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Collection Device for Dolphin Hormones in Blowhole Jet Flow Field

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ABSTRACT

Marine biologist are able to quantify the stress in bottlenose dolphins through analysis of hormones in mucus samples released from the blowhole while breathing. To capture the samples, petri dishes attached to an Unmanned Aerial System (UAS) can fly through the flow field of the dolphin's expelled breath. Analysis of the flow into the dish was performed with Particle Image Velocimetry and flow visualization. The resulting data was used to indicate key areas of flow across the petri dish indicating both clean and separation areas. In preparation for UAS trials, the collection device is connected to the UAS for flight-testing to measure significant changes in control, lift, and drag while the petri dishes open and close. For the UAS trials, the system is flown through the ``breath'' of a simulator to emulate the 20-140 liters per second in a timeframe of 0.26-0.31 seconds of the dolphin breath. The resulting data is used to provide validation of the systems capability for in flight sample collection..

Interface learning for coupling full and reduced order models in multifidelity simulations

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ABSTRACT

Hybrid physics-machine learning models are increasingly being used in simulations of transport processes. Many complex multiphysics systems relevant to scientific and engineering applications include multiple spatiotemporal scales and comprise a multifidelity problem sharing an interface between various formulations or heterogeneous computational entities. To this end, we present a robust hybrid analysis and modeling approach combining a physics-based full order model (FOM) and a data-driven reduced order model (ROM) to form the building blocks of an integrated approach among mixed fidelity descriptions toward predictive digital twin technologies. At the interface, we introduce a long short-term memory network to bridge these high and low-fidelity models in various forms of interfacial error correction or prolongation. The proposed interface learning approaches are tested as a new way to address ROM-FOM coupling problems solving nonlinear advection-diffusion flow situations with a bifidelity setup that captures the essence of a broad class of transport processes.

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Sweeping Jet Actuator in Water

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ABSTRACT

Flow separation has received a considerable amount of importance in drag reduction, fuel efficiency, and improved maneuvering. Active flow control (AFC) technology adds momentum or energy to the boundary-layer in a controlled manner to suppress separated flow, but it consumes power from aircraft. The sweeping jet (SWJ) actuator has opened a new dimension in this field. The SWJ actuator utilizes the Coanda effect without moving internal parts, making it more reliable and cost-efficient. The SWJ actuator produces a stable, sustaining, periodic oscillatory jet when pressurized with a working fluid. The versatile functionality of the SWJ actuator is not limited to aerodynamic applications and can be extended to hydrodynamic flows as well. However, the SWJ actuator designed for aerodynamics applications might experience cavitation in hydrodynamic flow control applications due to high-speed flow regions inside the SWJ actuator. Therefore, existing SWJ actuator geometry must be optimized for hydrodynamic applications. We will present a brief review of the experimental and computational research on flow control using the SWJ actuator and preliminary results from a multiphase flow simulation.

Human-robot Asymmetric Lifting Prediction

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ABSTRACT

In cooperative manipulation tasks like lifting, robots can potentially assist humans and significantly increase productivity. Human-robot interaction is a continuing research field with a wide range of techniques, applications, and high economic impact. In this study, we proposed an inverse dynamic optimization-based approach for human-robot collaborative asymmetric lifting motion prediction. A three-dimensional (3D) 13 degrees of freedom (DOFs) human arm model is constructed based on Denavit-Hartenberg representation. Similarly, the 3D box model has 6 DOFs, and the 3D robotic arm model has 10 DOFs. The cost function, which is the summation of the joint torque squares for human and robot, is minimized using a sequential quadratic programming algorithm. A collaborative asymmetric box lifting task is performed in the simulation. The results show an optimal lifting motion with reasonable joint torque profiles for human and robot, and the box grasping force profiles. Moreover, the proposed optimization is able to predict a more natural collaborative asymmetric lifting motion. Finally, these results and the lifting techniques can be adapted for preventing injuries during human-robot manipulation tasks.

Ballistic Performance Evaluation of Carbon Graphite Foam and Nanoparticle-Kevlar Composites Using Compressed-Air Guns

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ABSTRACT

Owing to their exceptional thermal and mechanical properties, materials such as Carbon-Graphite Foam (CGF) and Silica Nanoparticle-treated Kevlar (SNK) are of interest in many multifunctional applications. It is therefore desirable to evaluate their ballistic performance in comparison to baseline foams or untreated Kevlar, for instance. In this study, we evaluate CGF and SNK composite samples using Compressed-Air Guns (CAG). Firstly, an improved analytical model is developed to predict the projectile's velocities for CAGs. This loss-compensated model builds upon classical analytical models by incorporating clearance leakage, improved surface friction and air drag effects. CGF and baseline Aluminum foam samples are tested as per NIJ Standard 0101.06 using a large-bore gun. CGF is found to absorb nearly double the energy absorbed by the mass-equivalent, baseline samples. Next, SNK fabric samples were tested and compared to their neat counterpart using a small bore gun as per NIJ Standard 0108.01. 10, 30 and 40 wt.% of nanoparticle addition were considered. It is seen that adding 40 wt.% of nanoparticles provides a 20% mass advantage for the the SNK vis-à-vis neat Kevlar for the non-penetrative case. Post-impact inspection of the samples shows that the SNK engages more secondary yarns (other than the primary cross yarns at the impact location) to mitigate the impact, likely due to improved inter-yarn and inter-fiber friction. In conjunction with current additive and hybrid fabrication processes, structural materials such as CGF and SNK present strong potential to enable multifunctional structural solutions for emerging challenges.

Acknowledgement

Support for this work from the Ray and Linda Booker Fellowship is gratefully acknowledged. Thanks are due to the undergraduate student, Zack Krawczyk for help with the experiments.

The effect of solid particle erosion on different degree bend with various elbow curvature radii

Erosion/Corrosion cost the oil and gas industry hundreds of millions of dollars per year due to pipeline damages. The failure of pipelines, especially elbows that change the flow direction, is caused mainly by particles that cross the streamlines of flow, impacting pipe bends at high flow velocities. The purpose of this paper is to investigate alternative geometries to standard 90° elbows, where the ratio of elbow curvature radius to the pipe diameter is equal to 1.5 (r/D = 1.5). Paint removal study using water-sand and water-air-sand flows were performed in 50.8 mm pipe diameter. Where the curvature radius of 90° elbow with a of 2.5D and 5D, and a 45° elbow with a curvature radius of 1.5D. The paint study has been used to examine the location of maximum erosion and erosion patterns. In addition, computational fluid dynamics (CFD) simulations were conducted for three different 90° elbows with curvature radii of r/D = 1.5, 2.5, and 5 and a 45° bend with a curvature radius of 1.5D. The numerical simulations were compared with experimental paint removal studies in acrylic elbows. Good agreement has been observed between CFD and experiments for both erosion pattern and location of maximum erosion. Furthermore, the CFD results show that the erosion rate decreases with increasing elbow curvature radius, there is an erosion reduction of more than 60% when r/D is increased from 1.5 to 5, and it was found that the 45° bend presented approximately two times less erosion than the 90° elbow.

Additively Manufactured Stack for Thermo-Acoustic Devices

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ABSTRACT

The thermo-acoustic principle provides a means to convert acoustic energy to heat and vice versa without the need for moving parts. Overcoming the limitation of low power-to-volume ratio could allow its application to the construction of mechanically simple and robust energy harvesting systems. The porous stack that forms a set of acoustic waveguides constitutes a key component of thermo-acoustic devices. The stack's mechanical and geometrical properties play an important role in determining the overall performance of the device. In this study, the performance of various additively manufactured polymer stacks were evaluated against a commercially-available ceramic stack using a benchtop thermo-acoustic refrigerator rig which uses ambient air as its working fluid. Influence of stack parameters such as material, length, porosity, pore geometry and location are examined using experiments and correlated to simulations using DeltaEC (a numerical solver based on Rott's linear approximation). Structure-performance relationships were also established by extracting scaling laws for power-to-volume ratio and frequency-thermal gradient dependencies. Additively manufactured stacks are found to be able to provide performance comparable to ceramic stacks while being more affordable and customizable for thermo-acoustic transduction applications.

Acknowledgement

Support for this work from the NSF RII Track-4 Grant No. 2033399 and the Ray and Linda Booker Fellowship is gratefully acknowledged.

Finite Element Modeling of Blast Wave Transduction through Human Ear with Two-Chambered Spiral Cochlea

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ABSTRACT

Introduction: The ear is often subject to serious damage when exposed to blast overpressure waves. While the middle ear can be examined non-invasively, observing damage in the inner ear is challenging. Finite-element (FE) modeling provides a useful way to gain quantitative information about the inner ear response to pressure waves. Following the straight, two-chambered cochlea model by Brown et al. (2020), this study aimed to develop an FE model of a spiral cochlea to simulate blast wave transmission through the ear.

Methods: The FE model of the ear consists of the ear canal, tympanic membrane, middle ear ossicular chain and suspensory ligaments, middle ear cavity, and spiral cochlea with two chambers separated by the basilar membrane (BM). A pressure waveform recorded from blast tests was applied at the ear canal entrance, and the resulting pressures in the middle ear and cochlea were calculated using a coupled Fluent and Mechanical simulation in ANSYS.

Results: The FE model derived that the cochlear pressure difference across the BM was approximately 150 kPa at the base and decreased to zero at the apex. The stapes footplate displacement was up to 30 μm in the piston direction and the BM displacements was as high as 40 μm into the scala tympani.

Conclusion: Compared to the straight cochlea model, the spiral model yielded higher pressures within the cochlea and similar BM displacement variation from the base to apex. The results show that the spiral shape of the cochlea is an important contributor to cochlear mechanics.
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Analysis for Multi-Rotor Systems

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ABSTRACT

As the usage of small multi-rotor unmanned aircraft systems (sUAS) continues to grow there is a need to understand the complex flow and its interactions with the propellers and the sUAS airframe. This is particularly important to understand the interactions of the inflow and downwash with sensors mounted on the structure, such as chemical, thermodynamic, or wind sensors where interactions may contaminate the measurements. This effort maps the in-flow around a multi-rotor using experimental techniques of the PIV and flow visualization. These experiments determine the effectiveness of sensors onboard multi-UAVs for atmosphere measurements. The study includes a single rotor analysis to isolate the effects of a single rotor plane and expanding to double and quad rotor systems. The rotors are placed in an water tunnel to allow for the flow visualization PIV data collection

Acknowledgement

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Promote Agriculture 4.0 in India

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ABSTRACT

Although India is ranked as one of the top 20 economies of the world, around 40% of its population lives under the poverty line, and only a few have access to credit from the formal financial sector. Around 75% of Indian’s population under the poverty line live in rural communities, where the primary resources and governmental assistance are insufficient. As a result, microfinance institutions such as the Grameen Bank of Bangladesh came out in the 1970s. However, its business model cannot be reproduced everywhere in the country or by other institutions. Therefore, we aim to promote Agriculture 4.0 as a means of improving the success for rural entrepreneurs. Using this approach, we consider the differences between local cultures to adapt the baseline model to typical rural villages in India. We also address the social acceptance of a new lifestyle. Our ultimate goal is to promote India's financial inclusion by helping the population with no access get integrated into the country's formal financial sector. In this presentation, we showcase a microcredit institution's business model, providing more knowledge on the development, evaluation, and customization of microloan products.

Soot Formation in Biodiesel-Oxygen Enriched Air Laminar Diffusion Flames

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ABSTRACT

Oxygen enhanced combustion effects were studied by increasing the O_2 content in the oxidizer stream, from air (21%) up to 80%. The formation of carbon particles (soot) was studied in flames formed using two fuels. 1) a renewable fuel (biodiesel derived from canola vegetable oil) and 2) petro fuel (No. 2 diesel). A total of eight co-flow diffusion flames were studied: canola methyl ester (CME)/21% O_2, CME/35% O_2, CME/50% O_2, CME/80% O_2, diesel/21% O_2 (air), diesel/35% O_2, diesel/50% O_2, and diesel/80% O_2. As a result, a total of eight soot evolutions were obtained by transmission electron microscopy (TEM) analysis. The CME-air and diesel-air soot evolutions were used as a basis for comparison with the studied oxy-fueled flames. The soot particle samples were extracted from within the flame by thermophoretic sampling through the insertion of a TEM grid inside the luminous zone of the flame at various heights above burner (HAB) in the axial direction. For quantitative analysis, primary particle diameters (d_p) were obtained at various HAB in the axial direction of the flame. The soot evolutions demonstrate the process of soot formation from soot inception, surface growth, agglomeration, and oxidation. The increase of oxygen content in the oxidizer stream decreases the flame height, accelerates the soot formation process, and suppresses the formation of long aggregates.

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Invariant-EKF design for wind estimation from quadcopter

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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).

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Design of Powertrain Differential for Off-Road Vehicle

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ABSTRACT

The Sooner Off-Road Team is a collegiate engineering competition team that competes annually in an SAE-sponsored mini-BAJA competition with a custom vehicle, designed and manufactured in-house at the University of Oklahoma. The rules for the 2021-2022 season mandate a four-wheel-drive powertrain system in all competing vehicles, thus requiring the implementation of various new components in the powertrain subsystem, the largest and most complicated of which is the front differential. To minimize the size, complexity, and cost of the front differential, the Sooner Off-Road Team has elected for the custom design and manufacture of this component in the hopes of optimizing the function and performance of the front differential, while documenting the knowledge gained throughout the process for future use. This research has successfully identifed all the mechanical requirements to allow for safe and efficient power transfer to the front wheels while maintaining durability. The final design utilizes sprag clutch bearings to provide automatic transfer of power to the wheels based off a speed differential, allowing for a smooth and successful front-wheel-drive engagement with zero driver input. The research performed has led to the development of a front differential component that safely and efficiently meets the four-wheel-drive requirements set by SAE while also achieving the team size and performance goals.

A Newtonian Model of Drag-based Metachronal Swimming

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ABSTRACT

Metachronal swimming is the main underwater propulsion strategy used by many aquatic crustaceans. When swimming using this strategy, the Reynolds number of the flow around the swimming appendages can range from 10^0 to 10^4 depending on body size and swimming behavior. Inspired by this widely observed swimming technique, we designed and developed a metachronal paddling-powered remotely operated vehicle (MP^{2}ROV) and mathematically modeled its dynamic behavior to develop control policies. A system of nonlinear ordinary differential equations for general planar motion in the sagittal plane was derived, approximating each paddling leg as a two-dimensional hinged flat plate that oscillates with a sinusoidal motion profile. On the MP^{2}ROV, 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, the background flow was set to be equal to the swimming speed of the body, and fluid dynamc interactions between the legs were not included in the model. The propulsive force contribution of each leg was calculated using drag coefficient models that were summed to determine a total force. A comparison of the swimming speeds predicted by the mathematical model with those of the MP^{2}ROV will be presented.

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Membrane Distillation Processes and High Salinity Water Desalination

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ABSTRACT

The present study investigates the effectiveness of a benchtop membrane distillation (MD) process for the desalination of high salinity water, typical of osmosis reverse concentrate and the produced water in the gas and oil industry. The MD process consists of a thermally-driven transport of water vapor through a non-wetted porous hydrophobic membrane. The process's driving force is the water vapor pressure difference between the two sides of the porous membrane. This study is motivated by the eminent water scarcity conditions in large urban centers around the world. To meet the water demands of both the population and the industry, other sources of low-quality water, including produced water, may be a potential solution. The presenation will introduce the experimental setup as the planned measurements including inlcude process parameters and the water quality. The feed temperature and concentration are the parameters that are most relevant to the process due to their direct relationship with transmembrane vapor pressure difference, the process driving force. The process effectiveness will be measured in terms of salt rejection and water permeance. Also of interest in the present study is the scaling phenomenon and its influence on the process of water recovery will be investigated. The scaling phenomenon on the membrane surface would prevent the water vapor from going through the membrane pores, thus reducing the permeate flux.

Reynolds Number Dependence on Metachronal Swimming Performance

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ABSTRACT

Autonomous underwater vehicles (AUVs) used in oceanographic research and military missions are often designed for constant speed operation, are large (1-10 m in length) and have poor maneuverability. One possibility for improving maneuverability is to develop miniaturized AUVs with bio-inspired propulsion systems. Highly-maneuverable aquatic crustaceans commonly use metachronal paddling for swimming, in which multiple closely spaced limbs are oscillated in sequence starting from the back of the animal. The body length (BL) of metachronal swimmers ranges from 0.1 mm to 100 mm. We recorded the stroke frequency (*f*), stroke amplitude (SA) and swimming speed of ghost shrimp (BL~1 cm) to compare with published data on copepods (BL~1 mm) and krill (BL~4 cm). We found that Reynolds number (*Re*) based on limb length and tip speed ranges from 10^0 to 10^3. It is unknown how metachronal swimming performance scales across this broad *Re* range. Using a self-propelling metachronal paddling robot with fixed SA and paddle geometry, we vary *f* and fluid kinematic viscosity in order to determine how varying *Re* impacts swimming speed. For $50 \leq Re \leq 5x10^4$, the dimensionless Strouhal number (*St*), indicative of the efficiency of momentum transfer from the limbs to the fluid, was mostly constant and approximately 0.25. The independence of *St* from *Re* suggests that the design of a metachronal paddling system does not need to be optimized for frequency or size to improve fluid dynamic efficiency.

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Active Throttle Control in Small Hybrid Unmanned Aircraft: Sensor Limitations and Timing

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ABSTRACT

Hybrid propulsion systems offer potential solutions to energy density and related power supply issues in small unmanned aircraft (maximum take-off weights under 55lb). Oklahoma State University's Aerospace Propulsion and Power laboratory has been exploring systems in the 5-10kW range combining a jet turbine-battery hybrid power source and electric propulsors. These systems rely on active turbine throttle control for power balance and ensure constant supply to the propulsors via a 22V or 44V bus supply. The control system is currently on its second major design iteration. The first iteration showed the complexity introduced by assumptions from familiar hardware into electronic control systems. The turbines ran at speeds up to 7000rpm, exceeding the sensor capability to distinguish between shaft pulses and generating a continuous signal. Arduinos, while a familiar board, were not optimized for aircraft applications. Both the sensor read and signal write functions required exclusive control of the same timer hardware. This was overcome by splitting these into two microcontrollers at the cost of complexity and weight. The second iteration solves these problems by applying principles of electrical controls engineering and considering the physical characteristics of the mechanical system. System voltage is sampled at a rate closer to the response rate of the turbine to changes in throttle signal. This eliminated one timer entirely and freed up the computational load on the controller. The computational system provides active control to the throttle at an appropriate rate while running safety monitoring at speeds preventing system damage.

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Metachronal, Synchronous, and Hybrid Kinematics in Aquatic Paddling

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ABSTRACT

Metachronal paddling is a common drag-based aquatic locomotion strategy in which multiple appendages are stroked in sequence, beginning with the appendage nearest the tail end of the body, and with a phase delay between adjacent pairs of limbs. Many invertebrates, particularly crustaceans, swim by employing this metachronal paddling sequence. Gaits used by different species vary, but continuously swimming species such as krill generally use a purely metachronal stroke, while burst-swimming species such as many copepods and mantis shrimp typically use a hybrid stroke consisting of a metachronal power stroke followed by a synchronous or nearly-synchronous recovery stroke. These burst-swimming organisms rely on rapid acceleration in order to capture prey and to escape predation. By using a robotic model to compare metachronal and hybrid swimming gaits, we examine the effect of changing between the metachronal and hybrid gaits on swimming speed, acceleration, and wake structure. The main benefit to using hybrid as opposed to metachronal kinematics is that hybrid kinematics allow for a larger maximum stroke amplitude. This allows the hybrid kinematics to achieve faster swimming speed and greater acceleration than metachronal kinematics, regardless of the phase lag between limbs. Additionally, the wake jet generated by hybrid kinematics is more dispersed, while the metachronal wake generates a narrower, downward-angled jet which may be useful for hydrodynamic signaling in schools.

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Fluid dynamics of abnormal breathing patterns in idealized human airways

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ABSTRACT

Normal breathing is an involuntary action where expansion and contraction of the diaphragm and chest muscles facilitate inhalation and exhalation of air. The normal respiratory rate (RR) ranges from about 10-15 breaths per minute. Abnormal breathing patterns can occur due to changes in physiological or pathological conditions. This study aims to investigate the effects of varying breathing patterns such as tachypnea (approximately 1.5x increase in RR), bradypnea (1.5x decrease in RR), hyperpnea (deep breathing with abnormally large peak flow rate), and hypopnea (shallow breathing with abnormally low peak flow rate) on airway fluid dynamics. 3D transient computational fluid dynamics simulations were performed on an idealized airway model up to the 2nd bifurcation, using the k-ω SST turbulence model in ANSYS Fluent v19. A parametric study was conducted across varying: (a) peak flow rates (during inhalation and exhalation) and (b) cycle duration. Laryngeal jet length for each abnormal condition was measured and normalized with jet length of normal condtion to measure jet streaming. Jet streaming and jet length at peak inhalation were higher in tachypnea and lower in hypopnea. At peak inhalation, laryngeal jet showed secondary flow vortices for all breathing conditions. One minute exhalation ventilation volume at the outlets was higher for tachypnea compared to hyperpnea and lowest in bradypnea. Our results suggest that altering the RR at assumed metabolic levels can potentially estimate respiratory acid-base disorders.

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Feeding Currents of Upside-Down Jellyfish

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URL:

ABSTRACT

Small organisms, such as the upside-down *Cassiopea* jellyfish, feed at the intermediate scale (mesoscale), where inertial and viscous forces are balanced. Studies of the fluid-structure interaction underlying mesoscale feeding processes can inform the biologically inspired design of filtration devices for use in low-speed flows. Numerous animals that feed at the mesoscale rely on branched and bristled structures for particulate prey capture. *Cassiopea* medusae are found in shallow marine environments characterized by low (1 cm/s or smaller) background flows. For prey capture, *Cassiopea* medusae rely on the interaction of currents induced by bell pulsations with their highly branched and bristled oral arms. *Cassiopea* bell pulsations have been previously shown to induce an upward jet that is observed throughout the bell pulsing cycle. The purpose of this investigation is to determine whether the three-dimensionality of the bell motion or the elaborate oral arm network helps in maintaining the continuous upward jet. 3D particle tracking velocimetry (PTV) measurements were conducted on multiple *Cassiopea* individuals in a laboratory aquarium. In experiments where oral arms were excised from a medusa, PTV measurements showed persistent unidirectional flow above the bell. This suggests that the three-dimensionality of bell motion is necessary for synthesis of the continuous upward jets. To examine how the oral arm structure can impact prey capture, we examined volumetric flow rate through the oral arms and above the medusa. Flow generated near the oral arms and implications on prey capture will be discussed.

This work was supported by the National Science Foundation (CBET 1916061).

LuxSine Solar Heater

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ABSTRACT

Renewable energies have exploded in research and development in the past few decades. The demand for them has skyrocketed. LuXsine Energy Company, with the help of students from the School of Engineering at Oral Roberts University, have chosen to aid in the development of renewable energy, particularly, solar energy.

LuXsine has developed a solar energy apparatus that provides effective and efficient conversion of solar flux into mechanical heat energy. The solar energy apparatus stems from the thermal-solar technologies of solar troughs, power towers, and Stirling dish generators. LuXsin's apparatus is a thermal-solar heat exchanger that relies on a mirror system to generate mechanical heat energy from solar flux. This new technology will overcome the inefficiencies of the previous thermal-solar technologies, such as reflection losses, reradiation heat loss, and heat exchanger losses.

With LuXsine's research of this technology, the students from ORU are working on refining the design, building a workable scaled prototype, and testing it, through experimentation, for their undergraduate senior capstone course. The students, with the guidance of LuXsine, have employed the uses of software and hardware to develop this technology. They have used softwares such as Desmos website, SolidWorks CAD, and ANSYS SPEOS light simulation. They have also used the machine shop facilities at ORU to fabricate the prototype and LuXsine's facilities to experimentally test the prototype.

The team of students plan to show that this new technology can be scaled up to residential and industrial use and is a more effective and efficient way to capture solar flux and convert it into mechanical heat energy.

Deep **Learning-Supported Heterogeneous Membrane Property Prediction**

(unpublished materials)

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ABSTRACT

Heterogeneous membranes are thin, soft structures with spatial material and thickness variations. We propose a new method to characterize the membrane properties by combining full-field strain measurement and inverse modeling techniques. Lots of synthesized structures in the industry are heterogeneous thin membranes, and instability or fracture problems of these materials may cause issues in industrial productions and economic loss. Many biomaterials are also heterogeneous membranes, fracture of biomaterials can lead to different types of diseases such as eardrum or heart valve ruptures. Traditionally, mechanical behaviors of heterogeneous membranes are not very well understood due to the difficulties in obtaining accurate and reliable material property data. As a first step toward the long-term goal of characterizing complex heterogeneous bio-membranes, this research focuses on studying the heterogeneous membranes with flat geometry, uniform thicknesses of linear, elastic synthesized materials that deform in the small strain range (true strain < 10%). To acquire accurate and fast prediction results, we apply FEA-based machine learning method to expedite the optimization process of the inverse modeling. Experiments are conducted on synthetic and real data. Bothe data sets show that heterogeneous membranes with 2~4 different materials in different patterns can be effectively characterized by the proposed method.

∑3 Twin Boundaries in $Gd_2Ti_2O_7$ as pathways for fast oxygen migration

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ABSTRACT

Materials with fast oxygen transport play a critical role, in developing energy conversion and storage systems which are the key to design future hybrid-electric aircraft. For such advancements, the open challenge to materials community is to manipulate the materials properties at the atomic level. Pyrochlore oxides are the well-suited candidate for fast oxygen transport due to one inherent vacant oxygen site in the unit atomic structure. Recently, the introduction of twin boundaries (TBs) in complex oxide materials, including pyrochlore oxides, has attracted a lot of attention due to the potential of twin boundaries as fast oxygen transport pathways. The objective of this study is to provide atomic-scale insights into a $\sum 3(11\bar{1})\ \langle 1\bar{1}0 \rangle$ twin boundary present in pyrochlore-structured $Gd_2Ti_2O_7$ using atomic resolution electron microscopy and atomistic modeling. The formation of the observed TB occurs along $(11\bar{1})$ with a 71° angle between two symmetrically arranged crystals. We observe distortions (~3-5% strain) in the atomic structure at the TB with an increase in Gd−Gd (0.66 ± 0.03 nm) and Ti−Ti (0.65 ± 0.02 nm) bond lengths in the $(1\bar{1}0)$ plane, as compared to 0.63 nm in the ordered structure. The oxygen migration barrier for vacancy hopping at 48f−48f sites, which is the primary diffusion pathway for fast oxygen transport in the pyrochlore structure was further analyzed using atomistic modeling. The mean migration barrier is lowered by ~25% to 0.9 eV at the TB as compared to 1.23 eV in the bulk, suggesting the ease in oxygen transport through the ∑3 twin boundaries.

IMPACT OF ASSET MANAGEMENT IN A GREEN SUPPLY CHAIN

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ABSTRACT

With increasing concern about global warming caused by greenhouse gasses (GHGs), organizations have become more responsible for their operations. According to the U.S. EPA, companies with a supply chain (SC) generate about 42% of GHGs in their transportation(30%) and inventory systems(12%), which makes mitigating climate change through a green supply chain (GSC) management a reasonable solution.

To design a GSC, we model the SC as a network of customers and stores, with customers driving in cars to and from stores and the retailer resupplying the stores from a central warehouse. The number and location of stores are determined to find a low-cost and low emission configuration for the SC.

The key findings are (1) SC with more small stores caused less emission than the one with fewer large stores; (2) when achieving the lowest operating cost is more important than mitigating GHG emissions, fewer large stores are preferred than the more small stores; (3) SC with two warehouses results in a reduced number of open stores in a large area such as Puerto Rico.

Our contributions are (1) building a model of a GSC based on population data;(2) modeling a GSC in two-echelon solved simultaneously using a k-median approach;(3) evaluating the effect of having multiple warehouses on the overall GHGs emissions; (4) managing the incompleteness and inaccuracy of the data through implementing the compromise Decision Support Problem construct to identifying satisficing solutions.

In this talk, we will describe the aforementioned model and highlight important parameters that can impact the green GHG emissions reduction from a supply chain. We will also discuss how this approach can be employed for other design problems, including manufacturing and healthcare.

Acknowledgment

Sara Hajihashemi is grateful to Jack Williams for providing GSC GitHub and helping us to get data. Janet K. Allen gratefully acknowledges the John and Mary Moore Chair account's financial support at the University of Oklahoma. Sara Hajihashemi, Reza Alizadeh, and Farrokh Mistree acknowledge funding from the LA Comp Chair at the University of Oklahoma.

Integration of Advanced Computational Tools in Aerospace Capstone

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Improvement in the accessibility and capability of computational engineering design tools has changed how student teams approach aerospace capstone design projects. CAD integrated computational fluid dynamics packages, integrated finite element analysis packages, and affordable highly parallelized computers have made complex computational tasks far more accessible to undergraduate aerospace students. Optimization codes are able to include system models of increased complexity, find global optimal designs, and plot Pareto frontiers in reasonable time as a second benefit of affordable multi-threaded desktop computers, and accessible multithreaded software libraries. Including these advanced design opportunities in the senior aerospace engineering curriculum allows exceptionally driven students to improve their capabilities beyond their peers before entering the workforce. The educational and job placement benefit to students practicing the use of advanced computational tools has been apparent.

This presentation will discuss the use of advanced computational tools in the senior aerospace capstone program at the University of Oklahoma. An anecdotal history of how the tools have been developed through the past years of competition, and the positive and negative effects that increased accessibility has had on vehicle performance, and educational outcomes of participating students will be discussed.

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A Dashboard for Crowdfunding of Village Development

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ABSTRACT

Impediments to development in rural Indian villages include inaccessibility to food and clean water, gender inequality, and a lack of economic opportunities. Social entrepreneurs, such as SunMoksha, a local enterprise, work to organize sustainable practices to better village prospects longitudinally. Those who work with SunMoksha are capable of implementing a number of humanitarian endeavors, such as youth education programs, healthcare access pathways, and vocational training. Additionally, engineers at SunMoksha have developed sustainable technological solutions, such as AQUANet™ and NanoGrid™, methods to provide clean water and electricity, respectively. The success of these programs relies on philanthropic contributions from donors across India. To increase SunMoksha's funding base, an interactive dashboard to crowdfund projects has been developed. The foundation of the dashboard is a computational framework aimed at predicting yrealistic effects of intervention projects on such villages. Potential donors can use this dashboard to make informed decisions associated with how much to allocate to each opportunity to maximize the impact of their total donation on improving the quality of life of the villagers. In this presentation, the salient features of the dashboard designed for crowdfunding village development are described.

Acknowledgement: Special thanks to Vishnu Kamala for his work in developing the computational framework.

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Experimental Approach to Correcting Airspeed Measurments From Unmanned Aircraft

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URL: https://www.youtube.com/watch?v=???

ABSTRACT

Wind data today is composed mostly of near ground based measurements. In Oklahoma, the Mesonet network has 120 atmospheric towers stationed around the state. These towers are only able to acquire data up to 10m off the ground, and this has led to a deficit of information at altitude. This information will be key to improving forecasting. These measurements will also help enable the use of Unmanned Systems in urban areas where the lack of wind information creates a safety hazard. The maneuverability of a UAS can provide this valuable data that has never been able to be measured before. However, the instruments to get this data can be expensive with integration on vehicles having unsolved difficulties. Integration of airspeed sensors to multirotors and fixed wing aircraft lead to an addition of noise from vehicle dynamics to the measurements. An experimental approach to identify and correct the errors in these measurements will be presented, with an analysis of the effectiveness of an experimental approach.

Floating Caliper Design for Off-Road Vehicle

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ABSTRACT

The BAJA SAE Sooner Off-Road engineering team competes at an international competition each year with the vehicle that they design and manufacture. In order to stop the vehicle, a robust and well-designed brake system must be made so that the off-road car fits the requirements of the competition while also keeping manufacturing costs down. In the past, the team has outsourced brake calipers from other companies and fit our designs around those calipers. While outsourcing calipers has led to successful braking, it costs more in the long run to outsource brake calipers and also constrains designs on multiple subsystems within the car. The findings of the research are likely to suggest that much of the vehicle's brake subsystem is significantly stronger than is necessary and thus also much heavier than a more refined design could be. While this research is being completed specifically with the Sooner Off-Road team in mind, the process and methods can be applied to any vehicle consisting of a similar braking setup.

Distributed Power Turbo-Electric Unmanned Air Vehicle

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ABSTRACT

This presentation is a study into a potential platform for an unmanned air vehicle that has the endurance and versitility of an electrical air vehicle but also has the energy density that a gas turbine-powered system affords. After successfully building and testing a 7-kW, 44-V turbo-electric system for the 55-lb Mugin UAV with a wingspan of 4.5-m and a single aft-mounted electric motor, the focus was now to demonstrate the system's ability to be modified to distribute power across multiple motors, independent of each other. With two additional motors, one attached to either side of the wing's leading edge, the aircraft can achieve bursts of thrust when needed, such as in lift-off or during thrust-differential turning maneuvers. Two extra motors also prompt improved motor effieciency and future augmentation to articulation the motors for more complex flight control. The turbo-electric system, including the two leading-edge electric motors and the single, aft-mounted motor, were tested outside the Mugin fuselage to fine-tune the controller and power management system. Laser-cut, carbon fiber wing mounts for the leading edge motors were torsion testest beyond the capability of fluid and motor effects. Both components met their respective criteria of allowing the power management system to distribute power to individual outputs dependent on the need of each at that moment, and the wing mounts to withstand torsional loads more significant than those anticipated to encounter during operation. The final result was a successful flight and demonstration of a distributed power turbo-electric system.

Produced Water Polishing Utilizing Integrated Compact Separator System (ICSS)

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URL: https://www.youtube.com/watch?v=???

ABSTRACT

Management of the large amounts of produced water (PW) is one of the most critical challenges facing the Petroleum Industry today in the era of sustainability and "green operation". Each year, about 20 billion barrels of water are produced by industry in the USA. The PW can be used for irrigation, consumption, or be re-injected back into the formation either for disposal or for Enhanced Oil Recovery (EOR) operations. This requires "water-polishing", this is the removal of oil droplets from PW streams to reduce the oil concentration to the regulation levels prior to re-injection or reuse. Water polishing has been accomplished for decades utilizing the de-oiler Liquid-Liquid Hydrocyclone (LLHC). The LLHC operation is limited for oil concentrations at its inlet to only a few percent, 100 times the allowable underflow purity, which hinders polishing of PW streams with high oil concentrations.

An in-line Integrated Compact Separator System (ICSS) for PW polishing is developed, that enables free water knockout and polishing of PW streams with inlet oil concentrations up to 50%. This significantly improves industry capability to manage PW effectively and be more environmentally responsible, while at the same time increasing production. The proposed in-line ICSS consists of a combination of a Liquid–Liquid Cylindrical Cyclone (LLCC©) compact separator and a Liquid-Liquid Hydrocyclone (LLHC) in series. The LLCC©, which was developed at The University of Tulsa (TU), is utilized as a free water knockout device for PW streams with high oil concentrations to <1%. The knocked-out water flows into an LLCC© to polish the oil from the stream to concentrations that are required for re-injection (<1000 ppm) or disposal/reuse (< 50 ppm).

An ICSS prototype was designed and fabricated. It will be installed in an existing multiphase flow research flow loop. Detailed measurements of the oil concentration and droplet size distribution at the LLHC polished water outlet will be acquired under different inlet operating conditions and inlet oil concentrations. A mechanistic model will be developed to enable the prediction of the ICSS separation performance and efficiency under varying operating conditions. Design criteria for the ICSS to be used in industry will be recommended based on the acquired experimental data and the developed mechanistic model. The deliverables of this project are as follows: 1) Experimental data on the performance and efficiency of the ICSS; 2) Design criteria for the ICSS; 3) A mechanistic model for prediction of the ICSS performance and efficiency.

Biomechanical and Microstructural Characterizations of the Four Heart Valve Soft Tissue Leaflets

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ABSTRACT

The four heart valves (HVs) regulate the unidirectional flow of blood throughout the four chambers of the heart. The ability to maintain this one directional flow during the cardiac cycle is governed by the collagenous leaflets (or cusps) that prevent retrograde blood flow. When the structural integrity of the leaflets begins to fail (e.g., stenosis), the mechanical properties are affected, negating complete coaptation and resulting in the regurgitant flow. Understanding the relationship between the collagen microstructure and tissue mechanics of these heart valve leaflets will not only elucidate the underlying pathology, but also provide the constitutive relations necessary to inform multiscale computational models for improving the treatment of HV disease. To further examine the microstructural and mechanical properties of the HV leaflets, we employed an in-house opto-mechanical system, capable of quantifying the realignment and reorientation of the tissue's underlying collagen fiber architecture (CFA), *within the same specimen* subjected to varying biaxial mechanical loads. Our biaxial testing results displayed a typical J-shaped stress-strain relationship for each specimen, with greater extensibility in the tissue's radial direction than the circumferential direction under both equibiaxial (T_C:T_R=1:1) and non-equibiaxial loading (T_C:T_R=0.25:1, 1:0.25). Our CFA quantification showed that under equibiaxial loading, the collagen fibers become better aligned and reoriented towards the circumferential axis. Under non-equibiaxial loading, however, the collagen fibers displayed reorientation towards the direction of the greatest applied loading. This non-destructive, opto-mechanical system permits an improved understanding of microstructural changes under tissue-level deformation. The acquired experimental data can be used to develop HV multiscale models.

Acknowledgement

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Strategies for the reduction of hydrocarbon and carbon monoxide emissions in dual fuel engines at low engine load.

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ABSTRACT

In order to reduce global carbon footprint, it is necessary to use advanced combustion strategies to increase efficiency and decrease engine-out pollutants. Dual fuel low temperature combustion (DFLTC) is one such advanced combustion strategy. In DFLTC , a low reactivity fuel (e.g. methane) is ignited by appropriately timed high pressure injection of a high reactivity fuel (diesel) in a compression-ignited engine. The ensuing combustion is lean with ultra-low engine-out NOx and PM emissions; however, DFLTC suffers from high engine-out HC and CO emissions The present work uses a validated multi-dimensional DFLTC CFD model   to explore strategies to reduce engine-out HC and CO emissions in DFLTC. Various spray targeting strategies including multiple injections, variable included angle injection, variable nozzle hole sizes are explored for the reduction of hydrocarbons and carbon monoxide emissions and enhancement of fuel conversion efficiencies at low engine load operation. For diesel injection timing of 310 CAD, spray targeting revealed that two sets of included angles, 105 degrees, and 150 degrees, with 8 nozzles seem to simultaneously reduce NO, CO, and HC by 60%, 12%, and 11%, respectively while increasing closed-cycle indicated fuel conversion efficiencies (CC_IFCE) by 2.6% relative to the baseline 8 hole nozzle with 150 degrees included angle.

Acknowledgement
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On Designing a Home Energy Management System

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ABSTRACT

Load shifting entails moving home electricity use from on-peak hours to off-peak hours thus resulting in reduced utility bills. Peak load management also needs to be considered since the higher peak load might subject to penalty. For example, utilities might change their current tariffs for the next pay period once a higher demand is observed in grid. In Home Energy Management System (HEMS), we divide the system into three services: the flexible, non-thermal appliances, the thermal appliances, and the human being. A mathematical model to describe the relationship between each home appliance's status, the home electricity bills, and the power consumption profile has been built. The coupling effect between the thermal appliances and the non-thermal appliances and the homeowner's preference are accounted for. Since minimizing the electric cost and reducing the peak load are two conflicting goals, we transfer the model into a coupled Decision Support Problem (DSP) to find *satisficing* solutions. A smart single home is used to illustrate the efficacy of the designed HEMS. The HEMS can be extended to multiple homes and even to a communities with different building types. In this talk, the issues involved in designing a HEMS and some preliminary results will be covered.

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Three dimensional flapping flight of tiny insects using bristled wings

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ABSTRACT

Miniature flying insects with body lengths under 2 mm, such as thrips and several parasitoid wasps, are often observed to possess hairy/bristled wings and use wing-wing interaction (clap-and-fling) during free flight. Previous studies using 3D wingbeat kinematics have primarily focused on examining force generation by solid (non-bristled) wings across varying Reynolds number (*Re*). Our previous 2D clap-and-fling studies have shown that bristled wings augment lift-over-drag ratio at *Re*=10 relevant to tiny insect flight. This study aims to evaluate if the aerodynamic benefits of bristled wings are also observed when using 3D wingbeat kinematics. A dynamically scaled robotic model capable of replicating realistic 3D wingbeat kinematics of thrips, leaf miners and fruit flies during hovering was developed for this study. We examined force generation using solid and bristled wings (single wing and wing pair) at *Re* ranging from 10 to 120. For a single revolving wing at *Re*=10, solid wings produced larger drag than bristled wings. For both solid and bristled wings at *Re*=30 and *Re*=120, average lift over drag ratio was found to be higher for leaf miner kinematics as compared to those of thrips and fruit flies. Flow structures generated by the wings and their implications on force generation will be discussed.

This research was supported by the National Science Foundation (CBET 1512071 to A.S.).

Explosive Oxidation of Submicron Cu_2O Cubes with Low Power Laser

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ABSTRACT

We have observed explosive oxidation of submicron-sized cuprous oxide (Cu_2O) cubic particles, where single particles were excited by a 532 nm laser beam of less than 10 mW power. Complete disappearance of the cubes has occurred with formation of a halo-shaped debris, characterized as CuO by Raman spectroscopy. The nanostructured debris was also studied by scanning electron microscopy. Such rapid oxidation is attributed to Mie resonances in the cubes, responsible for enhanced light absorption and photothermal heating. Mie resonances were validated by single particle light scattering spectroscopy and numerical simulations. The elevated temperature due to photothermal heating is derived from the intensity ratio of anti-Stokes to Stokes Raman peaks. The electromagnetic field enhancement in the Cu_2O cubes was confirmed and quantified by Raman spectroscopy on single cubes against a Cu_2O powder standard. The photothermal heating was also observed to quench the oxygen-vacancy photoluminescence of Cu_2O at 750 nm, corroborating its excitonic nature.

In situ measurement of AC conductivity to quantify real-time alignment of graphene nanoplatelets (GNPs) in epoxy

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ABSTRACT

Graphene nanoplatelets (GNPs) are widely used as conductive fillers for various polymer nanocomposites. However, the actual performance of these materials is much lower than theoretical predictions due to natural tendency of GNPs to agglomerate. Contemporary techniques for random dispersion do not offer modulation on orientation of graphene and limits its capabilities, promoting the usage of higher concentrations that can lead to undesirable effects. Electric field alignment is a promising way to obtain significantly improved directional properties with low concentrations of GNPs. This study presents the use of real time AC conductivity measurements to characterize the alignment process of GNPs in thermoset epoxy polymer. Theoretical modeling of the effects of alternating electric field on a single transversely isotropic GNP reveals the key parameters that influences the alignment process. Namely, the size of the platelet, viscosity of the epoxy and content of GNP. Considering these parameters, an experimental setup is devised to create a perpendicular intersecting time varying alternating electric field in an aluminum mold separated by epoxy/GNP mixture. Time required for alignment is calculated based on the chain-formation and rotation time obtained from above parameters. Preliminary research shows a two to three-fold increase in electrical conductivity in aligned directions compared to randomly dispersed epoxy/GNP mixture. The effects of alignment are also revealed in an increment of mechanical strength resulting in a (10-15%) increase in Young's modulus in both the aligned directions. This significant property improvements also increased the percolation threshold of randomly dispersed epoxy/GNP mixture from 1 wt% to 0.4 wt%. To support the experimental data, an analytical model to predict the AC conductivity of graphene-polymer nanocomposite based on orientation dependent conductivity of GNP and percolation threshold during the alignment process for various content of GNP is developed.

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Tunable Performance Metrics for Acoustic Liners

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ABSTRACT

In the development of automated design tools for acoustic liners customized to mitigate diverse noise spectral characteristics, it is often beneficial to have a unified quantitative metric to discriminate between candidate designs, especially 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 liner design. A numerical study is conducted using a Zwikker-Kosten Transmission Line (ZKTL) based procedure to demonstrate the application of TPMs for the selection of acoustic liner designs for various scenarios. When liners with innovative 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 holistic means of evaluation.

Acknowledgement

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Large – Eddy Simulation Around Buildings in Crosswinds for Unmanned Air Systems Operation

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ABSTRACT

This study aims to evaluate crosswind airflow across large buildings and terrain, which could adversely affect Unmanned Aerial Systems (UAS) during their operation near these features. Unanticipated wind gusts or extreme flow conditions around obstructions cause major challenges for UAS and can cause property damage, or injury to bystanders as a result. Safety is a major concern in integrating UAS into every-day life, so this study can further understand airflow conditions in areas where UAS may be deployed. By better understanding flow conditions, the operation of UAS could be made safer and more predictable. Large - Eddy Simulation (LES) can be used to understand and predict the atmospheric air currents across complex surfaces or structures. In this work, we aim to use Large - Eddy Simulations to better predict and simulate turbulent flow events which could lead to improvements in UAS safety in the future.

Acknowledgements:

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Determination of a Strain Energy Density Function for the Tricuspid Valve Leaflets Using Constant Invariant-Based Mechanical Characterizations

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ABSTRACT

The tricuspid valve (TV) regulates the blood flow within the right side of the heart. Despite significant improvements in understanding the TV mechanical properties, limited attention has been devoted towards the development of TV-specific constitutive models. The objective of this work is to use the *first-of-its-kind* experimental data from constant invariant-based mechanical characterizations to determine a suitable invariant-based strain energy density function (SEDF) for the TV leaflets. Six specimens for each TV leaflet were characterized, and the experimental data was fit with three candidate SEDF forms: (i) polynomial, (ii) exponential, and (iii) combined polynomial-exponential SEDFs. Our results showed that the exponential and polynomial SEDF forms had similar fitting capabilities (R^2=0.92-0.99 vs. 0.91-0.97) that is superior to the combined polynomial-exponential SEDF (R^2=0.65-0.95). Furthermore, the mean Pearson's correlation coefficients for the polynomial form were larger than the exponential form (0.51 vs. 0.30), indicating a more well-defined search space. Our final assessment of the well-established *D*-optimality and condition criteria revealed that the exponential SEDF form model parameter's confidence regions were notably smaller and more eccentric than the polynomial SEDF counterpart. From these results, we conclude that the exponential form is better suited for the TV leaflets owing to its superb fitting capabilities and smaller model parameter's confidence regions. Forthcoming extensions of this work will use non-parametric bootstrapping to determine the optimal TV leaflet-specific model parameters, which can then be employed in *in-silico* simulations of functioning TVs.

Acknowledgments: Funding supports from the American Heart Association Scientist Development Grant (C.-H.L.), the Presbyterian Health Foundation (C.-H.L.), and the NSF Graduate Research Fellowship (D.W.L) are gratefully acknowledged.

Design, Deployment, and Analysis of the Ground-based Local Infrasound Data Acquisition (GLINDA) System

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ABSTRACT

Recently there has been evidence suggesting that, during tornadogenesis and through the life 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, and provide means of measurements at close range to mitigate atmospheric propagation over long distances, the design and deployment of the Ground-based Local Infrasound Data Acquisition (GLINDA) system was completed at Oklahoma State University. GLINDA has been deployed alongside storm chasers based out of Oklahoma beginning in May 2020 and has returned data over multiple severe weather events including the first tornadic measurements acquired with GLINDA on 22 May 2020 in Lakin, Kansas.

Experimental Analysis of Carbon Fiber Composite Bonding With Metal

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ABSTRACT

The Sooner Off-Road engineering competition team is seeking to create carbon fiber composite suspension links and drivetrain components. In order to use this material, the carbon fiber composite must be affixed to a metal whether it be aluminum or steel to interface with the rest of the vehicle components. This research specifically tests the bond between the two materials looking at different types of adhesives at different curing temperatures to determine the best option for Sooner Off-Road. All tests were conducted using ASTM E9 dimensions for the samples in an Instron 5969 Series Testing system to ensure reproducibility of the studies. Carbon fiber composite samples were tested to confirm a yield strength similar to the strength of 4130 steel, 63,100 psi, which was successfully confirmed. This was followed by adhering the two materials using 2 types of epoxies at 2 different curing temperatures in single-lap joints to test the shear strength of the bond surface. The results of the research confirmed that Lord's Epoxy would be best suited for the team based upon its availability, ease of use, and adequate shear strength properties.

Satisficing in the World of Engineering Design

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ABSTRACT

Engineering-design problems require a feasible solution space from which designers can explore robust solutions under different design scenarios. Optimization methods are often used for seeking 'optimum' solutions and mitigating uncertainty. This approach is often ineffective, especially when i) a problem has nonlinear, non-convex equations, ii) a problem contains goals and constraints structured using incomparable units, iii) coupled decisions such as selecting materials and designing geometry are required, iv) information is not available so that uncertainty is unavoidable, and v) there are only a few factors to control but a lot of requirements to be met. Moreover, for engineering-design problems, we often don't require an optimum solution, so much as a satisficing solution that is sufficient. Therefore, we seek to identify satisficing solutions to manage, rather than mitigate, uncertainties and satisfy multiple goals.

We use the compromise Decision Support Problem construct to design aircraft and to obtain a feasible design space that is populated by many satisficing solutions. By exploring the solution space, we identify that satisficing solutions are relatively insensitive to uncertainty. The results are verified using Kuhn-Tucker conditions and sensitivity analysis. In this presentation, we describe the problem, the salient features of satisficing strategy, the robustness of the solutions, and other findings during the design process.

In this talk, the problem, the salient features of the approach and the proncipal findings are preseneted.

Implementation of a Debouncing Circuit on an Emergency Cutoff Switch

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ABSTRACT

When designing machinery, it is essential to keep the safety of the user of the highest priority. One important piece to this is a panic switch; a quick cutoff to the power in the event of an emergency. The mechanism is simple; two metal parts come into contact to short the power from the supply. However, due to the mechanical nature of it, these two metal parts connect and disconnect many times before the actual connection is made, similar to the action of a ball bouncing until it comes to rest. This process is called *false triggering*, and it occurs when the button is pressed and also when it is released. It may not seem like a major problem, but false triggering results in the mechanism triggering like the button is pressed multiple times. For the purpose of an emergency cutoff switch, this could be disastrous. There are three main methods to go about eliminating debouncing, but this presentation will focus on only one, hardware debouncing. By smoothing the input signal from the switch which is rapidly oscillating, the power can be shut off quickly enough to prevent an emergency from occurring.

Rapid Synthesis of Carbonaceous Hydrophobic Layers via an Oxygen-Enriched Flame Deposition Process

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ABSTRACT

We report the rapid single-step flame synthesis of hydrophobic carbon layers (C-layers) on the surface of stainless-steel (SS) substrates using an oxygenated fuel (canola methyl ester). A non-premixed co-flow diffusion flame is used to generate a hydrophobic monolayer on the surface of the SS substrate upon its insertion into the reaction zone. C-layer deposition on the surface of the SS substrates varies by altering the oxygen content of the oxidizer stream and the substrate's position in the flame. The thickness, mass, and hydrophobic properties of the flame formed monolayer depended on the oxidizer and the substrate's insertion point into the flame. We hypothesize that a small inner cone of the biodiesel flame, along with a high soot propensity, results in an ideal medium to form uniform hydrophobic C-layers of unique hierarchical surface structure. Collected data shows that as oxygen percentages and flame temperatures increased, the size of the flame region to form hydrophobic C-layers decreased. Hydrophobic properties of the C-layers were quantified by measuring the contact angle of water droplets placed on the layer's surface. It seems that C-layers formed at higher oxygen contents becomes unstable and form curled/peeling layers that are easily detached. We believe the instability of these layers is caused by thermal stresses experienced as C-layers are formed in oxygen enriched-air flames. Increased oxygen content led to surfaces with large cracks that grew as oxygen content was increased. Further research is needed to fully understand the effect of oxygen on the formation of these carbonaceous hydrophobic layers.

Acoustic Sand Monitors for Multiphase Flow Systems

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ABSTRACT

The effect of solid particle erosion in the oil and natural gas industry can be damaging to pipes fittings and equipment, which can lead to maintenance or in worst case a production shutdown. In both cases this represents a huge economic loss for the industry. Acoustic sand monitoring is one the most widely used practices to estimate the amount of sand in the flow. In this work, a broad range of operating conditions has been investigated with acoustic sand monitors at Tulsa University Sand Management Project (TUSMP) facilities to determine the effectiveness of sand monitoring in multiphase flow. The main objective is to use the acoustic sand monitors is to determine the Threshold Sand Rate (TSR). This is the minimum sand rate necessary to achieve monitor output higher than the background noise level. Experiments were performed with two type of acoustic monitors (Roxar and Clampon) placed upstream and downstream of standard (r/D =1.5) elbows while varying superficial gas and liquid velocities, sand size (25, 75, 150 and 300 micron), pipe diameter (1-inch, 2-inch, 3-inch, and 4-inch), viscosity of liquid, and flow orientation (horizontal and vertical). The experimental conditions were selected to cover different flow regimes such as annular, annular-mist, slug, churn, bubble, and stratified flow. The experience gained from these experiments shows important results about the comparison between the different parameters which make an impact on TSR. For instance, if the pipe diameter is increased, the TSR will also increase. On the other hand, if the flow rate of gas is increased, the TSR tends to decrease. Regarding the pipe orientation effect, horizontal flow showed higher TSR than vertical flow. In all flow regimes, annular flow showed lower TSR values than other flow patterns. Finally, if the size of sand particles is increased, the TSR decreases.

Stabilization of the Acoustic Mack Modes with Metasurface

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ABSTRACT

Future hypersonic vehicles require boundary-layer transition control for a relatively economic flight because it has a first-order impact on aerodynamic heating, drag force, and vehicle performance. Although there are various instability waves, the acoustic Mack second mode is one of the dominant instability waves that trigger early laminar to turbulent boundary-layer transition for bodies that have a relatively sharp leading edge, such as X-51A. There are various techniques to delay the transition; however, these techniques affect the mean flow while stabilizing the Mack modes. Acoustic waves within the boundary-layer move and grow by reflecting between the sonic line and the surface of the body. This movement within the boundary-layer may be stopped by the small cavity holes on the surface. Since flow speed is high and the cavity holes are so small, the change in the mean flow due to cavity holes will be minimal. Metasurface placed on the nose of the body may significantly stabilize the acoustic modes by trapping them to the cavity holes. Moreover, their effect on the mean flow will be minimal among the other techniques. In this poster, the behavior of the acoustic perturbations over the metasurface will be presented.

Deep learning approaches for subgrid scale parameterization in chaotic dynamical systems

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ABSTRACT

The parameterization of subgrid-scale processes in geophysical flows is very important for an accurate weather forecast. Despite the success of machine learning to represent subgrid-scale processes in geophysical flows, their online deployment is marred by instabilities and biases, which in turn can lead to inaccurate prediction. To tackle this issue, we exploit the data assimilation technique to correct the physics-based model coupled with the neural network as a surrogate for unresolved or unknown flow dynamics in multiscale systems. In particular, we use a set of neural network architectures to learn the correlation between known flow variables and the parameterizations of unresolved flow dynamics and formulate a data assimilation approach to correct the hybrid model during their online deployment. We illustrate our framework in a set of applications including the Lorenz 63 model, the two-scale Lorenz 96 system for which the parameterization model for unresolved scales is exactly known, and the two-dimensional Kraichnan turbulence system for which the parameterization model for unresolved scales is not known a priori. Our analysis, therefore, comprises a predictive dynamical core empowered by (i) a data-driven closure model for subgrid-scale processes, and (ii) a data assimilation approach for forecast error correction. The successful synergistic integration of the neural network and data assimilation for chaotic dynamical systems shows the potential benefits of such hybrid methods in complex weather models.

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Designing a Multi-echelon Inventory Model from a Climate Change Mitigation Perspective

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ABSTRACT

The production-inventory problem embodies decisions of order size and inventory level which have significant impact on greenhouse gas emissions. We design an inventory model with greenhouse gas emissions considerations while considering the context of a multi-echelon supply chain. We consider a multi-echelon supply chain with different external suppliers, warehouses, and stores. We use the model to provide interesting insights for firms and policymakers. Such insights would be difficult to obtain with classical production-inventory models. For instance, the integration of lead times does not show how the amount of greenhouse gas emissions changes with the variation of customer lead time and orders frequency. The consideration of an inventory policy does not show how policies (such as the base stock and the fixed order quantity) impact the emissions. In this presentation, the features of the inventory model are described. The salient features and the initial findings are covered in the talk,

150 words

Data Curation for Fail-Safe Healthcare Networks

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ABSTRACT

The healthcare system often suffers from hidden bottlenecks and causal loops, hence people's well-intentioned interventions fail to increase efficiency and patient satisfaction. To maximize the efficiency of the healthcare network, we need to understand its dynamics and cause-and-effect nature. When authentic data is limited or with low quality, process-driven methods with domain expertise and metaheuristics allow us to generate synthetic data. In this presentation, we apply synthetic data generated by simulation tools to the model of the Orlando Veteran's Affairs Medical Center (VAMC) created by Bobbie Afrifah. We capture the cause-and-effect relations among factors in the Orlando VAMC, identify the control factors, sensitive factors, and the interactions among the factors; through analyzing the patient flow, we identify bottlenecks in the Orlando VAMC. By leveraging the control factors in the decision model, we remove some bottlenecks and improve the model's efficiency. We verify the results using statistical tests and domain expertise. In this presentation, the problem, the salient features of the method and findings are presented.

Cable-Driven Linear Actuator with Large Relative Displacement

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ABSTRACT

Most linear actuators (screw, pneumatic, hydraulic, etc.) consist of a stationary housing and a moveable (piston) extension component. In order to keep the piston constrained laterally, and due to other mechanical limitations, the pistons for these systems are incapable of translating more than the distance of the stationary housing. The relative translation distance is limited for those traditional linear actuators. In this study, a novel cable-driven linear actuator is designed that can provide both axial tension and compression forces, and be capable of extending to a final length that is over twice its original length. It uses a set of wires arranged in a helix configuration that extends or contracts axially due to a torsional rotation. These wires are constrained from shifting laterally and from buckling when under compression. Prototypes are constructed using mostly 3D printed components, and the relationship between the input torque, output force, and output contraction distance are determined experimentally.

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Parametric Analysis of Surface Dielectric Barrier Discharge Plasma Actuators

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ABSTRACT

Since 2018, there has been a resurgence in the utilization of electroaerodynamic (EAD) force as a primary means of propulsion. The induced ionic wind from a surface dielectric barrier discharge (SDBD) actuator has demonstrated a marginal level of efficiency for thrust production, enough to perform steady level flight under specific conditions. The main benefit of the proposed plasma propulsion system is its solid state propulsive nature. There is a need for the exploration and optimization of several types of plasma to ensure efficient solid state propulsion. This project focuses on the end goal of developing a sizing equation for SDBD plasma actuators. The project centers around an in-depth look at the velocity magnitudes produced by several SDBD actuator configurations. The number of actuators, pulse rate, and gap size will be controllable variables towards the best thrust to weight ratio (TWR) for the propulsion system. Particle image velocimetry (PIV) will be used to characterize the flow fields generated by the plasma actuators. It is expected that with proper configuration, the SDBD system will hold the best thrust to weight ratio due to its inherent induced force, relatively low power requirements, and additive momentum transfer nature.

Air-Assisted Atomization of Micro Beveled Needle Injector

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URL: https://www.youtube.com/watch?v=???

ABSTRACT

The air-assisted atomization of micro liquid jets injected from beveled needle point style injector is studied experimentally motivated by its potential applications in biomedical devices. Pressure injection was used to feed the test liquid and the air from two different syringes into a co-flow atomizer. The atomizer is built from two beveled needles (16G and 30G) one inside the other, with the smaller needle resting against the inner wall of the larger needle. The test procedure consists of the following steps: adjusting the liquid and the air volumetric flow rate, making sure to reach steady state and then activating the optical system. In order to accommodate rigidly-mounted optical instrumentation, the injector assembly was traversed in order to measure the spray field. The injector was mounted on a plate which had been traversed using two linear translational stages. The primary breakup mechanism is investigated using doubled pulsed shadowgraphy and digital holography. The measurements included the location of onset of liquid jet breakup, size of ligaments and drops at onset, drop sizes as a function of distance, and the spatial spray distribution. The present injector design is inexpensive and is effective in controlling the spray size distribution using the velocity ratio of the two fluid streams.

Modeling the Viscoelastic Soft Elasticity of Liquid Crystal Elastomers

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ABSTRACT

Pressure Ulcers (PUs), a common and preventable health condition, affect 2.5 million patients per year in the US and their treatment costs $11 billion annually. PUs are injuries of the skin resulting from prolonged tissue pressure on a bony prominence and mostly affect bedridden patients or wheelchair users. Our goal is to use a smart skin made of Liquid Crystal Elastomers (LCEs) to treat and prevent PUs by distributing the pressure on the tissue.

LCEs are crosslinked polymer networks combining the rubber elasticity of elastomers with the orientation of liquid crystals. They exhibit shape memory actuation and soft elasticity behavior, an increase in strain at constant stress. Due to their unique properties and biocompatibility, they are attractive candidates for biomedical devices. A proper computational constitutive model is required to simulate and design LCE devices.

In this study, we developed a viscoelastic soft elasticity model of LCEs. We assume that the Young's modulus depends on the phase transformation from disoriented to oriented states. The model is implemented in the finite element software FEAP and the material parameters are fitted to experimental results at different strain rates. The developed model predicts the slope of the stress-strain curve before, during, and after the transition according to strain rate.

This model will allow to simulate the behavior of the smart skin at the contact with the tissue to evaluate its impact on the peak pressure and possible PU development.

Evaluation of the Tricuspid Valve Annulus Mechanics in Newborns with Hypoplastic Left Heart Syndrome Using 4D Echocardiograms

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ABSTRACT

Hypoplastic left heart syndrome (HLHS) is associated with an underdeveloped left ventricle and mitral valve, which limits the heart's capability to deliver oxygenated blood to the body. This life-threatening ailment is present in approximately one of every 4000 newborns each year in the U.S., and only palliative surgical treatment or heart transplant is available for addressing HLHS. Tricuspid valve dynamics plays a crucial role in this challenging population, as evidenced by one-third of all HLHS patients suffering from a regurgitant tricuspid valve within 4 years of the initial valve surgical repair. A better understanding of HLHS and its treatments will aid in the development and refinement of improved surgical procedures to prevent adverse outcomes. In this study, we provide insight into the tricuspid valve annular dynamics and mechanics at different stages in the palliation procedure, and compare the results to healthy, non-HLHS-afflicted patients. Specifically, we perform image segmentation of the TV annulus from 4D echocardiographic (4DE) data of both healthy and HLHS-afflicted newborns and use the generated point cloud data to inform a non-uniform rational B-spline (NURBS) curve fit. From our analysis pipeline, we quantify: clinical metrics (e.g., circumference, area, and diameter), mechanics-based metrics (e.g., strain, strain rate), and geometrical metrics (e.g., curvature, bend, and twist). This detailed insight to the TV annular mechanics and dynamics will be useful for improving the understanding of the initiation and progression of tricuspid valve abnormalities in HLHS, which will be useful for determining the optimal timing and selection of the TV surgery.

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Structure-property Relationships in 4D-printed Liquid Crystal Elastomers

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ABSTRACT

Liquid Crystal Elastomers (LCEs) are active smart materials that exhibit two-way reversible shape changes via the transition between the nematic or liquid crystal state and the isotropic state with the application of heat, light, magnetic field, etc. 4D printing is a form of 3D printing involving smart materials that allows for a change in shape in the post-fabrication phase. The 4D printing programming techniques currently used are predominantly structure-based and mostly reliant on multi-material printing. In this study, we explore the site-specific shape change of a single 3D printed material (LCE) by controlling various printing parameters like printing speed, printing angle, etc. We also explored the viscoelastic properties of printed LCEs.

We found that the actuation strain of 4D printed LCEs increases with the increase in printing speed and the actuation strain can be as high as 42%. In addition, 4D printed LCEs tend to bend more with response to heat when printed at higher printing angles. By precisely regulating these printing conditions, we fabricated functional hinges, a 2D grid, a self-folding box, a 3D pyramid from a 2D rectangle and 3D helices from a 2D ribbon. We also found that 4D printed LCEs exhibited a higher storage and loss modulus than bulk LCEs. Storage modulus, loss modulus and Young's modulus of 4D printed LCE decrease with the increase in printing angle.

These results show the potential of additively manufactured heat responsive LCEs capable of reversibly actuating between two pre-programmed shapes for applications in soft robotics, biomedical prosthetics and implants, dynamic functional architecture, etc.

Quantifying the Impact of Social Drivers on Policy Recommendations

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ABSTRACT

Rural communities in India are among the poorest demographics, and a major target for development within the country. However, limited resources to implement developmental policies, make it essential to maximize the policy's effects through promotion. Therefore, promotions need to address not only economic, but also the social, and environmental drivers that motivate villager's decisions to increase the adoption of policy without increasing policy expense. However, many of these social drivers are not directly measurable. Drivers like reputation, or caste, can have a significant impact on decision making, but the degree of their impact cannot be easily quantified. To quantify these "immeasurables," we propose using survey data from villagers comparing more measurable goals to these immeasurables to develop indices of relative importance that can quantify the reaction to various promotional incentives. In this paper, we discuss how these indices can account for variability in the relative importance of drivers between villages and allow for modelling of the effects of social and environmental drivers on rural behavior. Through simulating promotions that address non-economic drivers with Agent-Based Modelling, we can gauge the any improvements in the community that result from promoting the policy advantages that affect specific drivers. Based on this, we can improve the effectiveness of policy recommendations and subsequent promotion to best increase the quality of life in these rural communities.

Word Count: 220

Development of a robotic arm-gantry simulation using ROS and Gazebo

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ABSTRACT

Robotic arms can perform repetitive tasks with high speed, accuracy, and precision, making them highly suitable for industrial applications. These capabilities can also be leveraged in applications that require a high degree of precision, such as robotic surgeries and in experiments that involve model testing. Nevertheless, such applications require a robust simulation since prototype testing poses the risk of catastrophic damage to the experimental setup. Robot Operating System (ROS) is the most popular framework for creating robotic applications due to its easier hardware abstraction, code reusability, and compatibility with popular open-source libraries. The present study focuses on a system consisting of an inverted robotic arm coupled with a gantry. This presentation presents the creation of the simulation of a robotic arm–gantry system in ROS using Gazebo and its integration with Moveit for motion planning.

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Minimum Cost Variance Controller for Quadrotor Under Wind Turbulence

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ABSTRACT

Leveraging turbulence model information from a Large Eddy Simulation (LES) and stochastic differential dynamic model, we design a minimum cost variance (MCV) controller for a quadrotor operating in a turbulent environment. The turbulent environment may be imposed on a quadrotor by structures, landscapes, terrain and most importantly by the unique physical phenomena in the lower atmosphere. Turbulence negatively impacts quadrotor performance and operational tasks. Minimum cost variance controller deals with systems that are impacted by stochastic disturbance and aim to minimize the cost in terms of its variance. We linearize the quadcopter dynamics and examine MCV controllers derived from a set of coupled algebraic Riccati equations with full-state feedback. Our initial results show reduction in mean trajectory error and variance compared to a traditional linear quadratic regulator.

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Densification and Wear Behavior of Spark Plasma Sintered Non-equiatomic High Entropy Alloy

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ABSTRACT

Non-equitaomic High Entropy Alloy is an extension of the High Entropy Alloy (HEA) family. Spark Plasma Sintering (SPS) is one of the most popular and favored fabrication technique used for HEAs owing to its remarkably high densification rate. Mechanically alloyed (MA) HEA powder is largely used for research but, these powders are susceptible to impurities and inhomogeneity. Gas atomized powders have higher purity, homogeneity, and economic feasibility, and are a popular choice for industry level manufacturing. In this research work, gas atomized powder of $Al_{0.5}CoCrFeNi_2$ non- equiatomic HEA was sintered using SPS at 800°C, 850°C, 900°C, 950°C, 1000°C and 1050°C. The density of the sintered samples increased with sintering temperature and complete densification was achieved at 1000°C. The non-equiatomic HEA exhibited a stable FCC phase for all sintering temperatures. Average grain size increased slightly with increase in sintering temperature. Samples sintered at 800°C and 850°C showed lower hardness value of 201 ± 10 HV and 217 ± 8 HV respectively due to high percentage of porosity. For sample sintered at 900°C, 950°C, 1000°C and 1050°C, average hardness of 245 ± 5 HV was recorded. Hardness was not influenced by minor increase in grain size. The mechanical properties of $Al_{0.5}CoCrFeNi_2$ were found to be comparable to that of Inconel 718 (aged at 900°C). For $Al_{0.5}CoCrFeNi_2$, the dry sliding wear rate decreased with decrease in porosity. Oxidation assisted abrasive wear was observed in the HEA and coefficient of friction value fluctuated between 0.6 and 0.7.

A Machine Learning Approach to Predict Wind Field Data

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ABSTRACT

Spatio-temporal wind field data prediction is becoming increasingly essential for many systems' safe operation, like wind energy generation and gust avoidance for small Unmanned Aerial Systems (UAS). These systems are susceptible to changes in local wind patterns. Wind field prediction and forecasting in real-time are necessary for robust and continuous operation. While state-of-the-art local and global Numerical Weather Prediction (NWP) tools are available at our disposal, the computational cost associated with them makes their use immensely prohibitive for 'real-time' or close to 'real-time' predictions. However, with the recent advancements in Machine Learning algorithms and techniques, it is possible to harness Neural Networks and associated frameworks for wind field prediction. Using Large Eddy Simulation (LES) data from numerical solvers for atmospheric flows as an offline training data set, we could train the Neural Networks model. Subsequently, it can be deployed for short-term prediction of the local flow fields from the trained network. Building upon other robust mathematical techniques like Principal Component Analysis (PCA) or Proper Orthogonal Decomposition (POD), we could further decrease the computational cost associated with training and deployment of Long Short-Term Memory (LSTM) Neural Networks for the problem reducing the overall cost. This work aims to provide a machine learning approach for wind field prediction using numerical solutions for atmospheric flows over a domain of interest.

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DESIGN, DEVELOPMENT, AND FLIGHT TESTINGOF A MAV FOR METEOROLOGICALDATA COLLECTION

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ABSTRACT

To have accurate forecasting models for weather systems, data must be collected on the thermodynamic structure of the Atmospheric Boundary Layer (ABL). Currently this information is gathered using weather balloons, but they are easily influenced by wind and rise through the ABL quickly, providing low vertical resolution. Additionally, the sensors on board a weather balloon are only reusable if they happen to be recovered wherever they land. Other meteorological data collection methods such as aircraft, radar, and mesonet towers are also insufficient due to being fixed in place or requiring extensive preparation time to deploy. Thus, there is a critical need to develop a low cost, easy to manufacture, gliding radiosonde which can take high resolution vertical samples and return to a ground station for reuse. This system has 2 major advantages: it allows for more data to be collected on atmospheric conditions leading to better forecasting, and it cuts down on cost over time due to its reusable nature.

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Design of Bellwether: A Flying Wing Applying the Bell Spanload

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ABSTRACT

This paper describes the development of the Bellwether aircraft, an unmanned flying wing designed to carry scientific payloads for an atmospheric sensing research effort. The aircraft is optimized for minimum induced drag by using the Prandtl Bell spanloading, incorporated in the configuration via careful design of the wing's twist distribution. Additional benefits from the lift distribution, important to the intended mission, include lower root bending moment than a comparable span aircraft would see without twist, and the presence of proverse yawing moment with deflection of the ailerons making any vertical flying surfaces unnecessary to coordinate a turn. In addition to showing our design process using rapid, medium-fidelity aerodynamic tools, we demonstrate our designed twist distribution yields the expected performance benefits via computational fluid dynamics solutions, adding rigor to the recent results from a NASA demonstration program. Initial comparisons between medium- and high-fidelity aerodynamic solutions are shown in this body for work. Full results will be provided in the final manuscript.

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Custom Multi-Purpose Cart for Southwest United

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ABSTRACT

Southwest United Industries (Tulsa, OK), who specializes in metal finishing and repair, ran into the common issue of parts and products becoming unnecessarily damaged while on facility grounds. The company expressed that one of the key issues in products becoming damaged is lack of adequate means to transport the items which lead to various collision events such as part-on-environment and part-on-part. Four students studying engineering with a concentration in mechanical are committed to tackling this company's issue in the most effective, yet simple and practical way possible. The company specifically requested that the students create the blueprints for a cart that can help reduce the number of collision possibilities that occur to both small and large parts. In order to accomplish this task, students utilized Solidworks to design a model that would suit the types of parts the company wanted the cart to hold. Solidworks was also used to simulate the types of stress the cart would experience when parts of different weight are placed. Once we found out where stress was most accumulated, students utilized a program called ntopology to reinforce the areas of stress and lessen the material on parts where stress was not applied in order to reduce the cost of the cart while at the same time obtaining a product that meets the company's standards.

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A Novel Compression and Expansion Fusion for Improving Vapor Compression Refrigration Cycles

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ABSTRACT

Refrigeration accounts for 20% of the world's overall electricity consumption. Improvements to the efficiency of refrigeration cycles could offset the predicted increase in their energy consumption due to global warming (double by 2050). Previous studies have shown the improvement in the coefficient of peroformance (COP) is possible by adding an expander to the refrigeration cycles. The present study investigates a novel compressor-turbine fusion device that transfers heat from the hot compressor to the cold turbine. Five different working fluids are considered to examine the potential benefits for both traditional HFCs and natural refrigerants. The thermodynamic analysis of the the cycle revealed that the device can improve the COP from that of an isentropic compressor and turbine by as much as 20%. The increase in COP for refrigeration of the common HFC refrigerants was small with 1% for R134a and 3% for R410a. Natural refrigerants like CO_2 and Ammonia saw greater increases in COP of 7% and 13% respectively. The greatest increase of COP was for water vapor which increased by 20%. A similar trend was observed for the heat pump cycle; however, increases were not as pronounced.

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Computer Software Integration in a Virtual Reality Flight Simulator

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ABSTRACT

The development of a stewart-platform based virtual-reality flight simulator is aided by the implementation of multiple, unrelated software. These programs are carefully configured and used in conjunction to achieve a realistic flight simulator, capable of performing motion with six-degrees-of-freedom. Analysis is being done on the computer engineering aspects of a much larger project; a project which contains mechanical, electrical, and computer engineering applications. The project makes use of a program called SimTools, in conjunction with a game called X-Plane 11, as well as an HTC VIVE virtual-reality headset. There is a connection between multiple pieces of computer hardware, each running together simultaneously. An Arduino Uno is programmed to receive data from SimTools via a UDP network connection. SimTools automatically retrieves the data from X-Plane but must then be parsed through the Arduino and sent via I/O ports to multiple Sabertooth Motor drivers. Included is a thorough explanation of the software integration, with technical diagrams and the concepts behind the code used to drive the system.

Infrasound Propagation in the Atmospheric Conditions of Tornado Producing Storms

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ABSTRACT

Tornadic storms have been shown to produce sound that is emitted at frequencies below the human threshold of hearing (20 Hz), also known as infrasound. This infrasound can propagate over large distances due to low atmospheric attenuation of sound at low frequency. Therefore, early detection of this infrasound could aid in the lead time of tornado warnings. This work investigated the propagation of infrasound in the atmospheric conditions of storms utilizing computational modeling of the weather conditions and sound propagation. This was done by generating atmospheric models with AVO-G2S and modeling infrasound propagation with NCPAprop, both of which are open source codes. The propagation simulations give an approximation of how an infrasound signal would behave during a specific storm events. Thus, this work will report the finding of running propagation simulations of tornado producing storms that occurred in 2017 and 2019 in Oklahoma. Specifically focused on the likelihood that an array located in Stillwater, OK could detect infrasound emitted from these storm events.

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Effects of Shock and Vibration on Electronic Components

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ABSTRACT

To ensure the reliability of electronic equipment, it is important to predict the life cycle of the equipment at the design stage and/or test the prototype in simulated environments. There are three major causes of failure of electronic components mounted on printed circuit board (PCB) assemblies: high temperature, vibration/shocks, and humidity. Reliability prediction methods are categorized into three groups including handbook methods, physics-of-failure methods, and test data methods [1]. Both the handbook methods and field data methods are based on databases of electronic component failures, but the latter group is a significantly improved version of the former. All physics-of-failure methods require two steps: finding structural response of a PCB for given vibration or shock and relating the structural response to component failure criteria [2]. Test data methods are for testing a PCB in a simulated operating environment; such testing is necessary for high risk equipment.

This study focused on the effects of vibration and shocks at room temperature and used the physics-of-failure approach. An FEM model for a selected PCB product, and its dynamic response to vibration were developed and analyzed using ANSYS. Stress and strain profiles were computed along with the deformation profile of the PCB. We plan to perform experiments on the PCB to verify the FEM model.

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** Member, ASME

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Enhanced photodegradation in polystyrene/C_{60} blends

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ABSTRACT

New generation polymers undergoing rapid photodegradation in the environment are of significant interest for remediation of disposed plastics and mitigation of plastic pollution. The present work investigates enhanced photooxidation of polystyrene with C_{60} fillers. To this end, we prepared several hundred nanometer thick polystyrene films, containing 0%, 0.5%, 1%, 2%, and 4% of C_{60} by weight, through spin casting on quartz substrates. Subsequently, the films were exposed to UVB radiation of 2.5 mW/cm^2. Photooxidation kinetics and photoproducts were studied using UV-Vis absorption and vibrational spectroscopy (FTIR), respectively.

Photooxidation in neat polystyrene exhibits a superlinear increase of carbonyl (C═O) density with time. The superlinear trend is owed to an autocatalytic reaction between photosensitized singlet oxygen ($^1O_2$) and C─H, yielding the photoproduct C═O, being also the $^1O_2$ photosensitizer. A systematic decrease of aliphatic/aromatic C─H and aromatic C─C vibrational bands is observed by FTIR along with an increase of C═O vibrational bands. This initial regime is followed by saturation and decay of C═O density due to exhaustion of C─H and photodissociation of C═O (Norrish reactions). Muconic aldehyde, acetophenone, carboxylic acid, ketone in the chain, and pester are assigned as photoproducts based on the deconvoluted FTIR peaks. Accelerated photooxidation is observed in the presence of C_{60} with no difference in photoproducts. The photooxidation rate monotonously increases with the C_{60} content. This enhancement is attributed to C_{60}'s being an efficient and stable extrinsic $^1O_2$ photosensitizer, boosting the $^1O_2$ density at the onset of photodegradation, which otherwise is limited due to the low concentration of intrinsic C═O photosensitizers.