Online Proceedings

Poster Session 1

MGH 241, Easel 143

11:00 AM to 1:00 PM

UAS Operation and Navigation in GPS-Denied Environments Using Multilateration of Aviation Transponders

Helen Kuni, Senior, Aeronautics & Astronautics
Undergraduate Research Conference Travel Awardee
Mentor: Christopher Lum, Aeronautics & Astronautics

This research involves the design of a system for an unmanned aerial system (UAS) to operate and navigate in an environment devoid of a Global Navigation Satellite System (GNSS) such as the Global Positioning System (GPS). The system operates by interrogating an aviation transponder (either mode C or S) that is carried by the UAS and measuring the time elapsed for the response to multiple, ground-based antennas and using triangulation (multilateration) to locate the transponder and by association, the UAS. The ground-based system then routes this position information back to the UAS via the UAS's data telemetry link. The autopilot then utilizes this position information for navigation in much the same way it would utilize a GPS-based position report. Our research focused on the system architecture to enable a UAS to operate in a GPS-denied environment. Flight test results are presented utilizing a customized version of the popular Pixhawk/ArduPlane avionics platform and demonstrate that the system is capable of guiding a UAS through a series of waypoints in the absence of GPS signals. Furthermore, the customized controller that was designed to consume this alternate source of position information performed well in highly unfavorable environmental conditions. This success illustrates the feasibility of the system as a practical alternative to GPS.

Poster Session 1

MGH 241, Easel 140

11:00 AM to 1:00 PM

Refit and Construction of a Rotating Detonation Engine Laboratory

Chinmay S. Upadhye, Senior, Aeronautics & Astronautics, Physics: Applied Physics
Andrew Jacob, Senior, Civil Engineering
Andrew Joseph Milligan, Junior, Aeronautics & Astronautics
Mentor: Carl Knowlen, Aeronautics & Astronautics
Mentor: James Koch, Aeronautics and Astronautics

The University of Washington High Enthalpy Flow Laboratory (HEFL) has constructed a purpose built laboratory for experimental research on Rotating Detonation Engines (RDE). This refit included the rebuilding of the lab apparatus, the assembly of the RDE and supporting equipment such as downstream piping, vacuum system, gas handling plumbing, and the redevelopment of the experimental instrumentation. The assembly of the lab apparatus consisted of the construction and mounting of fuel, oxygen, and nitrogen lines for the RDE, and the assembly of back pressure controlled exhaust tubes leading to a dump tank and an optical imaging port. A stand for the engine apparatus itself as well as much of the plumbing support equipment was also constructed. The assembly of the RDE consisted of the assembly of the various engine parts, followed by the connection of the various instruments such as pressure sensors, temperature sensors, ion probes to the engine itself. The hardware and software components of the instrumentation systems were also redeveloped to allow for very high instrument density for pressure and temperature sensors on the RDE. The software component of the instrumentation involved developing MATLAB scripts for valve actuation, data acquisition, and sensor calibration. The hardware aspect of the instrumentation involved selecting the sensors to be used on the engine based on their signal conditioning, as well as designing and building power supply and signal processing circuits to connect the sensors to a rebuilt data acquisition computer system.

Session 1K

Physics: Fundamental and Applied

Session Moderator: Alejandro Garcia, Physics

MGH 254

12:30 PM to 2:15 PM

* Note: Titles in order of presentation.

Effect of Wall Condition on Spheromak Plasma Density Profile on HIT-SI3
Kuan Wei Lee, Junior, Physics: Comprehensive Physics
Mary Gates Scholar
Mentor: Aaron Hossack, Aeronautics and Astronautics

HIT-SI, also know as steady-inductive helicity-injected torus experiment, uses three coplanar inductive helicity injectors to form and sustain a spheromak equilibrium. Spheromak is a configuration of the plasma that forms into a shape of smoke ring and it is a promising approach to nuclear fusion energy based on its long confinement time and the confinment achieved by the self-induced current. This project is centered around data analysis from a new tomography diagnostic system to assess the symmetry of spheromak plasma density while varying the key current drive parameters of the HIT-SI3 plasma physics and fusion energy. The tomography diagnostic system consists of four toroidal chord fans and three sets of three poloidal fans that provide 3D plasma emission information. Each fan expands from 130 degree wide angle lenses coupled to bundles of fiber optics. The light collected by the fiber optics is split, filtered at 668 nm and 728 nm, and imaged by a high-speed camera. Since the ratio of the 668/728 nm emission has a strong plasma density dependence within the range of typical HIT-SI3 plasma parameters, the 3D emissivity profile constructed by inverting line-averaged emissivity along chords can be related to the plasma density profile. The objective of this project is to find the correlations between parameters affecting wall conditioning and the plasma density profile, then use the results from the analysis to maximize the performance of the plasma toward the goal of improving confinement. The initial analysis will include all available data covering a variety of experimental plasma conditions. After the correlation is established from the initial analysis, a series of carefully controlled experiments will be conducted to test and improve the certainty of the initial results. In the controlled experiments, plasma discharges will be taken under more specific settings so the effects of different conditions on the plasma profile can be isolated and better understood.

SESSION 2M

MCNAIR SESSION - FROM CHAOS TO ORIGAMI: ADVANCES IN MATH, PHYSICS, CHEMISTRY AND ENGINEERING

Session Moderator: Therese Mar, OMAD and Department of Environmental and Occupational Health Sciences
MGH 288
3:30 PM to 5:15 PM
* Note: Titles in order of presentation.

Multitransformable Leafout Origami
Kyle Johnson, Junior, Electrical Engineering
Louis Stokes Alliance for Minority Participation, Mary Gates Scholar, McNair Scholar
Mentor: Jinkyu Yang, Aeronautics and Astronautics
Mentor: Koshiro Yamaguchi, Aeronautics and Astronautics

With the increased development of space programs globally, more space probes are being funded for sample-return missions. Versatility and power limitations are some of the critical issues that these extraterrestrial sampling rovers are seeking to overcome in order to reliably deploy autonomously. Exploring the rough and unpredictable surfaces of other celestial bodies requires more adaptable and energy efficient robotics, which is what makes bio-inspired origami structures so appealing. Leaf-like origami is reconfigurable, which means that it can walk, jump, grasp, and actuate other useful motions all within the same device. Typical robots have redundant actuators and structural systems, but origami devices can build up potential energy before converting it into a mechanical motion. Due to this, rigid origami design approaches have the potential to be more compact, versatile, and energy efficient than conventional devices. Studying reconfigurable origami-based robotics can lead to devices that can be transformed into multiple configurations for various tasks. To design a versatile origami-based structure, I followed up on the research that Professor Jinkyu Yang and the members of his research group had on leaf-like origami, specifically leaf-out origami. This origami structure shows multi-transformable features. This means that the structure can be configured in a stable-stored or stable-deployed shape without having an external power supply maintaining its configuration. By finalizing the design, fabrication method, and discovering the optimized folding patterns for jumping and grasping motions, we will be able to start implementing the structure into more complex systems. Designing more structurally efficient systems may be the most practical solution we currently have to combat power and versatility limitations for autonomous space probes.

POSTER SESSION 3

MGH 241, Easel 129
2:30 PM to 4:00 PM

Advanced Composite Design and Production Application to the Hyperloop Prototype
John Benjamin Buffalo, Senior, Mechanical Engineering
Mary Gates Scholar
Mentor: Marco Salviato, Aeronautics and Astronautics

Fiber-reinforced composites are advanced materials that combine polymeric matrices with fibers to achieve low densities along with high strengths and moduli. These properties make composites invaluable to industries that rely on materials with high strength-to-weight ratios, such as aviation and

aerospace. This contribution discusses the structural design of the Hyperloop Prototype built by the University of Washington's team competing in the SpaceX Hyperloop Competition. As the Structures' team lead, my work has centered around designing a reinforced sandwich panel c-channel design, for the upcoming fourth competition, to optimize the total structural weight to 16lbs respect to the third competition design's weight of 60lbs. I then analyzed and optimized this design using 1D beam analysis scripts written in MATLAB as well as 2D composite shell analysis in Femap and Hypersizer software to validate SpaceX's structural stiffness and strength requirements. The structures team conducted an extensive testing campaign to capture flexural properties and identify limit loads of the design. This campaign included three-point-bend tests to capture sandwich panel properties and insert hardpoint testing to validate performance of the mechanical joints between the primary structure and propulsion, stability and braking modules. Finally, with the support of Boeing composite production advisors, the team manufactured prototype composite structures making use of advanced industry procedures including use of FlexCore, carbon puck hardpoints and autoclave cure cycles. This work serves as a critical example of composite material technology application to student-lead design projects as well as the engineering knowledge that can be developed outside of the traditional classroom setting through research and independent studies.