min and 30min. While FCC peaks of Al dominate the XRD, peaks of superlattice intermetallic tend to superimpose with that of Al. No elemental segregation is observed in the interface region. The nanoindentation data and TEM analysis confirms the formation of Ni3Al intermetallic nanocrystals uniformly distributed in the interface region. The wear analysis of the Al-HESA composite shows that the interface is too brittle to hold the matrix and tends to crack under applied load which is a direct consequence of intermetallic precipitation.

Graduate Student Posters: Session II & Coffee Break

Khaled I. Alghamdi

Co- Authors: Jeffrey D. Spitler

Advisor: Dr. Christian K. Bach

Feasibility Study for a Residential A/C System Integrating Thermal Energy Storage for Load Shifting Using a Novel Three-Fluid Heat Exchange.

Room 265 – Ballroom, 2:30 PM – 4:00 PM

Abstract: Renewable energy causes temporal imbalances between energy demand and supply, requiring fossil fuels or costly electric energy storage to prevent grid blackouts. Alternatively, using HVAC systems can convert electric energy and store it in thermal form. Required non-renewable excess capacity can then be reduced on the end-use side by shifting production and use of thermal energy. We propose to integrate an air-conditioning system with water-based thermal energy storage (TES) using a novel three-fluid heat exchanger (TriCoil™). We developed a model for TriCoil™ as an evaporator and adopted condenser, compressor, and TES models, and then connected them in a framework to work as a system. In addition, we developed a rule-based supervisory controller for the operational modes of the system. We then studied the system's potential for shifting loads and reducing electricity costs under time-of-use utility rate scenarios. We studied the system's potential using cooling load profiles of single-family houses in three locations in the United States. Preliminary results show the system reduces the yearly electricity cost for cooling by up to 30% and shifts up to 85% of the cooling load to off-peak time.

Braydon Revard

Co- Authors: Trevor Wilson

Advisor: Dr. Jamey Jacob

Experimentation and Validation of UAS Based Wind Sensors for Urban Applications.

Room 265 – Ballroom, 2:30 PM – 4:00 PM

Abstract: UAS technologies are becoming more widely utilized in civil and commercial fields and military applications. Amazon's drone delivery service and Boeing's eVTOL air taxi are some examples of this. With small urban UAS applications becoming common, infrastructure, such as UAS traffic management for low-altitude airspace management and monitoring, is being developed. Safety and efficiency of UAS operations are strongly impacted by low-altitude wind, such as gusts around buildings. Gusts can negatively affect pilot operations, reduce flight time, and cause damage to the UAS system. For this project, a fleet of specialized UAS quadrotors will collect local wind data around buildings and urban environments to aid in creating a "wind map" to model gust behavior. UAS systems equipped with ultrasonic anemometers are being experimentally validated through comparison flights near Oklahoma Mesonet towers and mast mounted anemometers. Wind measurements are also being taken around buildings on the Oklahoma State University campus, specifically the Kerr-Drummond buildings and Boone Pickens Stadium, to model wind gusts inside of an urban environment to create a "wind map" model concept.

Md Raqibul Hasan Prince

Advisor: Dr. Wei Zhao

Binary Variables based Weight Minimization of Lightweight Manufacturable Composite Laminated Structures.

Room 265 – Ballroom, 2:30 PM – 4:00 PM

Abstract: Composite materials have been widely used in practical structural applications due to their high specific stiffness-to-weight and strength-to-weight ratios. The number of layers, fiber path orientation and layer thickness for composite laminate structures are often limited by the manufacturing constraints, resulting in a discrete design optimization problem. Various evolutionary optimization algorithms have been considered for such structural design considering manufacturing constraints including Genetic Algorithm (GA), and others. However, these optimization strategies often fail in obtaining a converged solution when the design space is large. Therefore, we propose to employ an integer programming approach for manufacturable composite laminates design. The layer thickness and fiber path orientation are described using binary variables. The composite laminate stiffnesses are expressed in terms of these binary variables. Symmetric and balanced composite laminated panels are studied whose explicit stress and buckling load expressions are available. Weight minimization is conducted using Gurobi optimization software to obtain an optimal stacking sequence. GA is also employed for this study. Optimization results obtained using Gurobi and GA are then compared and discussed.

Bipin Khafle

Advisor: Dr. Khaled Sallam

Gravitational effects on the wettability of microporous hydrophobic tubular surfaces.

Room 265 – Ballroom, 2:30 PM – 4:00 PM

Abstract: Membrane wetting is problematic as it causes the permeate quality to deteriorate and contact angle is one of the most effective parameters to evaluate the wettability. The goal of this study is to increase the hydrophobicity of the tubular membrane using dynamic effect to reduce the wetting phenomenon. However, the measurement of the contact angle is greatly affected because of the curvature of the tubular membrane. A polypropylene (PP) tube with micropores was used as the membrane surface for this study. The droplets of different liquids with different volumes were deposited on their surface to analyze the effect of gravity in the same direction and the opposite direction keeping the membrane in the horizontal position. Droplets of Water and NaCl solutions were deposited on top of the membrane surface with volumes 2 μL,5μL, and 10μL using a micropipette. The effect of gravitational force, Bond (Bo) number, on membrane wetting was investigated. It was noted that in tubular membranes, on a horizontal position, the effect of gravity for droplets with volume from 2μL to 5μL is insignificant but for 10μL it is noted that there is a significant effect of gravity. Also, the result assures that when the Bo number increases, and the contact angle decreases significantly.

Kevin Bhar

Co- Authors: Jemin George, Carl Busart

Advisor: Dr. He Bai

Asynchronous Local Computation in Decentralized Bayesian Learning.

Room 265 – Ballroom, 2:30 PM – 4:00 PM

Abstract: Due to the expanding scope of machine learning (ML) to the fields of sensor networking, cooperative robotics and many other multi-agent systems, decentralized deployment of inference algorithms has received a lot of attention. These algorithms involve collaboratively learning unknown parameters from dispersed data collected by multiple nodes. There are two competing aspects in such algorithms, namely, intra-node computation and inter-node communication. Traditionally, algorithms are designed to perform both simultaneously. However, certain circumstances need frugal use of communication channels as they are either unreliable, time and resource expensive. In this paper, we analyze the effects of multiple local intra-agent computations between successive inter-agent communications in a decentralized unadjusted Langevin algorithm for Bayesian sampling of unknown parameters. We propose a framework in which each node has the liberty to asynchronously perform multiple computations within a certain bound before a synchronous communication stage. We observe faster initial convergence and improved performance accuracy, especially on the low data range.

Nahid Uzzaman

Advisor: Dr. He Bai

Predicting dynamic covariances of the label even when the inputs are uncertain using variational Wishart processes.

Room 265 – Ballroom, 2:30 PM – 4:00 PM

Abstract: We consider the problem of forecasting the dynamic covariance when there is uncertainty in the input data. Different Bayesian techniques, such as the Variational Wishart process, have been applied in the past to forecast covariance with known input data. However, the VWP fails to accurately predict covariance when the input is uncertain. To address this limitation, we propose three new VWP methods that can predict the covariance of the data label even when input data is uncertain. Through simulations, we demonstrate that our proposed methods can perform more accurate predictions when dealing with uncertain input. The study presents a comparative analysis of the performance of all the methods used based on the simulation results.

Tochukwu Elijah Ogri

Co-Authors: Masoud Sakha, Zachary I. Bell

Advisor: Dr. Rushikesh Kamalapurkar

Joint State-Parameter Estimation for Adaptive Optimal Trajectory Tracking in Nonlinear Systems.

Room 265 – Ballroom, 2:30 PM – 4:00 PM

Abstract: This paper presents a novel approach to adaptive optimal control design that addresses limitations of traditional adaptive control methods, such as reliance on full state measurements and knowledge of the system's dynamics. The proposed method uses a critic-only model-based reinforcement learning architecture that utilizes partial state measurements and a parameter estimation scheme that utilizes memory as recorded data. A critic, trained using the state and parameter estimates, evaluates the optimality of the controller, and the controller is improved online based on the feedback from the critic. This design allows for asymptotically optimal tracking of a desired trajectory for a general class of nonlinear systems. The proposed method is validated through simulations and its effectiveness is established through a Lyapunov-based analysis. The significance of this controller lies in its ability to adapt to complex and uncertain environments, which is crucial for satisfying control requirements in various applications such as robotic systems and aircraft systems.

Bryce Randall

Advisor: Dr. Jamey Jacob

Stability and control analysis using CFD for low aspect ratio low Reynolds number aircraft.

Room 265 – Ballroom, 2:30 PM – 4:00 PM

Abstract: With the ever-evolving world of small electronics, allowing the shrinking of aircraft to micro aerial vehicle levels, there arises a need to better understand the stability and control of these designs. However, given how small these systems are and that they operate in a low Reynolds number flow at low aspect ratios, conventional analysis does not yield the best results. Given that the scale of such aircraft is lower, this also means that when it comes to CFD, the computational resources are lower as well. As a result, the domains used are smaller than those of a conventional manned aircraft. Due to low aspect ratio low Reynolds number flow regime, an inverse Zimmerman planform with an arc airfoil will be used in the analysis. The arc airfoil is chosen because typical airfoil shapes at lower Reynolds numbers in the 50,000-100,000 range do not perform well. Furthermore, given the desire to construct an aircraft in the sub-250-gram weight category while also being powered, the inverse Zimmerman allows for a more significant size of control surfaces as this causes the broader portion of the wing to be in the rear as opposed to a typical Zimmerman having this portion on the leading edge. This allows the ability to change control surfaces throughout the design process.

Shafi Al Salman Romeo

Co- Authors: Pedram Hashem Dabaghian

Advisor: Dr. Omer San

Machine Learning Applications on Predicting Turbulence Closure Term.

Room 265 – Ballroom, 2:30 PM – 4:00 PM

Abstract: Closure modeling for high-resolution spatiotemporal systems, needs to be improved due to its imperfections and inaccurate predictions resulting from different physical insights and mathematical approximations. Machine Learning models have been in trend to predict these complex patterns from simulation data. Although this leads to improved parameterization models and better coarse grid prediction, concerns such as poor generalization, lack of interpretability and violation of physics make it challenging. In this work, we focus on a Rotational Invariant closure framework to improve model accuracy and generalizability of data learning-based subgrid-scale closure models by entrenching physics straight into the structure of Convolutional Neural Network so that desired physical constraints are theoretically guaranteed without needing regularization terms. We tested our proposed framework on a 2D vortex merger problem and finally demonstrated a decaying turbulence case for different initial conditions. Our results indicate that the proposed model shows numerical stability with different initial conditions and predicts the source term precisely maintaining the physics. This work promises a step toward developing physics-based data driven modeling paradigms in turbulence closure models.

Peter Ramsdale

Advisor: Dr. Jamey Jacob

The Development of Testing Criteria and Methods for the Evaluation of a Counter Unmanned Aerial System Platform as a Viable System.

Room 265 – Ballroom, 2:30 PM – 4:00 PM

Abstract: The objective of this paper is to analyze the testing criteria and methods that should be used to evaluate the effectiveness of newly developed Counter Unmanned Aerial Systems (CUAS) platforms. A case study that focuses on the types of Unmanned Aerial Systems (UAS) encounters the platform would face in a wide variety of environments will be done to help create a wide array of realistic scenarios for the CUAS platform to be tested against. The goal of these testing criteria and methods would be to assess the CUAS platforms performance in areas such as functionality, reliability, effectiveness, accuracy and cost. The results of these tests will help provide consistent and standardized data that will help provide important information about a CUAS system's performance so that potential customers can decide about the viability of a CUAS platform for their specific needs.

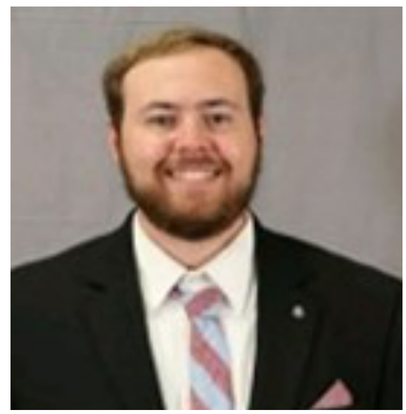
Patrick Williams

Advisor: Dr. Imraan A. Faruque

Orbital Debris Encounters Analysis about ISS Orbit.

Room 265 – Ballroom, 2:30 PM – 4:00 PM

Abstract: Orbital debris mitigation missions require identifying target orbits that have a greater risk of collisions due to the growing presence of orbital debris. This work analyzes a field of currently tracked debris and provides conjunction analysis for target satellite systems by direct numerical simulation. This analysis was accomplished by developing a low-earth orbit simulation in MatLab and populating the debris field with 2,000 publicly tracked debris items from their two-line elements. Restricted two body problems were solved to calculate each element's position and velocity relative to the International Space Station over an orbital period. Within the ISS orbit, twelve tracer satellites were simulated at 30-degree intervals based on the true anomaly. Debris risks were estimated by range. The results indicate the risk of debris encounters increases for true anomaly starting positions within 120-300 degrees with orbital velocities around 8 km/s.



Mohammed Abir Mahdi

Advisor: Dr. Wei Zhao

Experimental and numerical analysis of lattice structures using homogenization approaches.

Room 265 – Ballroom, 2:30 PM – 4:00 PM

Abstract: Homogenization approaches are employed to study structural responses of spatially periodic lattice structures. These were accomplished by treating the porous lattice structures as solid models with effective material properties. A lattice core sandwich plate available in the literature is first investigated in this study. The beam theory approach-based homogenization and the first-order shear deformation theory-based plate modeling have been employed to study the bending deflection of the lattice-structured plate under uniform pressure. The present results are in an excellent agreement with the results available in the literature, slightly 2% higher than Abaqus complete shell elements-based results. Then, the same model was studied by the developed FEM code for different lattice geometries (Square cell, Hexagonal cell, Triangular cell, etc.) to investigate their structural performance in weight savings and load-carrying capacities. Further, test coupons for the latticed structures will be manufactured using resin 3D printers and tested through ASTM three-point bending deflection experiments, enabling us to verify the developed code experimentally. Lastly, different unit cells and homogenization approaches for the lattice structures will be studied and discussed.

Rohit K. S. S. Vuppala

Advisor: Dr. Kursat Kara

Machine Learning based Reduced Order Modeling for wind-field prediction in urban spaces for Unmanned Aerial Systems.

Room 265 – Ballroom, 2:30 PM – 4:00 PM

Abstract: In recent years, Unmanned Aerial Systems (UAS) have penetrated the domain of civilian applications for various mission profiles. The ongoing urban expansion and ever-increasing interest in unmanned aerial vehicles have created the need for UAS in urban applications. Urban areas are usually characterized by heterogeneous landscapes primarily consisting of buildings with different shapes and sizes, leading to complex wind patterns in the urban canopy. Unlike UAS applications elsewhere, their applications in urban spaces are characterized by their significant size and weight restrictions due to the dense nature urban ecosystem. Small Unmanned Aircraft Systems have rapidly evolved to tackle these limitations but remain susceptible to external factors like gusts in urban wind fields. While numerical simulation models like Large Eddy Simulations (LES) accurately depict the unsteady wind in urban spaces, they are computationally expensive. Therefore, they are not feasible for real-time prediction. In comparison, Reduced Order Models (ROMs) are computationally less expensive. With the advent of machine learning (ML), robust ML-based Reduced Order Models (ML-ROMs) could be generated completely non-intrusively using the data or with some knowledge about the underlying physics.

Undergraduate Student Posters

Sam Glenn

Co-Authors: Mitchell Ford

Advisor: Dr. Arvind Santhanakrishnan

Morphological characterization of wing shapes of tiny insects

Room 265 – Ballroom, 4:00 PM – 4:45 PM

Abstract: The bristled wings of numerous species of tiny insects such as thrips and fairyflies show remarkable diversity in shape, ranging from short, teardrop-shaped to long, slender profiles. We document the interspecific diversity in forewing shape of thrips and fairyflies based on principal component analysis of wing geometries of 13 species of thrips and 28 species of fairyflies. Wing shapes and geometric characteristics (chord, wingspan, wing area) were measured in ImageJ from published forewing images of thrips and fairyflies. The first three principal axes of variation were found to be linearly correlated ($p << 0.01$) with: Axis 1 = total wing area (AT, R^2 = 0.91); Axis 2 = ratio of leading edge to trailing edge wing area (LE/TE, R^2 = 0.46), and Axis 3 = LE/TE (R^2 = 0.2). While wing area is well known to directly impact aerodynamic force generation, the effects of varying LE/TE on the flapping flight of tiny insects are unknown. Based on this information, we fabricated 3 scaled up elliptical wing models with LE/TE of 0.5, 1 and 2 which were tested at Reynolds number (Re) = 10 on a 3D flapping robotic model to determine the effect of LE/TE variation on flapping wing performance. Time varying lift and drag forces will be presented to examine aerodynamic effects of varying LE/TE.

Tuyen Nguyen

Co-Author: Furkan Oz

Advisor: Dr. Kursat Kara

Dynamic Stability Analysis of the Orion Capsule at Transonic Speed

Room 265 – Ballroom, 4:00 PM – 4:45 PM

Abstract: Atmospheric entry is a significant process for re-entry vehicles to safely land on a target planet or Earth. The vehicle decelerates from high Mach numbers to low supersonic/transonic regions during its descent because of the high drag force. For a safe landing, a parachute is required to reduce the vehicle's speed further. However, decelerating from high Mach numbers to a transonic regime induces a strong oscillation in the vehicle but the oscillation needs to be within a limit to safely deploy a parachute. Hence, it is a significant step of the landing, and it needs to be simulated extensively. However, the simulations are expensive because of the complex physics. Recent studies showed that reinforcement learning (RL) based reduced order modeling (ROM) is a powerful method to reduce the computational burden of high-fidelity simulations. In this study, we will investigate the flow around the Orion capsule in the transonic region to investigate the dynamic stability of the vehicle. The results will be compared with the available data in the literature. Moreover, the obtained spatiotemporal data will be used in the training of the novel RL based ROM approach.

Austin Rouser

Co-Author: Drew Cooley

Advisor: Dr. Kurt Rouser

An experimental evaluation of leading-edge surface roughness effects on propeller performance

Room 265 – Ballroom, 4:00 PM – 4:45 PM

Abstract: This poster presents the design and experimental results of two propellers with surface roughness compared to a baseline propeller. The motivation for this study is to gain understanding of ice accretion effects on propeller performance using surface roughness. Experiments were conducted on a subsonic wind tunnel dynamometer with a 3-ft by 3-ft test section. The test articles were based on an APC 16-in diameter propeller with a 10-in pitch. The leading-edge surface roughness was made with a staggered configuration of imbedded spheres. The surface roughness covered two spanwise extents along the leading edge. The area covered was composed of 17 spheres and 29 spheres to cover the two extents. The experiments for this study were conducted at three wind tunnel air speeds, ranging from 20-ft/s to 40-ft/s, and six propeller rotational speeds to achieve advance ratios, ranging from 0.25 to 0.70. The results from these experiments use thrust coefficient to capture propeller performance. The results indicate that some roughness can improve propeller thrust coefficient depending on the conditions. The observations from this study impact designers and operators that work with unmanned aircraft powered by propellers which operate in ice accumulating conditions and the research community around ice accumulation or surface roughness effects.

Mason Biliske

Advisor: Dr. Kurt Rouser

Aluminum-Infused PLA for Hybrid Rocket Fuel

Room 265 – Ballroom, 4:00 PM – 4:45 PM

Abstract: This study aims to explore the potential of using Aluminum-infused Polylactic Acid (PLA) as a hybrid rocket fuel. Hybrid rocket engines, which combine solid and liquid fuels, have gained attention in recent years for their use in rocket propulsion with enhanced performance enabled by additive manufacturing. Conventional PLA has been widely used as a solid rocket fuel due to its biodegradability and availability. However, its performance is limited in terms of specific impulse, mechanical properties, and thermal stability. Infusing aluminum into PLA is expected to improve its performance as a rocket fuel.

Static ground tests were conducted to gather relevant data and to evaluate the specific impulse, mechanical properties, and thermal stability of both conventional PLA and Aluminum-infused PLA. These experiments involve burning the PLA fuel grains in a hybrid rocket test stand and using load cells to measure data. Experimental results were analyzed to determine the effectiveness of Aluminum-infused PLA as a hybrid rocket fuel compared to conventional PLA. Final results provide valuable information for the development of more efficient and environmentally friendly hybrid rocket fuels.

Peyton Pierson

Co-Author: Furkan Oz

Advisor: Dr. Kursat Kara

Blunt re-entry vehicle Reinforcement Learning Model with adaptive mesh refinement to reduce computational load

Room 265 – Ballroom, 4:00 PM – 4:45 PM

Abstract: Blunt reentry vehicles entering the atmosphere experience significant drag forces. These drag forces decelerate the vehicle to low supersonic speeds to safely deploy a parachute. However, this process often introduces oscillatory behavior in the vehicle, particularly in low supersonic/transonic regimes. While current simulation techniques exist for investigating this phenomenon, they are computationally expensive, and reduced order modeling (ROM) can be used to investigate the dynamical stability of the vehicle within a more practical time. Closure models are common in many nonlinear spatiotemporal systems to account for losses due to reduced order representations, including many transport phenomena in fluids. Reinforcement learning (RL) is a powerful yet relatively uncharted method in fluid dynamics. An RL-based ROM may be a model that significantly decreases the solution time with high-accuracy results. However, RL-based ROM requires data generation for the training, which is computationally expensive. This study aims to simulate a nonlinear spatiotemporal problem with adaptive mesh refinement to reduce the computational burden. The number of elements will be adaptively changed based on the flow gradients. The results will be validated with experimental and numerical data.

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Frances Smith	Graduate College
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