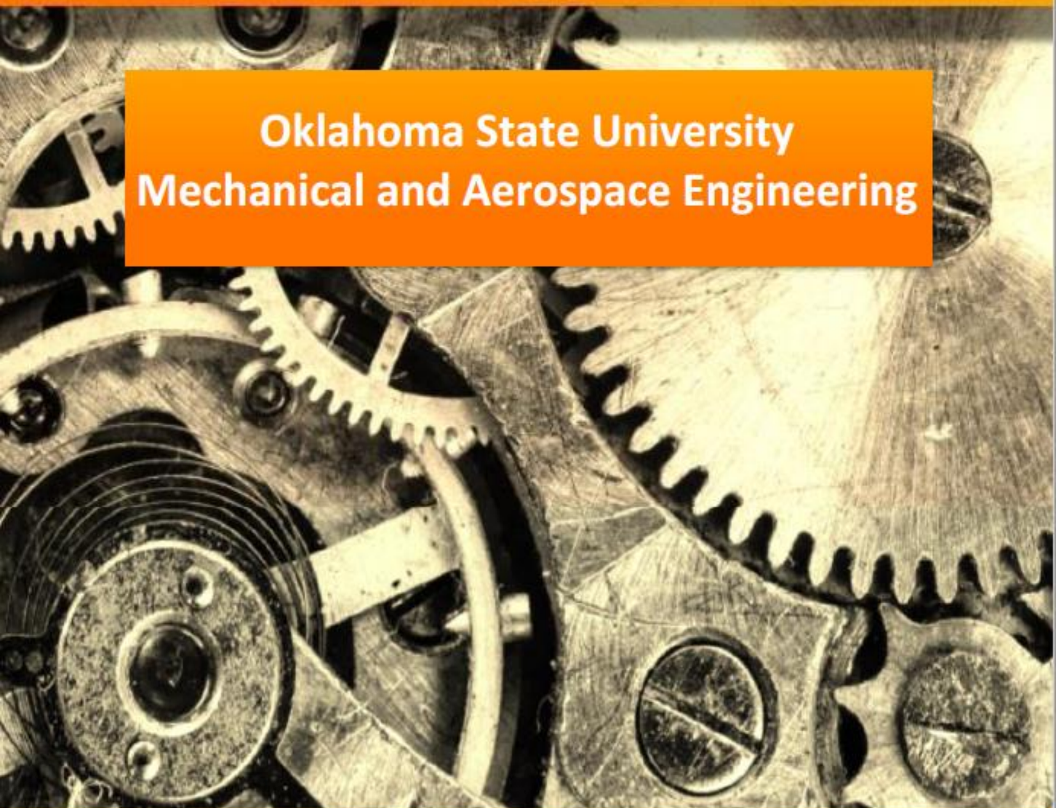
Oklahoma State University
Mechanical and Aerospace Engineering



4th Annual OSU MAE Graduate Research Symposium
March 30, 2022

Sponsors:
OSU Office of the Vice President of Research

@GSC_MAE   MAE GSC OKSTATE

ORGANIZERS

MAE Graduate Activities Committee

Dr. Arvind Santhanakrishnan
(Chair)

Dr. Rushikesh Kamalapurkar
(GROW-MAE)

Dr. Christian Bach

Dr. Craig Bradshaw

Dr. James Manimala

MAE Graduate Student Council

Mazharul Islam
(President)

Mehnaz Sharna
(Vice President)

Amjid Khan
(Secretary)

Table of Contents

Event location

ConocoPhillips OSU Alumni Center
201 Conoco Phillips Alumni Ctr (University Ave. & Hester St.)
Stillwater, OK 74078

4th Annual OSU MAE Graduate Research Symposium

March 30, 2022

Oklahoma State University

Event Schedule

7:30 - 8:00	Attendee Check-in & Breakfast
7:45 – 7:50	Welcome Remarks by MAE HOD, Dr. Sandip Harimkar
7:50 – 8:00	Opening Remarks by Dr. Arvind Santhanakrishnan
8:00 - 9:00	**Plenary Talk (Room: Click East):** Edwin Lee, Topic: What is a Graduate Student?
9:00 - 10:30	**Graduate Talks: Session 1;** **Room: Click East**
9:00 - 9:15	Presenter: Shady Ahmed, Topic: Hierarchical learning to generate surrogate models in fluid dynamics
9:15 - 9:30	Presenter: Leila Rezaei, Topic: Nanoscale chemical imaging of core-shell high-entropy oxide nanoparticles synthesized by nanosecond pulsed laser ablation
9:30 - 9:45	Presenter: Bryce Randall, Topic: Multi agent atmospheric data collection from rocket launched micro aerial vehicles
9:45 - 10:00	Presenter: S M Rakibur Rahman, Topic: Mechanical Characterization of Heterogeneous Hyperelastic Membrane Using Inverse Methods
10:00 - 10:15	Presenter: Samarjith Biswas, Topic: Exploring the Feasibility of Thermoacoustic Energy Harvesting

10:15 - 10:30	Presenter: Caleb Robb, Topic: Turning Dynamics of an Aircraft Featuring the Bell Span load
9:00 - 10:30	**Graduate Talks: Session 2;** **Room: Click West**
9:00 - 9:15	Presenter: Mitchell Ford, Topic: Know when to fold em: appendage bending kinematics in drag-based swimming
9:15 - 9:30	Presenter: Md Arif Billah, Topic: Multi-Agent Group Motions Generated by Models of Insect Small Target Detector Neurons and Feedback
9:30 - 9:45	Presenter: Suraj Pawar, Topic: Physics-constrained Deep Learning for Subgrid Modeling in Geophysical Flows
9:45 - 10:00	Presenter: Asma Tabassum, Topic: Towards Wind Aware Navigation and Control for Safe Urban Operation of Small Unmanned Aircraft System: Autonomous and Human-Centric Approach
10:00 - 10:15	Presenter: Furkan Oz, Topic: Application of the Quantum Computing for Heat and Burgers Equations
10:15 - 10:30	Presenter: Shuvrodeb Barman, Topic: Joint Fatigue-Based Optimal Posture Prediction for Maximizing Endurance Time in Box Carrying Task

10:30-12:00

Posters: Session 1 & Coffee Break;

Graduate Poster Presentations:

Poster 1, Presenter: Moad Abudia, Topic: System Identification with Error Bounds Using Carleman Linearization

Poster 2, Presenter: Mobashera Alam, Topic: Characterization of Sweeping Jet Actuator Flow Field using DMD Analysis

Poster 3, Presenter: Kevin Bhar, Topic: Tackling stochasticities in distributed Bayesian Langevin Dynamics

Poster 4, Presenter: Daniel Gassen, Topic: Advancement in Noninvasive Hormone Monitoring of Dolphins Using UAS Sample Collection Device

Poster 5, Presenter: Abby Haddox, Topic: A Smart Skin to Treat and Prevent Pressure Ulcers

Poster 6, Presenter: Amirarsalan Mashhadian, Topic: A brief overview of defrost detection methods for heat pumps

Poster 7, Presenter: Zackery Bycko, Topic: Design of a Hybrid Rocket Engine with 3D Printed Fuel Grains

Poster 8, Presenter: Talha Khan, Topic: Manufacturing of Efficient-Compact Thermal and Water Management Systems for Novel Space Technology using Laser Based Additive Manufacturing

Poster 9, Presenter: Braydon Revard, Topic: Urban Air Mobility Wind Collection

	Poster 10, Presenter: Shahbaz P Qadri Syed, Topic: Exploration of Approximate Inference for Control of Robotic Systems
	Poster 11, Presenter: Abhishek Tikar, Topic: Al0.5CoCrFeNi2 High Entropy Alloy Reinforced Aluminum Matrix Composite Using Spark Plasma Sintering
	Poster 12, Presenter: Jared Town, Topic: Learning Quadcopter Pilots Intent with Observer based Inverse Reinforcement Learning
	Poster 13, Presenter: Nick Zizzo, Topic: Piloted Simulation Environment Development Utilizing MATLAB/Simulink and FlightGear
	Poster 14, Presenter: Ashish Kumar Gupta, Topic: Synthesis of multi-principal element alloy functional nanoparticles by nanosecond pulsed laser irradiation
12:00 - 13:00	**Lunch Break**
13:00 - 14:30	**Graduate Talks: Session 3;** **Room: Click East**
13:00 - 13:15	Presenter: Shahzad Yousaf, Topic: Physics Informed Machine Learning Based Reduced Order Model of Unitary Equipment
13:15 - 13:30	Presenter: William Kresl, Title: Tunable Performance Metrics for Acoustic Liners
13:30 - 13:45	Presenter: Andrew Cole, Topic: Development and Evaluation of a 360Â° Differential Pressure Gust Sensor for Extreme Weather Environments

13:45 - 14:00	Presenter: Hao Chen, Topic: Invariant-EKF design for wind estimation from quadcopter
14:00 - 14:15	Presenter: Truc Ngo, Topic: Watch your step! Towards predicting osteoarthritis onset based on side-to-side imbalances
14:15 - 14:30	Presenter: Joshua Johnsen, Title: Integration and Testing of a 7-kW Turboelectric Power System in a Vertical Take-off and Landing Unmanned Aircraft
13:00 - 14:30	**Graduate Talks: Session 4; Room: Click West**
13:00 - 13:15	Presenter: Matthew Blair, Topic: Identifying Cognitive Load During Walking for Early Detection of Dementia
13:15 - 13:30	Presenter: Soroosh Farsiani, Topic: Cohesive peel of ultraviolet cross-linkable adhesive in polymer laminated metals
13:30 - 13:45	Presenter: Diego Colón, Topic: Dumb it down: A simplified metachronal locomotion mathematical model
13:45 - 14:00	Presenter: Bryce Lindsey, Topic: Development of Version 2 of the Ground-based Local Infrasound Data Acquisition (GLINDA 2.0) System
14:00 - 14:15	Presenter: Mehrdad Zomorodiyan, Topic: Nonlinear proper orthogonal decomposition for compressible flows

14:30-15:45

Posters: Session 2 & Coffee Break;

Undergraduate Poster Presentations:

Poster 1, Presenter: Hussein Alizereej, Topic: Effect of processing and sawing techniques on the measurement of aerosolized formaldehyde from cutting bone tissue samples

Poster 2, Presenter: Braxton Beavers, Topic: Atomic-Scale Insights on Large-Misfit Heterointerfaces in LSMO/MgO/c-Al2O3

Poster 3, Presenter: Vishal Barot, Topic: Development and Analysis of Bioresorbable Flow Diverting Stents to cure Brain Aneurysm

Poster 4, Presenter: Max DeSantis, Topic: Development of Wind-Aware Piloting Interfaces and Dynamic Quadrotor Simulator with Spatiotemporally Varying Wind

Poster 5, Presenter: Thomas Goebel, Topic: Hypersonic Boundary-Layer Stability Analysis for Local Wall Cooling

Poster 6, Presenter: Reuben Lane, Topic: Bioabsorbable Interlocked Nail System for 3D Printed Segmental Bone Defects

Poster 7, Presenter: Gabriel Webb, Topic: Wake characterization comparison between multi-appendage rowing and flapping at low Reynolds number

Poster 8, Presenter: Pramod Nayak, Topic: Design and Development of human brain phantom model to study traumatic brain injury

Poster 9, Presenter: Tuyen Nguyen, Topic: Computational Flow Analysis of 2D Wedge from Subsonic to Hypersonic Speeds

Poster 10, Presenter: Joel Quarnstrom, Topic: Adjustable Rehabilitation Elbow Exoskeleton Design and Prototype

Poster 11, Presenter: Patrick Williams, Topic: Lidar Applications in UAV Point-cloud Prediction

16:00 - 17:30 **Posters: Session 3 & Coffee Break;**

Graduate Poster Presentations:

Poster 1, Presenter: Ryan Narrell, Topic: Lessons Learned from Rocket Deployed UAS Development

Poster 2, Presenter: Scout Hernandez, Topic: Perspectives on weather communication products for decision-making

Poster 3, Presenter: Sanzida Hossain, Topic: Mixed Integer Optimization for Co-operative Driving of an Intelligent Human Vehicle (IHV)

Poster 4, Presenter: Emalee Hough, Topic: A Review of the 2021 NASA PSTAR Solar Balloon Campaign

Poster 5, Presenter: Rohit Vuppala, Topic: Wind Prediction for safe operation of small Unmanned Aerial Systems using Machine Learning

Poster 6, Presenter: Matthew McCool, Topic: Development of noise reducing geometry for a lightweight ceramic composite propeller for use in small unmanned air systems

Poster 7, Presenter: Kerrick Ray, Topic: Experimental Observations of the Boundary Layer and Movement of Barchan Dunes using Unmanned Systems

Poster 8, Presenter: Shafi-Al-Salman Romeo, Topic: Modeling Networking Flows in Elastic Tubes

Poster 9, Presenter: Mehnaz Sharna, Topic: Wind-aware sampling-based path planning UAV navigation

Poster 10, Presenter: Nahid Uzzaman, Topic: State-Dependent Noise Covariance prediction with Variational Wishart Process

Poster 11, Presenter: Zach Yap, Topic: Solar Balloon Trajectory Prediction

Poster 12, Presenter: Nissrine Aziz, Topic: 4D-Printed Liquid Crystal Elastomer Hinges for Soft Robotics Applications

Poster 8, Presenter: Soumya Mandal, Topic: Nanoscale chemical imaging of core-shell high-entropy oxide nanoparticles synthesized by nanosecond pulsed laser ablation

Plenary Speaker

Presenter: **Edwin Lee**

Biography: Edwin Lee is a researcher in the commercial buildings research group at the National Renewable Energy Laboratory (NREL). Edwin manages technical development of EnergyPlus, including maintenance and implementing new features. Prior to joining NREL, Edwin completed his graduate research at OSU. He developed and validated an EnergyPlus heat transfer model as MS work, followed by an improved solution algorithm for hydronic systems as his PhD work. His expertise is primarily in the fields of building heat transfer, building simulation tool development and ground heat transfer modeling.

Title: ***What is a Graduate Student?***

Abstract: In this talk, I will discuss my impression of life as a long-term graduate student at Oklahoma State University from an alumni perspective. My time there included positive and important experiences I encountered, and that shaped my interpersonal capabilities, enabling growth past graduation. I also enjoy staying in touch with the OSU thermal systems research crew, and with other alumni. In my talk, I will also highlight the importance of the education I received, the opportunities that my graduate experience opened, and also some lessons learned.

Graduate Research Abstracts for the Talk

Session 1:

Presenter: **Shady Ahmad**

Advisor: Dr. Omer San

Title: ***Hierarchical learning to generate surrogate models in fluid dynamics***

Abstract: We propose a hierarchical learning approach to extend the variational multiscale (VMS) methodology and build computationally efficient and accurate reduced order models (ROMs) for fluid flows. In the first step, ROM projection is used to naturally separate the flow scales into three categories: (i) resolved large scales, (ii) resolved small scales, and (iii) unresolved scales. In the second step, the terms representing the interactions among the three types of scales are explicitly identified. The novelty of the proposed framework is displayed in the third step, where we apply novel physics guided machine learning (PGML) algorithms to construct robust structural closure models for the interaction among the three types of scales. Specifically, the new framework builds ROM operators that are closest to the true interaction terms evaluated with the available data. Our numerical experiments for vorticity transport problems show that the new PGML-VMS-ROM paradigm maintains the low computational cost of current ROMs while dramatically increasing the solution accuracy.

Presenter: **Leila Rezaei**

Advisor: Dr. Aurelie Azoug

Title: ***Nanoscale chemical imaging of core-shell high-entropy oxide nanoparticles synthesized by nanosecond pulsed laser ablation***

Abstract: This work presents a detailed study on the nanosecond pulsed laser-induced dewetting phenomenon in nanoscale thin films leading to the formation of core-shell nanoparticles (CSNPs) of high-entropy oxide (NiCoCrFeMnO) via ultrafast melting and quenching. In this approach, NPs are formed via breaking the energetically unstable thin film using pulsed laser irradiation. The strong intermolecular interaction of atoms causes instability leading to the formation of holes followed by polygonal nanostructure and finally to NPs. It has been observed that the CSNPs have a near-spherical shape with an average size of ~160 nm and a contact angle of ~145Âº. Electron microscopic analysis reveals the formation of core-shell morphology in the NPs which is further confirmed by atom probe tomography investigations determining a Cr2O3-rich core and Fe2O3-rich shell. Another important observation is that shell thickness remains nearly constant regardless of the size of the CSNPs. Using numerical thermal simulations, it is deduced that the lower thermal conductivity and relatively slower cooling rate of Fe2O3 during rapid solidification process allow its segregation as a shell-layer around the core region causing the atomic-scale elemental rearrangements and the formation of high entropy oxide CSNPs.

Presenter: **Bryce Randall**

Advisor: Dr. Ryan Paul

Title: ***Multi agent atmospheric data collection from rocket launched micro aerial vehicles***

Abstract: Weather forecasting is pivotal in the world we live in today. However, it does have a flaw, the reliance upon weather balloons, a technology that has not changed much since its inception. This has not needed to change given that it works; however, it is a wasteful process because only about 20 percent of radiosondes are recovered. This is one of the issues with the weather balloons that they are not reusable. This is coupled with the fact that there is not much vertical resolution, given that once a weather balloon is released, it travels up at a set speed. Also, it coasts and does not give a vertical column of data. This is where a system of micro-ariel vehicles could be used. This offers significant advantages of being able to return to a point to be recovered, as well as powered flight, allowing the aircraft to have a slower sink rate vs. ascent rate of a weather balloon. This would better resolve data returned from the atmospheric boundary layer. If these vehicles were placed in a hobby rocket, it would also give a rapid response to changing conditions that would allow for more accurate forecasting, given that balloons are only launched twice a day. This could increase reusability and response times in weather forecasting as well as give better data resolution in the ABL.

Presenter: **S M Rakibur Rahman**

Advisor: Dr. Shuodao Wang

Title: ***Mechanical Characterization of Heterogeneous Hyperelastic Membrane Using Inverse Methods***

Abstract: Many soft biological tissues are heterogeneous, having different properties at different locations. Characterizing these tissues is very important for virtually testing potential medical technologies or protocols. Some synthetic thin structures used in various manufacturing processes are also complex in material composition. Determination of the mechanical properties of these structures is critical for industrial production. These materials can undergo very large deformation in actual applications and their behavior is nonlinear, makes their characterization difficult. In this study, hyperelastic material properties of a heterogeneous synthetic flat membrane with two constituent materials are determined using two inverse methods. One method is the traditional Finite Element Model Updating Method, and the other is based on machine learning using a deep neural network. Inverse modeling was done in moderate strain range (engineering strain up to 37 %) with the Neo-Hookean material model and in the large strain (engineering strain up to 93%) range using the Yeoh model. Both the inverse methods were found to have very good accuracy. The machine learning method was six orders of magnitude faster than the Finite Element Model Updating Method.

Presenter: Samarjith Biswas

Advisor: Dr. James Manimala

Title: ***Exploring the Feasibility of Thermoacoustic Energy Harvesting***

Abstract: The thermoacoustic effect provides a means to convert acoustic energy to heat and vice versa without the need for moving parts. This enables the realization of mechanically robust, noise mitigating energy harvesters, although there are limitations to the power-to-volume ratio achievable. The mechanical, thermal and geometric properties of the porous stack that forms a set of acoustic waveguides in thermoacoustic devices are key to its performance. In this feasibility study, firstly, various 4-inch diameter ceramic and polymeric stack designs are evaluated using a custom-built thermoacoustic test rig. The influence of stack parameters such as material, length, location, porosity and pore geometry are correlated to simulations using DeltaEC, a software tool based on Rotts linear approximation. An acousto-thermo-electric transduction scheme is employed to harvest useable electrical power using the best performing stack. Steady-state peak voltage generated was 5.5 mV for a temperature difference of 30°C between the hot and cold sides of the stack at an acoustic excitation frequency of 117.5 Hz. Further investigations are underway to establish structure-performance relationships by extracting scaling laws for power-to-volume ratio and frequency-thermal gradient dependencies.

Presenter: **Caleb Robb**

Advisor: Dr. Jerome Hausselle

Title: ***Turning Dynamics of an Aircraft Featuring the Bell Span load***

Abstract: This research is a study over the dynamics of an aircraft featuring the bell span load lift distribution theorized by Ludwig Prandtl. This lift distribution is thought to give the minimum induced drag given a wing-root bending moment constraint, a good metric in the comparison of structural weight. A side-effect of this lift distribution is the production of provers yaw upon traditional aileron application, caused by a small outboard section of the wing producing inviscid drag acting in the opposite direction as the freestream. This work has tested this phenomenon using both an inviscid vortex-lattice code and CFD, using both the wing exhibiting this distribution and an untwisted planform that does not. The analysis shows that, at the operating lift coefficient, the sign of the slope of the yaw moment with respect to aileron deflection angle plot is different between the models, as expected. A comparison can then be drawn between both the different models and the testing methods. Additionally, by the time of the symposium, a set of dynamic simulation results will be available to assess the impact of provers yaw on turning dynamics. This simulation uses aerodynamics data collected using the methods above as the salient inputs for developing external aerodynamic forces/moments.

Session 2:

Presenter: **Mitchell Ford**

Advisor: Dr. Arvind Santhanakrishnan

Title: ***Know when to fold em: appendage bending kinematics in drag-based swimming***

Abstract: Numerous species of aquatic invertebrates use paddling or rowing of multiple appendages for swimming. These invertebrates have widely varying body and appendage morphologies, ranging from soft-bodied organisms that swim with thousands of tiny cilia, to hard-bodied crustaceans that swim with several pairs of jointed legs. The motion of these appendages is typically coordinated into a metachronal (phase-shifted) gait, and the appendages bend during recovery stroke and unbend during power stroke. In this study, we use computational fluid dynamics (CFD) to investigate how changing bending angle and time periods to fully bend and straighten each paddle affect momentum transport in the wake at paddle-based Reynolds numbers (Re) ranging from 0.1 to 100. A two-dimensional immersed boundary formulation (IB2d) was used to model metachronal motion of jointed paddles. We find that horizontal momentum flux in the paddling wake is most sensitive to changes in the phase lag between adjacent paddles at Re = 10 or less, and most sensitive to changes in the maximum bending angle at Re > 10. Additionally, we found that sensitivity to bending kinematics (recovery stroke) increased with increasing Re, but that sensitivity to unbending kinematics (power stroke) increased with decreasing Re.

Presenter: **Md Arif Billah**

Advisor: Dr. Imraan Faruque

Title: ***Multi-Agent Group Motions Generated by Models of Insect Small Target Detector Neurons and Feedback***

Abstract: Considerable progress has been made in developing experimentally consistent models of insects in-flight sensing and feedback at the individual airframe level. The performance of the resulting bio-inspired sensing and feedback approaches in multi-agent and group contexts are not well-understood, which has been a barrier to implementing these approaches in robotic swarm platforms. This study begins to address this gap by studying the performance of 6 sensing and feedback control approaches in a multi-agent group. The study introduces a simplified mathematical model of small target motion detector (STMD) neurons discovered in hoverflies and dragonflies, which operate on optic flow signal calculated by elementary motion detectors. Six contemporary models of insect feedback are considered as guidance laws operating on this input for an autonomous multi-agent control system. The feedback models range from pursuit strategies to obstacle avoidance and motion camouflage. The performance of the multi-agent group is evaluated in a multi-agent kinematic simulation. The results suggest that feedback from STMD neurons can help insects participate in swarm motion, and that tools like motion camouflage may have benefits over traditional approaches such as proportional navigation.

Presenter: **Suraj Pawar**

Advisor: Dr. Omer San

Title: ***Physics-constrained Deep Learning for Subgrid Modeling in Geophysical Flows***

Abstract: Turbulent flows involve multiple spatio-temporal scales that are tightly coupled and hence the accuracy and generalizability of closure models play a critical role in their evolution. In recent years, data-driven subgrid-scale (SGS) modeling has started to show promising results in coarse-grid simulation of turbulent flows. There are several challenges such as limited physical consistency and poor generalizability that must be overcome before these models can be applied in the real world. In this work, we propose a frame invariant neural network model that incorporates physical symmetries as inductive biases, and its successful performance is illustrated for Kraichnan turbulence. We show that our frame invariant model accurately predicts the SGS source term, respects the physical symmetries such as translation, Galilean, and rotation invariance, and is numerically stable when implemented within coarse-grid simulation with generalization to different initial conditions and Reynolds number. This work builds a bridge between extensive physics-based theories and data-driven modeling paradigms, and thus represents a promising step towards the development of physically consistent data-driven turbulence closure models

Presenter: **Asma Tabassum**

Advisor: Dr. He Bai

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

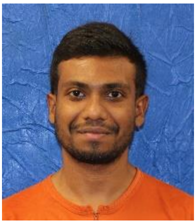
Abstract: In an effort to complement Urban Air Mobility efforts, we aim to address the rising operational and navigational challenges due to turbulence and investigate controller design concepts for both autonomous and human-centric operations. The wind-awareness in the onboard small Unmanned Aircraft System (UAS), as well as Ground Control Station, is expected to reduce the trajectory deviation, support the pilot in effective decision making, decrease remote pilot's cognitive load, and improve safe operations in low-altitude urban airspace in turbulent weather conditions. To do this, we design a turbulence rejection controller based on risk-sensitive control theory for efficient tracking in low-altitude flights. The initial result has shown improvement in tracking performance and can reduce the tracking error in terms of variance compared to traditional LQR as high as 7 times. For human-centric control, we are developing a wind-aware small unmanned aircraft system (sUAS) human-in-the-loop (HITL) simulator to study human-centric control and interaction during operation in a turbulent environment. The primary extension comprises integration of space and time-varying atmospheric boundary layer wind profiles in real-time simulation and wind information display in the UI.

Presenter: **Furkan Oz**

Advisor: Dr. Kursat Kara

Title: ***Application of the Quantum Computing for Heat and Burgers Equations***

Abstract: Quantum computing is in great interest not only for the aerospace industry but all areas that rely on high-performance computing heavily. Although utilization of quantum computing is extraordinarily challenging because of the difficulties in measurement and control, there is a significant investment for 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. In this paper, a recently introduced quantum algorithm for partial differential equations is implemented for well-known Burgers and heat equations, and a quantum CFD solver is developed. The performance of the quantum solver is assessed in one dimension with Burger's equation problem and two dimensions with heat equation problem. The problems are solved with both quantum and classical CFD solvers. The Quantum CFD results are compared with the solution obtained by classical CFD and an excellent agreement is found in between the results.



Presenter: **Shuvrodeb Barman**

Advisor: Dr. Yujiang Xiang

Title: ***Joint Fatigue-Based Optimal Posture Prediction for Maximizing Endurance Time in Box Carrying Task***

Abstract: In this study, the three-compartment controller fatigue model is integrated with an inverse dynamics optimization routine to predict the optimal posture, joint fatigue and endurance time for a box carrying task. The two-dimensional human model employed has 10 degrees of freedom. For the box carrying task, the feet are fixed on the ground, and the hand location and box weight are given. In the joint fatigue-based posture prediction formulation, the design variables are joint angles, three compartment control values, and total box carrying duration (endurance time). The objective is to maximize the total time subject to task and fatigue constraints including compartment unity constraint, residual capacity constraint, and a novel coupled failure constraint. The optimization successfully predicts the optimal posture, joint torque, endurance time, joint fatigue progression, and joint failure conditions. The proposed novel joint fatigue-based formulation predicts the optimal posture for maximizing the endurance time with given box weight for a box-carrying task. Finally, the simulation is computationally efficient, and the optimal results are achieved in just over 4 seconds CPU time on a regular computer.

Session 3:

Presenter: **Shahzad Yousaf**

Advisor: Dr. Craig Bradshaw

Title: ***Physics Informed Machine Learning Based Reduced Order Model of Unitary Equipment***

Abstract: Model predictive control strategies have become critical tools for building optimization over the past decade. For computational feasibility, these strategies require reduced order models of building equipment, including unitary equipment. Combining machine learning tools with conventional reduced order modeling approaches produces the potential for an enormous increase in the ability to select suitable models. This paper presents a machine learning based approach for modelling the performance of a variable speed, and load, unitary air-conditioning equipment. The experimental data is simplified by utilizing a feature selection methodology to accurately record and reduce the parameters while simultaneously preserving the physics of the system. A novel method is developed for model order reduction employing a Principal Component Analysis technique coupled with supervised Artificial Neural Network (ANN). The paper further explores the effect of ANN training methodologies for the problem at hand, conserving the fundamental relationship between input parameters and results. Preliminary results show that proposed technique can predict the equipment performance within ±5% of experimental results.

Presenter: **William Kresl**

Advisor: Dr. James Manimala

Title: ***Tunable Performance Metrics for Acoustic Liners***

Abstract: In the development of automated design tools for acoustic liners customized to mitigate specific noise spectral characteristics, it is often beneficial to have a unified quantitative metric to discriminate between candidate designs. Such metrics are especially useful when optimizing the packing of 3D folded cavities into a prescribed liner volume. We devise tunable performance metrics (TPM) that account for absorption parameters such as the peak absorption and the frequency at which it occurs, the bandwidth of appreciable absorption and its lower bound among others. Metrics are tuned by varying the weight functions for these absorption parameters in order to address the specific priorities for the liners design. A numerical study is conducted using a procedure based on the Zwikker-Kosten Transmission Line (ZKTL) theory to demonstrate the application of TPMs for the selection of acoustic liner designs for various scenarios. When liners with complex core geometries are used to enhance acoustic performance, TPMs that also include structural parameters related to mass, volume, stiffness or strength could be utilized to provide a more comprehensive means of evaluation.

Presenter: **Andrew Cole**

Advisor: Dr.Jamey Jacob

Title: ***Development and Evaluation of a 360° Differential Pressure Gust Sensor for Extreme Weather Environments***

Abstract: Measuring rapidly fluctuating high wind speeds and direction in the extreme weather environments of severe storms proves to be a difficult task with current sensors. For example, mechanical anemometers do not provide sufficient response time to detect micro-gusts and ultrasonic anemometers are quickly obscured by rain and other particles. In addition, most current systems are susceptible to damage from hail and debris. This effort details the design, implementation, and testing of a 360° gust probe using differential pressure sensors. Similar in concept to a multi-hole probe, this cylindrical probe uses multiple inlets connected to differential pressure transducer whose differential readings can provide high-resolution wind magnitude and direction measurements. This design can be manufactured using different transducers to allow for different accuracy, range, and resolution to meet the requirements for a wide range of applications, in its current test configuration the sensor is able to measure windspeeds. The probe has no external moving parts and is equipped with a purge system to vent water and debris from the inlets. This along with its small size and rigid construction make it damage resistant, creating a system uniquely suited to capture data in severe conditions.

Presenter: **Hao Chen**

Advisor: Dr. He Bai

Title: Invariant-EKF design for wind estimation from quadcopter

Abstract: Motivated by wind estimation techniques for small unmanned aerial vehicles (sUAVs) which can not only improve estimation performance and further improve the flight performance, but also can be used in environmental studies and meteorology, we consider a nonlinear estimation problem where a quadcopter moves under the wind field. We first show that the quadcopter dynamics is invariant and measurement equation is equivariant under actions of the SE(3) Lie group, and then we design an Invariant Extended Kalman Filter (IEKF) by taking advantage of symmetry in the system dynamics. The IEKF estimates the quadcopter position, relative wind velocity, orientation and wind field by using measured position, acceleration, magnetic field, angular velocity, and control thrust. The resulting design is successfully implemented and validated in simulations. Through Monte-Carlo simulations, we demonstrate that IEKF shows an improvement in transient performance over a conventional Extended Kalman Filter (EKF). We also build a thrust stand to find the accurate thrust model under windy condition and a quadcopter testbed system, which integrates a quadcopter, a motion capture system and a mobile robot for wind field measurement, to validate the effectiveness of IEKF experimentally.

Presenter: **Truc Ngo**

Advisor: Dr. Jerome Hausselle

Title: ***Watch your step! Towards predicting osteoarthritis onset based on side-to-side imbalances***

Abstract: Osteoarthritis (OA) is the most common form of arthritis, characterized by the progressive disappearance of cartilage. With no cure, OA onset causes joint pains and ultimately leads to surgical joint replacement. Side-to-side motion imbalances induce large joint contact force anomalies that correlate with a higher risk of OA onset. Therefore, developing an efficient clinical tool to assess imbalances can mitigate OA onset, improving the quality of life of millions of people. In developing a noninvasive predictive tool, we first implemented the simplest spring mass model possible, using a reduced set of experimental data to estimate motion imbalances during walking. The spring stiffnesses of each leg were optimized to reproduce vertical ground reaction forces (GRF) recorded during walking trials of several subjects. Our results confirmed that this simple mechanical model can reproduce human gait dynamics to help assess walking asymmetries. Next, we will establish the reliability of this model by using accelerations instead of GRF, which are feasible measures using a smart phone attached to a belt. This approach could then be used for a noninvasive clinical tool to evaluate large joint contact forces, and thus the risk of OA onset.

Presenter: **Joshua Johnsen**

Advisor: Dr. Kurt Rouser

Title: ***Integration and Testing of a 7-kW Turboelectric Power System in a Vertical Take-off and Landing Unmanned Aircraft***

Abstract: This paper presents the approach, implementation, and challenges associated with incorporating a 7-kW shaft power turboelectric system into unmanned aircraft system with a 390-N gross take-off weight. The aircraft selected for integration is a Mugin 3600. The stock configuration of the Mugin 3600 has four electric-driven lift rotors in an H-frame, boom-mounted arrangement, and a single aft-mounted piston-driven propeller for horizontal flight. The Mugin 3600 can be readily converted to an all-electric configuration by replacing the piston engine with an electric motor. This all-electric configuration, once fitted with a hybrid power system, becomes a flight representative subscale model of current conceptual urban air mobility vehicles. The scope of this work addresses aircraft physical layout, electric system design, and thermal management. The 12S power system includes two batteries capable of augmenting turbine power during vertical take-off and are rechargeable during cruise using available excess turbine power. Results of this paper include identification of key challenges and design choices, as well as the rationale and implementation for an aircraft with a safely integrated turboelectric power system.

Session 4:

Presenter: **Matthew Blair**

Advisor: Dr. Jerome Hausselle

Title: ***Identifying Cognitive Load During Walking for Early Detection of Dementia***

Abstract: Degenerative cognitive diseases are a major health issue. For example, there is currently over six million Americans diagnosed with Alzheimer's disease and this figure is expected to double over the next 30 years. Studies showed that subtle gait changes occur prior to any detectable cognitive decline, meaning gait-related parameters are good candidates for early detection of dementia. Our objective was to induce cognitive loading in healthy subjects and define measures that can detect changes in gait patterns. A total of 28 subjects walked five minutes on a treadmill under three levels of cognitive loading (arithmetic tasks). Coefficients of variation of nine kinematic and kinetic parameters were computed. We found that cognitive loading decreased the variability of the maximum pressure under the heel and toes, highlighting the tendency of the body to adopt a more cautious and thus less variable gait. Since plantar pressure can be measured using noninvasive insole sensors, this study provided relevant easy to measure parameters capable of detecting cognitive loading in healthy subjects. Future work will focus on building a larger database including healthy and demented older subjects, to determine a variability-based criteria for early detection of dementia.

Presenter: **Soroosh Farsiani**

Advisor: Dr. Hadi Noori

Title: ***Cohesive peel of ultraviolet cross-linkable adhesive in polymer laminated metals***

Abstract: Adhesively bonded polymer-metal laminates are of interest for many applications requiring multifunctional properties. The fracture characteristics of the adhesive bond are among the factors that determine the service conditions of these materials.

In this work, a UV cross-linkable adhesive layer (48 microns thick) was exposed to different UV doses to change its cross-linking degree and adhesion properties. The adhesive layer was sandwiched between a PET film (40 microns thick) and the AISI 430 stainless steel sheet (600 microns thick). Four weeks after preparation, the 180° peel tests at different peel rates were conducted on the laminated samples. In addition, the images of the sheet metal surface after peel tests were analyzed to calculate the areal percentage of adhesive that remained due to cohesive fracture.

The fractography showed a combined interfacial-cohesive fracture for all samples in the range of studied parameters. A higher UV dose and lower peel rate resulted in a more cohesive fracture. The increase in peel force with the peel rate for the lowest UV dose condition was nullified for samples with higher UV doses. Also, peel force was increased at least 6.5 times for higher UV dose conditions compared to the lowest dose condition.

Presenter: **Diego Colón**

Advisor: Dr. Arvind Santhanakrishnan

Title: ***Dumb it down: A simplified metachronal locomotion mathematical model***

Abstract: Metachronal swimming is the main underwater propulsion strategy used by many aquatic crustaceans. Inspired by this widely observed swimming technique, we designed and developed a metachronal paddling-powered remotely operated vehicle (MP2ROV) and modeled its dynamic behavior. A nonlinear ordinary differential equation for motion in the body's longitudinal axis was derived, approximating each paddling leg as two plates oscillating about their edges. On the MP2ROV, eight such legs were actuated using one servomotor per leg, and a common controller was used to prescribe kinematic parameters and phase lags to each leg. In the mathematical model, fluid interactions between legs were not included and the propulsive force contribution of each leg was calculated using an assumed drag coefficient to determine the total force. A comparison of the swimming speeds predicted by the mathematical model with those of the MP2ROV will be presented.

Presenter: **Bryce Lindsey**

Advisor: Dr. Brian Elbing

Title: ***Development of Version 2 of the Ground-based Local Infrasound Data Acquisition (GLINDA 2.0) System***

Abstract: Evidence suggests that during tornado genesis and through the life of a tornado, acoustic waves at frequencies below human hearing (i.e. infrasound) are produced. To date, data required to identify the fluid mechanism responsible for this infrasound has been extremely limited. To expand the number of samples, the design and deployment of the Ground-based Local Infrasound Data Acquisition (GLINDA) system was completed at Oklahoma State University in early 2020. GLINDA was deployed with storm chasers based out of Oklahoma in May 2020 and has returned data over multiple severe weather events including one confirmed tornado. The original GLINDA system used an expensive microphone and required integration with the data network used by the storm chaser. The 2nd version of this unit (GLINDA 2.0) is currently in development with the objective of reducing the physical footprint and total cost in addition to integrating its own data transmission capabilities. This presentation will give an overall introduction to the GLINDA system as well as the current GLINDA 2.0 development status.

Presenter: **Mehrdad Zomorodiyan**

Advisor: Dr. Omer San

Title: ***Nonlinear proper orthogonal decomposition for compressible flows***

Abstract: Solving nonlinear dynamical systems is computationally expensive. Reducing the computational costs while maintaining the accuracy will have a significant impact on many scientific studies and industrial projects. Toward this goal, we create a reduced order model (ROM) consisting of three main parts: (i) proper orthogonal decomposition (POD) is applied to extract modes containing 99% of the system's energy, (ii) the projection coefficients are converted to a latent space through an autoencoder network, and (iii) a time series predictor is applied to learn the latent space dynamics. To test our non-linear POD (NLPOD) framework, we first solve the Riemann problem in a 2D geometry with specific configurations for multiple initial conditions to obtain density fields at different times. The ROM is then trained on these snapshots, and it is used to predict the solution for an unseen initial condition. Our numerical experiments show the robustness of the proposed NLPOD method with respect to accuracy and efficiency. Moreover, our results indicate that we can generate effective ROMs for complicated dynamical systems with shocks and contact discontinuities while achieving accurate predictions.

Graduate Research Abstracts for the Poster

Session 1:

Presenter: **Moad Abudia**

Advisor: Dr. Rushikesh Kamalapurkar

Title: ***System Identification with Error Bounds Using Carleman Linearization***

Abstract: While identification of liner systems reduces to an order estimation problem and a parameter estimation problem, identification of nonlinear systems cannot be reduced to such well-defined problems, since there are an infinite number of nonlinear equations that can define a system for a given order. The method in this presentation is designed to identify uncontrolled or closed loop nonlinear systems with polynomial equations using a set of trajectories that are generated by the system in a domain of attraction. The focus of this project is to ensure that the trajectories of the identified systems are close to the trajectories of the real system, as quantified by an error bound that is prescribed a priori. A majority of existing methods for nonlinear system identification rely on techniques such as NNs, ARMAs, and spectral decomposition, that do not provide error bound guarantees. The developed method uses Carleman linearization to lift the nonlinear system to an infinite dimensional linear system, truncates it to a suitable order based on the prescribed error bound, and estimates the parameters of the truncated linear system. The results are demonstrated in simulations of Van der Pol oscillator, where the system is identified, and its trajectory is predicted within an error bound

Presenter: **Mobashera Alam**

Advisor: Dr. Kursat Kara

Title: ***Characterization of Sweeping Jet Actuator Flow Field using DMD Analysis***

Abstract: A sweeping jet actuator (SJA) is an active flow control device that creates a self-induced and self-sustained spatially oscillating jet at the outlet when pressurized with fluid. The SJA increases the local flow momentum without moving parts and is a promising way to suppress aerodynamic flow separation. In practical applications, the integration of SJA with curved aerodynamic surfaces results in various exit nozzle geometries that are different from an isolated SJA exit nozzle geometry. A previous computational study found that the oscillation frequency of SJA is not affected by external geometric variations such as exit nozzle shape. However, the velocity field downstream of the actuator is altered significantly, showing sensitivity to exit nozzle geometry. The poster will present the SJA flow field analysis using fast Fourier transformation and Dynamic Mode Decomposition methods.

Presenter: **Kevin Bhar**

Advisor: Dr. He Bai

Title: ***Tackling stochasticities in distributed Bayesian Langevin Dynamics***

Abstract: Bayesian learning provides an efficient sampling framework with an in-built uncertainty estimation to perform parameter estimation tasks as a robust alternative to traditional optimization techniques. Langevin dynamics-based Markov Chain Monte Carlo methods have received a lot attention to perform such Bayesian sampling. Although the framework itself is highly scalable for huge datasets, the computational and time requirements pose a bottleneck when it comes to such datasets.

This is primarily due to the gradient computation since Langevin dynamics inherently relies on the gradient information. Further difficulty arises due to the lack of availability of the entire data at a central server due to physical and privacy constraints. Under such circumstances often the data is distributed among a network of agents who work in tandem to conclude the best possible common parameters without exchanging the data itself. Here, communication among agents is key, but also poses an additional overhead. Inspired by these non-trivial challenges, we tackle the problem of distributed Bayesian learning among agents with various protocols to reduce the strain of heavy gradient calculation and inter-agent communication while guaranteeing convergence of the estimations in a probabilistic sense.

Presenter: **Daniel Gassen**

Advisor: Dr. Jamey Jacob

Title: ***Advancement in Noninvasive Hormone Monitoring of Dolphins Using UAS Sample Collection Device***

Abstract: Marine biologists can monitor the stress of dolphins by collecting and analyzing the hormone cortisol contained in the mucus that is produced from their blowhole during exhalation. This approach is noninvasive, whereas existing methods require the capture of wild dolphins to collect data on their stress levels. To collect mucus samples, a developed collection mechanism attached to an Unmanned Aerial System (UAS) can be launched from a boat, and then fly through the blow field of the dolphins expelled breath. A simulator that replicates the blow field of the dolphins breath was constructed to test the effectiveness of UAS collection mechanisms. Initial designs used a small, hand-launched, fixed-wing UAS using opening and closing Petri dishes attached to the bottom of the wings. To improve upon what was learned from this design, a larger, Vertical Takeoff and Landing (VTOL), fixed-wing UAS is used to increase endurance, allow for more space for improved sample collection mechanisms, and still allow for takeoff and landing from a small boat. The acoustics properties of the larger aircraft are tuned to avoid distressing the dolphins. Results from acoustics tests and flight tests over the dolphin breath simulator are used to validate the new systems capability for sample collection.

Presenter: **Abby Haddox**

Advisor: Dr. Aurelie Azoug

Title: ***A Smart Skin to Treat and Prevent Pressure Ulcers***

Abstract: Pressure Ulcers (PUs) are injuries of the skin and underlying tissue resulting from prolonged applied pressure on a bony prominence. They affect 2.5 million patients per year in the United States. One strategy to mitigate the risk of PUs is to reduce the peak pressure on the skin. The long-term 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 characterize the mechanical behavior of LCEs under local compression. We compressed cylindrical LCE specimens with a constant pressure during 0, 15, 30, or 60minute intervals. The specimen was then cured with UV light to the deformation into place and cut into slices to observe the transition in alignment of the molecules from disoriented to oriented. Preliminary results showed a transition zone of 6-mm radius in all specimens. This transition zone is expected to vary with time due to mechanical creep. In the future, these results will be compared to the responses of a constitutive model of the mechanical behavior of LCEs, currently under development in the lab. We will also measure the effectiveness of the smart skin by quantifying the decrease in peak pressure under human subjects heels due to the smart skin.

Presenter: **Amirarsalan Mashhadian**

Advisor: Dr. Christian K. Bach

Title: ***A brief overview of defrost detection methods for heat pumps***

Abstract: Heat pumps are energy-efficient heating devices for buildings. Frost can build up on the heat pumps evaporator surface depending on outdoor weather conditions. This decreases heat transfer rate. Consequently, the heat pumps performance decreases, eventually requiring energy intense defrosting.

One of the most employed techniques for defrosting is the reverse cycle method, temporarily turning the heat pump into an air conditioner removing heat from the building in winter. Defrosting at the optimum time reduces the impact of required defrost cycles.

Frost detection is essential for discovering the energy optimum time for defrosting. Several methods for frost detection exist in the laboratory. Conventional strategies to initiate defrosting are simple, but not energy optimal. In the worst case, defrosting occurs too late, leading to equipment malfunction. Here, we present a brief overview of the state of the art in defrost detection methods at the laboratory stage, along with their limitations.

Presenter: **Zackery Bycko**

Advisor: Dr. Kurt Rouser

Title: ***Design of a Hybrid Rocket Engine with 3D Printed Fuel Grains***

Abstract: This paper presents the design of a hybrid rocket engine with 3D-printed fuel grains. A hybrid rocket motor featuring 3D-printed fuel grains provides an engine system capable of reduced operational expenses with a low-cost reusable motor, reduced operational hazards by having separate fuel and oxidizer, and tailored rocket performance with custom grain geometry and composition. The potential use of these hybrid rocket motors could be for rocket assisted take off for high-speed UAS to achieve the minimum flight speed for sustained flight. This research evaluates the use of polylactic acid (PLA) filament as a potential propellant in a hybrid system. 3D-printing fuel grains provides a safer alternative to the volatile nature of solid rocket propellants, as well as simplifying manufacturing and easing storage requirements associated with fuel grains. Hybrid rocket motors consist of two different propellant states: a solid fuel and a liquid or gaseous oxidizer. This combination of propellant states offers a benefit of simplicity when compared to most bipropellant liquid motors, while out-performing solid and monopropellant liquid motors. With this technology, complex core geometries can be created to increase surface area in contact with the oxidizer for better burn characteristics.

Presenter: **Talha Khan**

Advisor: Dr. Nair Rajeev

Title: ***Manufacturing of Efficient-Compact Thermal and Water Management Systems for Novel Space Technology using Laser Based Additive Manufacturing***

Abstract: The 21st century has seen a race to provide an economical, reliable and safe access to outer space by various space agencies around the globe. In order to achieve this objective, NASA has identified the need for manufacturing next-generation thermal and water management systems. These systems are designed to provide cooling and water management in compact and lightweight spacecrafts/ CubeSat designs, thereby increasing the efficiency level of the existing systems. The current liquid-vapor, phase -change based thermal and water management systems employed by NASA, require a larger surface area for improved performance thereby resulting in increased weight, complexity of design and manufacturing and the cost of the spacecraft and the spacesuits. A novel microsecond pulsed-laser sintering/hot pressing technique using metallic micro powders is performed to create bimodal capillary wicks that having extremely low thermal resistance. This innovative evaporator/condenser wick-structure mechanism manufactured using a fast turnaround, laser based additive manufacturing process creates thermally efficient wick structures with controlled porosity and permeability, paving the way for a revolutionary thermal management system.

Presenter: **Braydon Revard**

Advisor: Dr. Jamey Jacob

Title: ***Urban Air Mobility Wind Collection***

Abstract: 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. A fleet of specialized UAS quadrotors will collect local wind data around buildings and urban environments and transmit the data in real time to ground stations in said urban environment to help in creating a real-time suggested flight path. Wind measurements will be taken around buildings on the Oklahoma State University campus, specifically the Kerr-Drummond buildings. One UAS quadrotor with a Trisonica Ultrasonic Anemometer to measure wind speed and direction, and a five-hole probe to collect atmospheric data will be utilized in initial testing phases. Once wind and atmospheric data can be accurately collected around urban environments, more UAS systems with the data collection technology will be built and implemented. After several UAS systems can capture wind speed in multiple locations, a system will be built to send the wind data from the UAS quadrotors to a ground station in real-time.

Presenter: **Shahbaz P Qadri Syed**

Advisor: Dr. He Bai

Title: ***Exploration of Approximate Inference for Control of Robotic Systems***

Abstract: The general Stochastic Optimal Control (SOC) problem is hard to solve exactly in all but the simple cases such as the LQG. Hence, it was suggested in the literature that a special class of SOC problems can be solved using probabilistic inference. Motivated by this idea the Approximate Inference Control (AICO) algorithm solves the Trajectory optimization problem using approximate inference on graphical models. In the present work, we study this algorithm for two cases 1) A robotic arm system that is linear in the state-space but non-linear in the observation space. 2) A non-holonomic mobile robot with an equality constraint on one of the controls. In particular, we explore the performance of the algorithm for the case where the total time of the trajectory is insufficient. Ideally, we expect the algorithm to be consistent with the dynamics even if it doesn't solve the SOC problem. However, we observed that in such situations due its intrinsic nature, the AICO algorithm infers trajectories that although solve the SOC problem, violate the system dynamics and hence are practically infeasible. We propose that a state extension of the original dynamics can overcome this limitation and drive the AICO algorithm to infer trajectories that are aligned with the expected behavior.

Presenter: **Abhishek Tikar**

Advisor: Dr. Sandip Harimkar

Title: ***Al0.5CoCrFeNi2 High Entropy Alloy Reinforced Aluminum Matrix Composite Using Spark Plasma Sintering***

Abstract: In this study, aluminum matrix composite with 5 vol% Al0.5CoCrFeNi2 high entropy alloy as reinforcement was processed using spark plasma sintering. The specimens were processed at 525°C at 70 MPa for a range of holding times (10, 15, 20, and 30 min). XRD data did not reveal the formation of any new phases in the composite material. The interdiffusion layer was not observed for the sample processed for 10 min. In rest of the samples, thickness of the interdiffusion layer also increased with an increase in processing time (7µm, 12µm, 14µm respectively). The interdiffusion layer had the smooth inner region, adjacent to the high entropy alloy particle, with uniform diffusion, and the outer non-uniform region, adjacent to the aluminum matrix. Nanoindentation data for the HEA particle, interdiffusion layer, and aluminum matrix suggested the formation of intermetallic precipitates in the interdiffusion layer. The specimen with 10min holding time showcased adhesive wear behavior. The samples with holding times of 15min, 20min, and 30min displayed abrasive wear mechanism. The microscopic inspection of the wear track revealed that the interdiffusion layer acted as a stress concentration zone and fractured during wear, debonding the high entropy alloy particle and the aluminum matrix.

Presenter: **Jared Town**

Advisor: Dr. Rushikesh Kamalapurkar

Title: ***Learning Quadcopter Pilots Intent with Observer based Inverse Reinforcement Learning***

Abstract: The problem of learning a quadcopter pilots intent (cost function) through observing their behavior (trajectories), known as inverse reinforcement learning (IRL), has proven difficult and computationally complex. Solving this will allow an accurate pilot model to test path recommendations against to not exceed the pilots skill. Also, modeling the pilots intent enables generated controllers to function like the pilot. We utilize a novel online IRL History Stack Observer (HSO) to learn the pilots cost function under the conditions that the pilot makes optimal decisions with regards to a quadratic cost function and that the IRL problem admits a unique solution up to a scaling factor. Simulation results indicate that the IRL HSO can discover an equivalent cost function that reproduces the observed behavior to an extent but cannot estimate the actual cost function. The results indicates that the pilot modeling problem does not satisfy the uniqueness assumption required for convergence of the HSO. As such, the development of a novel IRL method that does not require the uniqueness assumption and guarantees converges to equivalent (not true) cost function is needed to address the pilot modeling problem using IRL.

Presenter: **Nick Zizzo**

Advisor: Dr. Ryan Paul

Title: ***Piloted Simulation Environment Development Utilizing MATLAB /Simulink and Flight Gear***

Abstract: Traditionally, evaluating pilot workload is heavily reliant on the use of subjective rating scales, predominately the Cooper-Harper handling qualities rating (CHR), with some studies incorporating NASA TLX, DIPES, and others additionally. Several researchers have attempted to identify reliable metrics to quantify pilot workload quantitatively to avoid well-documented issues with pilot assessed workload, including intra- and inter-pilot variation from use of subjective scales. A recent Navy effort showed correlation between self-assessed pilot workload in the form of the ubiquitous CHR scale and candidate pilot inceptor workload (PIW) metrics. A complication in application of these PIW metrics to a group of pilots were the differences in apparent slope of the PIW metric to qualitative workload reported by each pilot. Initial data suggests reliable application of such PIW metrics will require baselining individual pilots prior to relying on the indications provided by the metric. To improve correlation of potential metric and subjective rating, the work herein aims to develop a suitable simulation environment for baselining pilot participants in the performance of a sum-of-sines tracking task.

Presenter: **Ashish Kumar Gupta**

Advisor: Dr. Ritesh Sachan

Title: ***Synthesis of multi-principal element alloy functional nanoparticles by nanosecond pulsed laser irradiation***

Abstract: We investigate the nanosecond pulsed laser-induced dewetting phenomenon in NiCoCr multi-principal element alloy (MPEA) thin films. MPEAs are single-phase solid solution alloys that consist of two or more principal elements in near equal mole ratios and are randomly distributed over the same atomic lattice sites. The laser-induced dewetting approach follows the breakup of energetically unstable films (<~20 nm) under laser irradiation leading to the formation of MPEA nanoparticles. We demonstrate thin film dewetting induced NiCoCr nanoparticle formation on inert substrates of SiO2 and Carbon with an average size of ~180 ± 15 nm and ~120 ± 15 nm, respectively, where individual nanoparticle demonstrates a uniform distribution of constituent Ni, Co and Cr elements. Electron microscopy investigations further show the nearly spherical shape of the NPs with contact angles between 125-145o owing to the surface energies of NiCoCr and the substrates. During laser irradiation, a unique microstructure is evolved in the NPs due to a fast-melting and solidification process which is investigated using a nanoscale data-analytics 4D-STEM approach. This uncovers an accurate determination of nanocrystalline grain arrangement within a single nanoparticle leading to new properties and applications.

Session 2:

Presenter: **Ryan Narrell**

Advisor: Dr. Jamey Jacob

Title: ***Lessons Learned from Rocket Deployed UAS Development***

Abstract: The Argonia Cup competition is based around a rocket deployed UAS. Certain design constraints must be followed for an entry to be successful. The payload of a golf ball is needed to reach an apogee of at least 8,000 feet, but the rocket could only launch on a maximum of a size L motor. From these simple constraints, the size of the rocket body and motor can be simulated to find the optimal components. To return the payload safely and as close to the target as possible there are multiple options for UAS vehicles. The option that can most accurately land at the center of the target would be a quadcopter. Although this has the highest change to land at the center, there are certain drawbacks that appear when trying to design a quadcopter that can be deployed from a rocket. The other main option would be a glider. This can be either piloted or fully autonomous but will be more difficult to land at the center of the target. This drawback is not as prominent if consistency and low complexity are the priority. Once the payload has landed, the vehicle and rocket have to be relaunchable without any maintenance for the entry to count. With all of the constraints and design challenges, Oklahoma State University has successfully won all four years of the competition since it began.

Presenter: **Scout Hernandez**

Advisor: Dr. Nicoletta Fala

Title: ***Perspectives on weather communication products for decision-making***

Abstract: Weather is a main influencing factor that determines if a pilot can fly on a given day. Unfavorable weather conditions lead to sensor malfunctions, uncomfortable flights, changed plans, and potentially, accidents which may result in injuries or death. In this research, we use focus groups to gather perspectives of General Aviation (GA) pilots and Uncrewed Aerial Systems (UAS) operators on weather communication products (such as Radar Summary Charts and Winds Aloft information) and how they influence their decision making. While pilots have used such products for years, UAS operators are newer to the airspace and may not use the products in the same way. Understanding how both pilots and operators prepare for their flying activities in regard to weather and weather prediction will help us modify the products to make them more useful to both the pilot and operator populations. New or modified weather communication products that result from data gathered through our focus groups may increase the comfort and confidence level of operators and pilots when they fly by helping them make better-informed decisions.

Presenter: **Sanzida Hossain**

Advisor: Dr. He Bai

Title: ***Mixed Integer Optimization for Co-operative Driving of an Intelligent Human Vehicle (IHV)***

Abstract: An Intelligent Human Vehicle (IHV) operates with both Human and autonomous inputs. This type of driving is called cooperative driving. A cooperative driving system is a hybrid dynamical system with continuous and discrete dynamics where the discrete-state transitions depend on both deterministic and stochastic events. Our research goal is to find the best method to optimize the performance of an IHV under various operating conditions. The optimization formulation is modeled using Mixed Integer Programming (MIP). Different methods to solve the MIP are being implemented and tested in our research. The data obtained from the various optimization methods will be used to train machine learning (ML) models so that an ML technique can replace the optimizer and thus enabling us to find the optimal solution faster.

Presenter: **Emalee Hough**

Advisor: Dr. Jamey Jacob

Title: ***A Review of the 2021 NASA PSTAR Solar Balloon Campaign***

Abstract: Helium weather balloons have been an integral part of atmospheric sciences since its inception. A main drawback to using a helium balloon is that it only takes a thin slice of the atmosphere over a short period of time and requires a large logistical cost for helium storage and transport. Recent advances in zero-pressure solar balloons have shown longer flight times, a greater array of flight path and altitude options, rapid deployment, and more robust construction. Solar balloons are made from low-cost lightweight materials that absorbs solar radiation for buoyant lift and can carry a two-pound payload up to over 20 km. Solar balloons float at ~20 km altitude and drift with prevailing wind, which mitigates ground contamination effects that can impact ground-based measurements. Ongoing research is being conducted at Oklahoma State University with the NASA Jet Propulsion Laboratory and Sandia National Laboratory, using zero pressure solar balloons and infrasonic microphone packages to detect small magnitude earthquakes as a proof of concept for atmospheric studies on Venus. Last summer OSU held a campaign, launching 52 solar balloons over the course of 3 months for seismic observation. Details of this campaign, flight system and instrumentation will be discussed more in depth.

Presenter: **Rohit Vuppala**

Advisor: Dr. Kursat Kara

Title: ***Wind Prediction for safe operation of small Unmanned Aerial Systems using Machine Learning***

Abstract: There has been an ever-increasing interest in recent years for Unmanned Air Systems due to their diverse applications and ease of access. As the complexity around these systems grew, so did the need to augment these vehicles with ground control stations (GCS), command and communication links, and other auxiliary subsystems. Recently, UAS applications have penetrated the civilian domain for various mission profiles like law enforcement, general reconnaissance, aerial structure inspection, disaster management, urban mapping and in the near future delivery and catering services. However there are significant, size and weight restrictions for many of these applications in the urban environment due to the urban ecosystem's dense nature. Small Unmanned Aircraft Systems have rapidly evolved to tackle these limitations, but they remain susceptible to external factors like wind, gusts, and turbulent wakes produced by urban structures. Pilot awareness of wind predictions could greatly improve the reliability and safety associated with the systems for robust operation. This work is an effort to use high-fidelity data from CFD simulations like Large Eddy Simulations and make wind predictions for safe wind-aware navigation of Unmanned Aerial Systems in city spaces using Machine Learning

Presenter: **Matthew McCool**

Advisor: Dr. Jamey Jacob

Title: ***Development of noise reducing geometry for a lightweight ceramic composite propeller for use in small unmanned air systems***

Abstract: The main focus of this project is the propellor geometry development for the acerolaۥ program, a radically new lightweight ceramic composite propeller for use in small unmanned air systems (SUAS). The team consists of Hydronalix, Inc. and the Oklahoma State University Next Generation Materials Laboratory who will design, fabricate, and test a new Scimitar type propeller design to radically increase aerodynamic efficiency through implementation of this new propeller design. This design will seek to maintain required thrust characteristics of a given airframe while reducing the noise signature considerably when compared to state-of-the-art commercially available propellers. This could be achieved via combination of both propeller optimization and Blade Vortex Interaction Reduction. Most importantly, the application of this propeller design will improve UAV performance without any additional modification to the existing platform designs.

Presenter: **Kerrick Ray**

Advisor: Dr. Jamey Jacob

Title: ***Experimental Observations of the Boundary Layer and Movement of Barchan Dunes using Unmanned Systems***

Abstract: Desert dunes offer unique geophysical interactions, and these aeolian 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. We pursued whether the movement of desert dunes can be accurately measured using unmanned aerial systems (UAS) data and a structure-from-motion as well as tracking boundary layer propagation and change in the topography during the boundary layer interaction. This volatile landscape makes an ideal setup for tracking imagery combined with the effect of atmospheric data.

Atmospheric profiles were flown using UAS with a 3D ultrasonic anemometer onboard. Since the wind comes predominately from the South at the site, the profiles progressed from an upstream location to a downstream location. Each flight was flown remotely from approximately half a mile away. The anemometer was sampling at a rate of 10 Hz. The data is promising, despite some noticeable noise, and shows the wind acting as expected flowing smoothly over the crest before becoming turbulent at the base of the leeward side.

Presenter: **Shafi-Al-Salman Romeo**

Advisor: Dr. Omer San

Title: ***Modeling Networking Flows in Elastic Tubes***

Abstract: In diagnosis of heart disease, such as atherosclerosis, arrhythmia or hypertension, blood flow rate and pressure are good indicators for the presence of blockage in the arteries. One-dimensional modelling of the human cardiovascular system based on the Pulsed Flow Equations (PFE) can be useful in predicting the dynamics of blood flow propagation through these arterial elastic tubes. Here, the consequent nonlinear coupled system of equations is solved by the finite-differences methods like Lax-Wendorff scheme and WENO scheme and is then applied to an open 1D axisymmetric model arterial network of the human vascular system containing the largest 55 arteries. The critical effect of the nonlinear term in bifurcation points in the network has been solved with iterative schemes (e.g., Newton-Raphson method). Moreover, the various lumped parameter outflow boundary conditions for distal terminal points are also analyzed. The results indicate that the proposed numerical model can be used as an effective tool for investigating the dynamics of reduced-order models of flows in physiological systems and would be a good candidate for the macroscopic level of description of geometric multiscale of physiological systems.

Presenter: **Mehnaz Sharna**

Advisor: Dr. Rushikesh Kamalapurkar

Title: ***Wind-aware sampling-based path planning UAV navigation***

Abstract: Establishing secure navigation in cluttered environments and in the presence of unpredictable wind gusts for unmanned aerial vehicles (UAVs) is crucial for applications like package delivery and rescue missions. Existing methods typically plan trajectories assuming there is no wind and use a robust internal loop controller to ensure that the path is followed accurately in the presence of real wind. In this paper, we develop a method in which a clean and collision-free path in the presence of unknown wind disturbances is generated in real time for a quadrotor. In this work, inspired by Luders et al., 2016 a family of wind models is developed for different wind conditions and is used to find a dynamically feasible trajectory using a Chance Constrained RRT (CC-RRT) trajectory planner that takes the wind model into account to anticipate future disturbances. Then, a dynamically feasible trajectory is generated by the trajectory planner by smoothing the RRT path. The new approach is validated using a simulated quadrotor as it navigates around obstacles using an obstacle avoidance method. The simulation results indicate that the developed method can efficiently compute wind-aware paths for Unmanned Aerial Vehicle (UAV) navigation.

Presenter: **Nahid Uzzaman**

Advisor: Dr. He Bai

Title: ***State-Dependent Noise Covariance prediction with Variational Wishart Process***

Abstract: In our research, we address the problem of modeling and predicting covariance matrices using machine learning techniques. A covariance matrix is an indication of the uncertainty and has importance in many fields of science and engineering, such as control theory, meteorology, economics, etc. In control theory, the accuracy of the state estimation by the widely popular Kalman Filter (KF) largely depends on the precise knowledge of the noise covariance matrix. If the noise is state-dependent, the KF loses its ability to estimate the states accurately. In this research, we used a Bayesian variational Wishart Process (VWP) to predict the covariance matrix of a state-dependent Gaussian noise. The noise signal is then sampled from the Gaussian distribution with zero mean and the covariance predicted by VWP. We performed simulation experiments using various data sets. Simulation results show good prediction capability of the formulated VWP. We also designed a novel adaptive extended Kalman filter (AEKF) that uses the VWP to predict the state-dependent noise covariance at each time step. Our AEKF simultaneously learns the system behavior to predict noise covariance for the next step while estimating the states accurately.

Presenter: **Zach Yap**

Advisor: Dr. Jamey Jacob

Title: ***Solar Balloon Trajectory Prediction***

Abstract: Solar balloons are a new and emerging low-cost high-altitude balloon design used for atmospheric observations. To best utilize solar balloons for observation requires reliable trajectory prediction to use resources efficiently and aid in determining launch locations and balloon flight oath. Since solar balloons receive their buoyant lift directly from solar radiation, to reliably predict the trajectory of a solar balloon requires a new type of prediction algorithm when compared to helium balloons whose buoyant force is a result of the difference in density between helium and the surrounding ambient air. In contrast, the buoyant force on a solar balloon is driven by the change in air density inside the balloon envelope as a result of solar heating, which gives solar balloons a unique flight profile due to gradual and continuous solar heating during the balloon's flight. As a result, our new flight prediction algorithm can account for direct and reflected solar heating as well as IR radiation emitted from the earth to generate predicted flight profiles and incorporate high altitude wind and weather forecasts to plot possible solar balloon flight trajectories. Results of the flight prediction algorithm and comparison with the balloon trajectories will also be presented.

Presenter: **Nissrine Aziz**

Advisor: Dr. Aurelie Azoung

Title: ***4D-Printed Liquid Crystal Elastomer Hinges for Soft Robotics Applications***

Abstract: Four-dimensional printing, where stimuli-responsive materials are 3Dmeh-printed, is widely used in multiple fields, such as aerospace and bioengineering. Liquid crystal elastomers (LCEs) respond to a change in their environment by reversibly changing shape. Those reversible properties allow LCEs to contract and bend without damaging themselves. This research focuses on creating LCE hinges with targeted folding angles. A hinge is created by printing a narrow contracting band on a passive specimen. LCE hinges of widths between 1.5 and 4 mm are printed at printing speeds between 3 and 12 mm/s. Pictures of the hinge folding are recorded with a flat-field camera and analyzed in MATLAB. The folding angle quantifies the actuation of the hinge. We then compare the programmability of LCE hinges with other materials. The folding angle evolves from 160 to 0 degree and hence highly depends on the width and the printing speed. In addition, LCE actuation is fully reversible and in general, shows little fatigue effects. The folding in LCEs is however less localized than in other systems, sometimes even approaching bending. Finally, LCEs hinges are more flexible, which offers them the capability of a wider range of motion compared to non LCE hinges.

Presenter: **Soumya Mandal**

Advisor: Dr. Ritesh Sachan

Title: ***Nanoscale chemical imaging of core-shell high-entropy oxide nanoparticles synthesized by nanosecond pulsed laser ablation***

Abstract: This work presents a detailed study on the nanosecond pulsed laser-induced dewetting phenomenon in nanoscale thin films leading to the formation of core-shell nanoparticles (CSNPs) of high-entropy oxide (NiCoCrFeMnO) via ultrafast melting and quenching. In this approach, NPs are formed via breaking the energetically unstable thin film using pulsed laser irradiation. The strong intermolecular interaction of atoms causes instability leading to the formation of holes followed by polygonal nanostructure and finally to NPs. It has been observed that the CSNPs have a near-spherical shape with an average size of ~160 nm and a contact angle of ~145Âº. Electron microscopic analysis reveals the formation of core-shell morphology in the NPs which is further confirmed by atom probe tomography investigations determining a Cr2O3-rich core and Fe2O3-rich shell. Another important observation is that shell thickness remains nearly constant regardless of the size of the CSNPs. Using numerical thermal simulations, it is deduced that the lower thermal conductivity and relatively slower cooling rate of Fe2O3 during rapid solidification process allow its segregation as a shell-layer around the core region causing the atomic-scale elemental rearrangements and the formation of high entropy oxide CSNPs.

Undergraduate Research Abstracts for the Poster

Presenter: **Hussein Alizereej**

Advisor: Dr. Morshed Khandaker

Title: ***Effect of processing and sawing techniques on the measurement of aerosolized formaldehyde from cutting bone tissue samples***

Abstract: Pathology band saws are designed for histopathology laboratories for cutting hard tissue (e.g., bone, cartilage) and soft tissue (e.g., liver, spleen) and metal/ceramic/plastic/composite implants with tissues. As hospitals and other pathology facilities process tissue samples in formaldehyde solution, it produces aerosolized formaldehyde (HCHO) in the air during the cutting process of the tissue samples. Containment of aerosols during cutting of any of the above samples is an environmental and health safety issue. No study quantifies the amount of aerosolized formaldehyde that is released before and after sawing of bone tissues using pathology band and how the pathology sawing techniques such as blade material, thread, and water circulation affect HCHO emission from sawing with time. Therefore, the objectives of this study are to measure the level of formaldehyde produced during the processing of the sample (before cutting using the saw machine) and to measure the effect of sawing techniques on HCHO emission rate from the cutting of formaldehyde-soaked bone. Based on the above results, the butcher saw machine without the hood showed a high level of concern with HCHO emission value higher than acceptable health risk value, where under vacuum pressure in the hood, the level of HOCO.

Presenter: **Braxton Beavers**

Advisor: Dr. Ritesh Sachan

Title: ***Atomic-Scale Insights on Large-Misfit Heterointerfaces in LSMO/MgO/c-Al2O3***

Abstract: This work is a detailed study on the atomic structures of heterogeneous interfaces in La0.7Sr0.3MnO3 (LSMO) film grown epitaxially on c-Al2O3 (0001) with a buffer layer of MgO. Using aberration-corrected scanning transmission electron microscopy, we detected nucleation of periodic misfit dislocations at the interfaces of the large misfit systems of LSMO/MgO and MgO/c-Al2O3 following the domain matching epitaxy paradigm. It was experimentally observed that the dislocations terminate with 4/5 lattice planes at the LSMO/MgO interface and with 12/13 lattice planes at the MgO/c-Al2O3 interface. Using the atomic-resolution image data analysis approach to generate atomic bond length maps, we investigated the atomic displacement in the LSMO/MgO and MgO/c-Al2O3 systems. Minimal presence of residual strain was shown at the respective interface due to strain relaxation following misfit dislocation formation. Further, based on electron energy-loss spectroscopy analysis, we confirmed an interfacial interdiffusion within two monolayers at both LSMO/MgO and MgO/c-Al2O3 interfaces. In essence, misfit dislocation configurations of the LSMO/MgO/c-Al2O3 system have been thoroughly investigated to understand atomic-scale insights on atomic structure and interfacial chemistry.

Presenter: **Vishal Barot**

Advisor: Dr. Mohammad Hossan

Title: ***Development and Analysis of Bioresorbable Flow Diverting Stents to cure Brain Aneurysm***

Abstract: Flow diverters (FDs) have become an efficient endovascular device for the treatment of Brain Aneurysms (BAs). Metallic FDs, once inserted in the body, are permanent and can contribute to future complication such as late thrombosis and restenosis, etc. This research presents mechanical testing and analysis of bioresorbable, non-braided poly(Îµ-caprolactone) (PCL) FDS. Non-braided PCL FDS were designed and fabricated using an in-house flow diverter fabrication unit with various porosity, pore density, and wall thickness. To analyze the mechanical properties, tensile, three-point bending (3PB), flat plate radial compression (FPRC) tests of the FDS were conducted using the UniVert biomaterial testing system. Each test was conducted with five samples according to the ASME and ASTM standards for mechanical testing of biomedical devices. The average dimensions of the PCL FDS were 6.3 mm in diameter, 0.6 mm in wall thickness, and 10 mm in length. The FPRC tests produced force from 1.5 to 2.5 N at an average displacement of 4.5 mm. The 3PB test produced force from 2.0 to 3.0 N at an average displacement of 6.2 mm. The average elongation for the tensile test was about 3.5 mm and tensile force ranged between 2 and 5.5 N. The longitudinal tensile, radial, and bending flexibility were found to.

Presenter: **Max DeSantis**

Advisor: Dr. He Bai

Title: ***Development of Wind-Aware Piloting Interfaces and Dynamic Quadrotor Simulator with Spatiotemporally Varying Wind***

Abstract: With increasing adoption of low-altitude Unmanned Aerial Vehicles (UAVs) in urban environments, alongside present-day research into low-altitude Urban Air Mobility (UAM) vehicles, there exists a need for high quality environmental feedback for pilots operating in dense urban areas. Currently, pilots have minimal awareness as to the wind conditions their aircraft is experiencing beyond natural perception and their previous weather observations. Our work is to develop wind-aware piloting interfaces that modify existing, popular software to provide this feedback in a natural and helpful manner. Furthermore, the development of simulation environments to enhance these interfaces and gather pilot feedback is desirable. Current dynamic quadrotor simulators have sparse support for wind velocities varying with time and space. Our work has resulted in the development of modifications to Microsofts Airsim simulator to allow support for spatiotemporally varying winds pre-generated by high-fidelity computational fluid dynamics software. By developing improved interfaces and simulation capabilities, this research has the potential to spur further growth in the development of urban flight.

Presenter: **Thomas Goebel**

Advisor: Dr. Kursat Kara

Title: ***Hypersonic Boundary-Layer Stability Analysis for Local Wall Cooling***

Abstract: One of the biggest challenges in sustained hypersonic flight is laminar to turbulent boundary-layer transition, which leads to high heat transfer rates to the vehicles body. Traditionally, design engineers tried to overcome this challenge by utilizing a heavy and expensive thermal protection system for the vehicles surface. Instead of focusing on thermal protection, stabilizing the boundary layer by slowing the amplification or damping the disturbances may reduce the heat transferred to the body. Previous studies showed that the local wall cooling affects the hypersonic boundary-layer disturbance propagation. In this poster, local cooling is applied to a 5-degree half-angle blunt cone with a nose radius of 0.0254mm to investigate the stabilization behavior of the local wall cooling. The mean flow is numerically investigated at a free-stream Mach number of 6 and a unit Reynolds number of 25.59 million per meter. The simulations are carried out by solving axisymmetric, compressible, Navier-Stokes equations using high-order numerical schemes. The growth rates of disturbances are calculated using linear stability theory. The results showed that the amplification of the disturbances significantly decreased by the local cooling.

Presenter: **Reuben Lane**

Advisor: Dr. Morshed Khandaker

Title: ***Bioabsorbable Interlocked Nail System for 3D Printed Segmental Bone Defects***

Abstract: Critical-size segmental defects are large nonunion bone fractures which will not heal without intervention. Methods of treatment for these defects are limited, so novel solutions have been developed using bioabsorbable 3D engineered scaffolds in place of bone grafts. These defects have also been treated using interlocking nail systems (INS) intramedullary nails with transfixion screws for added stability and support. The goal of this study was to design and implement a 3D-printed bone scaffold implant to promote osteoblast growth in critical-sized segmental defects of rabbit tibia as well as an INS to fix the scaffold in place and provide support. A porous polycaprolactone (PCL) scaffold was produced by 3D-printing, tested to evaluate its mechanical properties, treated with agar hydrogel, and seeded with osteoblast cells for cell viability testing, while the INS was designed and printed using photopolymer resin and examined for degree of precision. Testing confirmed adequate yield stress of the scaffold but did not confirm promoted osteogenesis, while fit testing of the INS found excellent precision of the resin printing method. Further research is required to determine the efficacy of this treatment method for critical-size segmental bone defects.

Presenter: **Gabriel Webb**

Advisor: Dr. Arvind Santhanakrishnan

Title: ***Wake characterization comparison between multi-appendage rowing and flapping at low Reynolds number***

Abstract: Aquatic organisms primarily use two locomotion strategies; rowing and flapping; across wide ranges of speeds, body sizes, and body morphologies. Metachronal rowing is a drag-based swimming strategy used by many species of arthropods, where a series of appendages are oscillated with a phase lag relative to each other to generate propulsive force mostly parallel to appendage motion. In contrast, flapping of fins or tails provides lift-based propulsion, where propulsive force is mostly perpendicular to appendage motion. While flapping is mostly used at large scales corresponding to Reynolds number (Re > 1,000), rowing is mostly used at smaller scales (Re < 1,000). The individual effects of mean stroke angle, inter-appendage phase lag and Re on the flow generated by multi-appendage stroking remains unknown. Using a tethered robotic model, we examine how varying inter-appendage phase lag and mean stroke angle affect wake characteristics for Re~100. Increasing starting angle increased horizontal momentum flux (HMF) in the wake and decreased vertical momentum flux (VMF). Increasing phase lag had minimal effect on the ratio of peak HMF to peak VMF across the tested mean stroke angles.

Presenter: **Pramod Nayak**

Advisor: Dr. Morshed Khandaker

Title: ***Design and Development of human brain phantom model to study traumatic brain injury***

Abstract: Traumatic Brain injury is dramatic is a physical event that causes disruption in the normal function of the brain caused by a high-speed or large force impact to the head. Previous studies using in vitro models suggest that cavitation may serve as a damage mechanism contributing to TBI resulting from blast-induced injuries. As a pressure wave comes into contact with a head, a shock wave is transmitted through the skull, cerebrospinal fluid, and brain tissue, and causes a negative difference in pressure observed at the opposite side of impact. An event that causes a quick difference in pressure within the CSF and comes with a directional force, may result in gas bubbles forming opposite the site of impact, and accusing damage to the surrounding tissues. Shock-wave-based demonstrations were run to investigate the possibility of cranial cavitation from realistic non-impact blast loading. A simplified surrogate model of the head consists of a transparent and shatterproof spherical dummy, and a simplified phantom model of the head consists of a transparent ellipsoid with dimensions of a rabbit skull. In all tests, cavitation at the contrecoup should be observed to coincide temporally with periods of negative pressure, and the collapse of the cavitation bubbles caused by the surrounding.

Presenter: **Tuyen Nguyen**

Advisor: Dr. Kursat Kara

Title: ***Computational Flow Analysis of 2D Wedge from Subsonic to Hypersonic Speeds***

Abstract: Fluid mechanics has a wide range of applications in aerospace and mechanical engineering systems. The study of fluid flow is essential for successful system operation. We can determine a fluid flow solution in three different methods, i.e., analytical, experimental, and computational. Analytical solutions are only possible for simplified problems; hence, they are impractical for complex systems. Experimental flow measurements provide valuable information for challenging cases; however, they are significantly costlier than numerical simulations. Computational fluid dynamics simulations enable us to study a broad range of design parameters and constraints and reduce the number of experiments and prototypes needed for a successful product design. While all three approaches can improve the performance and safety of the fluid systems, accurate computational simulations are critical throughout the design stages. This poster presents the numerical solution of a flow field around a two-dimensional wedge for the flow conditions, starting from subsonic to hypersonic speeds. The Navier-Stokes equations are solved using computational fluid dynamics (CFD) software, Ansys Fluent. We compared the simulation results with the data in the literature and found excellent agreement.

Presenter: **Joel Quarnstrom**

Advisor: Dr. Yujiang Xiang

Title: ***Adjustable Rehabilitation Elbow Exoskeleton Design and Prototype***

Abstract: Patients who have suffered weakness or loss of control of their arm due to a stroke or other injury need rehabilitation to regain the use of their arm. The goal of this project is to design and prototype an exoskeleton for elbow rehabilitation. The lifting goal for this exoskeleton is to provide the power required to raise the users arm holding a 5lb weight in 3 seconds. The torque profile for this motion was calculated and the maximum torque was used to select the motor and belt drive system. A large problem for exoskeleton design is the difficulty of aligning the exoskeletons joint with the users joint. This prototype featured a novel joint adjustment mechanism that could shift the exoskeletons joint with 3 degrees of freedom to align it properly. The system was designed with many 3D printed parts which were initially printed from PLA and later printed with carbon fiber infused nylon. Various machining methods were used for the metal parts. The system used a potentiometer for joint angle control. An Arduino ran the control system, and a PCB was printed to wire the electrical components. During testing, the exoskeleton was attached to a mannequin arm, and it was able to achieve the lifting goal of 5 lbs.

Presenter: **Patrick Williams**

Advisor: Dr. Imran Faruque

Title: ***Lidar Applications in UAV Point-cloud Prediction***

Abstract: Fully autonomous UAV swarms are an area of active research, due to their wide applications. This study is a preliminary investigation of spatial lidar capabilities to detect, model, and eventually, track the expected number of lidar points of a fixed-wing UAV in flight. By conducting stationary tests, a point-cloud model of UAV data points was created based on straight-line distance, for comparison to multiple UAV flight passes over a stationary lidar unit. The results indicate successful detection of useful UAV data points within an acceptable range over the region of interest. The results of this study analyze the possibility of utilizing lidar for ground and air-based detection and tracking to facilitate the pursuit of a fully autonomous fixed-wing UAV drone swarm.

Presenting Authors- Graduate Students

Shady Ahmed	shady.ahmed@okstate.edu
Leila Rezaei	leila.rezaei@okstate.edu
Bryce Randall	bryce.randall@okstate.edu
S M Rakibur Rahman	rakib.rahman@okstate.edu
Samarjith Biswas	samarjith.biswas@okstate.edu
Caleb Robb	caleb.robb@okstate.edu
Mitchell Ford	mitchell.ford@okstate.edu
Md Arif Billah	arif.billah@okstate.edu
Suraj Pawar	supawar@okstate.edu
Asma Tabassum	asma.tabassum@okstate.edu
Furkan Oz	foz@okstate.edu
Shuvrodeb Barman	shuvrodeb.barman@okstate.edu
Shahzad Yousaf	shahzad.yousaf@okstate.edu
William Kresl	will.kresl@okstate.edu
Andrew Cole	andrew.cole11@okstate.edu
Hao Chen	hao.chen@okstate.edu
Truc Ngo	tructn@okstate.edu
Joshua Johnsen	joshua.johnsen@okstate.edu
Matthew Blair	matthew.blair@okstate.edu
Soroosh Farsiani	soroosh.farsiani@okstate.edu
Diego Colón	dcolon@okstate.edu
Bryce Lindsey	bryce.lindsey@okstate.edu
Mehrdad Zomorodiyan	Mehrdad.zomorodiyan@okstate.edu

Presenting Authors- Graduate Students

Moad Abudia	abudia@okstate.edu
Mobashera Alam	mobashera.alam@okstate.edu
Kevin Bhar	kbhar@okstate.edu
Daniel Gassen	daniel.j.gassen@okstate.edu
Abby Haddox	abby.haddox@okstate.edu
Amirarsalan Mashhadian	Amashha@okstate.edu
Zackery Bycko	zackery.j.bycko@okstate.edu
Talha Khan	txkhan5@shockers.wichita.edu
Braydon Revard	braydon.revard@okstate.edu
Shahbaz P Qadri Syed	shahbaz_qadri.syed@okstate.edu
Abhishek Tikar	abhishek.tikar@okstate.edu
Jared Town	jared.town@okstate.edu
Nick Zizzo	zizzo@okstate.edu
Ashish Kumar Gupta	ashish.gupta10@okstate.edu
Ryan Narrell	ryan.narrell@okstate.edu
Scout Hernandez	scout.hernandez@okstate.edu
Sanzida Hossain	sanzida.hossain@okstate.edu
Emalee Hough	emalee.hough@okstate.edu
Rohit Vuppala	rvuppal@okstate.edu
Matthew McCool	mccoome@ostatemail.okstate.edu
Kerrick Ray	kerrick.ray@okstate.edu
Shafi-Al-Salman Romeo	sromeo@okstate.edu
Mehnaz Sharna	msharna@okstate.edu
Nahid Uzzaman	nahid.uzzaman@okstate.edu
Zach Yap	zyap@okstate.edu
Nissrine Aziz	nissrine.aziz@okstate.edu
Soumya Mandal	smandal@okstate.edu

Presenting Authors- Undergraduate Students

Hussein Alizereej	halizereej@uco.edu
Braxton Beavers	braxton.beavers@okstate.edu
Vishal Barot	vbarot@uco.edu
Max DeSantis	max.desantis@okstate.edu
Thomas Goebel	teverettgoebel@sbcglobal.net
Seth Harriet	sharriet@uco.edu
Reuben Lane	rlane10@uco.edu
Pramod Nayak	pnayak@uco.edu
Tuyen Nguyen	tuyen.nguyen@okstate.edu
Joel Quarnstrom	jdq537@gmail.com
Gabriel Webb	gabe.webb@okstate.edu
Patrick Williams	patrick.j.williams@okstate.edu