Poster Session 1

Commons East, Easel 73

11:00 AM to 1:00 PM

3D-Printed, Elbow-Driven Orthosis for Individuals with Limited Hand Function

Jessy Ha, Senior, Mechanical Engineering
Karley Benoff, Senior, Mechanical Engineering
Mentor: Katherine Steele, Mechanical Engineering
Mentor: Keshia Peters, Mechanical Engineering

Orthotic devices are prescribed for individuals who have partially lost motor control, such as stroke survivors or those with cerebral palsy, to assist with stability and function. Unlike prostheses, devices available for those missing part of a limb, there is a limited market for upper-limb orthoses. As a result, options for users can be clunky, expensive, and hard to customize. The goal of this research was to develop a 3D-printed elbow-driven orthosis that is inexpensive, adjustable, and helps users to perform two-handed daily tasks. Inspired by our participant who has limited hand function on her left side due to a seizure reducing brain surgery, we took a user centered design approach. By tuning the cable length running from the elbow to the hand, we took advantage of her existing range of motion to activate a clamp near the palm. We chose a modular approach for the clamp to suit a variety of daily activities, such as picking up small objects and holding a drumstick. In comparison to traditional devices that can reach hundreds of dollars, our cost has been reduced to roughly $20 largely because of the use of 3D printed parts. Through a continuous cycle of prototyping, receiving feedback, and modifying the design accordingly, we have created a device adapted to suit both adult and child sizes. While feedback from unimpaired participants was primarily received, we also plan to further test the device on individuals with limited hand function for more diverse perspectives from potential users. Ultimately, we aim to publish our designs open-source to promote further modifications and availability.

Poster Session 1

Commons East, Easel 74

11:00 AM to 1:00 PM

Impact of Print Settings and Annealing on the Structural Properties of 3D-Printed Materials

Michael B. (Michael) Mac Connell, Senior, Mechanical Engineering
Mary Gates Scholar
Mentor: Katherine Steele, Mechanical Engineering

Additive manufacturing (3D printing) has gone from being relatively unknown 20 years ago to being nearly ubiquitous today. Although 3D printers have become more and more common and the list of different types of 3D printers continues to grow, little work has been done to quantify the material properties of 3D printed materials. Finding relationships between shell thickness, infill percentage, infill shape and other print settings would give the 3D printing community a more quantitative way to increase print strength for a given filament type and print geometry. A relatively new aspect of 3D printing is the use of annealing to increase the strength of the printed part. By doing so the filament softens enough to spread out and form additional bonds between the layers and theoretically increases the strength of the print in the print plane. To facilitate this research and to find relationships between print settings and annealing, tensile testing was performed on dog-bone shaped samples (constructed using a fused deposition printer) using different print settings, and on annealed specimens. At the same time mechanical testing was performed, a computer generated model of 3D printed materials was generated using a method called finite element analysis. Tensile testing data was used to check the model for accuracy and insure the predicted 3D printed material behavior in the model is representative of what is seen in test specimens.

Session 1I

McNair Session - Exploring Science from Cells to Exoplanets

Session Moderator: Janneke Hille Ris Lambers, Biology

MGH 254

12:30 PM to 2:15 PM

* Note: Titles in order of presentation.

Systems Engineering of the Advanced Noise Control Fan

Victor Rosa, Junior, Mechanical Engineering, Cleveland State University
McNair Scholar
Mentor: John Lucero, National Aeronautics and Space Administration (NASA)

The NASA Glenn Research Center's Advanced Noise Control Fan (ANCF) started its research in the early 1990s at the Aero-Acoustic Propulsion Laboratory (AAPL). The ANCF was used to support noise reduction in engine fan components. ANCF was developed to identify successful concepts for engine fan acoustic testing. These concepts were then implemented into high speed fan designs that were tested at the 9x15 WT, which incurs a significantly higher cost. In this way, the ANCF has substantially contributed to the advancement of the understanding of the physics of fan tonal noise generation. Due to the technological advancements of high speed fan designs over the last several decades, there became a critical need for a new Fan Test Rig that would enable successful completion of the NASA/Industry noise reduction program goals. To make room for this new capability, it was decided that the ANCF would be loaned to the Notre Dame University institution to support continued testing for interested companies and to provide educational opportunities. This presentation will discuss how a Systems Engineering method was used to document and detail the dismantling, shipping and reassembly of the components of the ANCF into its new location.

Poster Session 2

Commons East, Easel 57

1:00 PM to 2:30 PM

Fabricating Tooth Fixture for X-Ray Computed Tomography 3D Scan

Minh Thu Thu (Minh) Tran, Junior, Mechanical Engineering
Mentor: Eric Seibel, Mechanical Engineering

In modern dentistry, the goal is to remineralize small lesions in the teeth, before there is a cavity. To monitor the healing process in teeth, infrared 3D optical imaging is being developed at the UW that does not have the safety risk of x-ray imaging. However, to calibrate this new prototype, teeth with natural lesions need to be imaged with x-ray to create a gold standard of lesion volume and density. This project will design, build, and test a fixture that will hold a tooth of various shapes, sizes, and orientations for microCT (computed tomography) scanning to obtain a high resolution 3-D image. X-Ray CT scanning can provide a high quality 3D image; however, it is harmful to use directly on humans due to large dose of radiation needed to form 3D images. This research and development project will use the new UW CT Scanning system in Moore Hall with highest 3D resolution of 2 microns. The fixture was designed by taking dimensions of the existing rotational plate of the CT Scanner, and the CAD design file is in the process of being 3D printed. The fixture must mitigate any effects from the CT scanner during operations (such as heating and vibration during scanning), and must be versatile so that it can hold different sizes of teeth at different orientations. The fixture design will be designed to also accept commercially available calibration specimens of known spatial and density values to ensure that image quality is being preserved.

Poster Session 2

Commons West, Easel 9

1:00 PM to 2:30 PM

Effects of Elevated Levels of Zinc on the Uptake of Calcium in the Pacific Oyster, *Crassostrea gigas*

Andrew Ness, Sophomore, Mechanical Engineering, North Seattle College
Leroy Miller, Sophomore, Oceanography, North Seattle College
Mentor: Ann Murkowski, Biology, North Seattle College
Mentor: Marina Halverson, Biology, Seattle Central College

Zinc is essential for the regulation of many biological processes in all known species. However aquatic species, especially invertebrates, are relatively sensitive to zinc toxicity compared to most terrestrial organisms. As oceans warm due to climate change, zinc previously trapped in ocean sediment will be released into the water column, exposing sensitive benthic and coastal species to elevated, potentially harmful zinc levels. Our study focuses on the impacts of elevated zinc on the calcium uptake of the pacific oyster. Previous research has shown that zinc can mimic other ions, disrupting calcium uptake in the gills. This is thought to be due to their similar size and charge, and could be especially harmful to shellfish and other organisms which use calcium to form their calcium carbonate ($CaCO_3$) shell. In our study, sixty-four oysters were randomly distributed into four tanks of varying elevated zinc concentrations. Following a 72 hour exposure period, the oysters were dissected and the gills were analyzed using Flame Atomic Absorbance Spectroscopy (FAAS) for calcium concentrations. The uptake of calcium through the gills of the oyster is expected to decrease as the concentration of zinc exposure increases. These results contribute to the growing body of knowledge concerning the interplay between zinc and calcium ions in aquatic organisms. Additional research is needed to characterize this effect on a wider variety of marine organisms, especially those in areas with significant run-off from urban or industrial localities.

Poster Session 2

Commons East, Easel 71

1:00 PM to 2:30 PM

Swarm Robotics
Jesse Hernandez, Junior, Physics: Applied Physics
Nini Hong, Junior, Mechanical Engineering
Mentor: Santosh Devasia, Mechanical Engineering

Swarm robotics consists of multiple robotic systems that interact with each other within a set environment. Inspiration for swarm robotics comes from behaviors observed in biological systems, namely insect colonies, that migrate collectively. Robots in a swarm are decentralized and behave independently, but their movements are based on that of their surrounding neighbors, thus collective movement is reliant on sensing and modification of each robot. Different algorithms are available for different types of swarms, but the overarching idea of decentralization and simplistic independent behavior persists. The collaborative effort between these robots is critical when performing a task in an efficient and timely manner. However, methods of attaining advanced swarm robotic behavior is limited to expensive laboratory manufacturing. To address this limitation, this work focuses on developing a process for creating low-cost, three-dimensionally printed robots with swarm intelligence. The design of the robotic swarm consists of wheeled robots equipped with sensor electronics, such as proximity and accelerometer sensors, and computer software applications for robot control. Currently, the main application is for tabletop uses such as having the robots work together to form shapes and move small objects. Future applications include human-robot interaction, such as utilizing the robots to provide assistance for the physically disabled. Thus, the main contribution of this work is a manufacturing process for low-cost, three-dimensionally printed swarm robots.

SESSION 2E

ADVANCED TECHNOLOGIES FOR HEALTHCARE AND OTHER APPLICATIONS

Session Moderator: Daniel Kirschen, Electrical Engineering
MGH 238
3:30 PM to 5:15 PM
* Note: Titles in order of presentation.

The Impact of Blade Mounting Geometry on Cross-Flow Turbine Performance
Noah E (Noah) Johnson, Senior, Mechanical Engineering
UW Honors Program
Mentor: Brian Polagye, Mechanical Engineering
Mentor: Benjamin Strom, Mechanical Engineering

Cross-flow turbines are a promising approach for extracting renewable energy from tidal and river channels. These turbines consist of a set of blades rotating about an axis perpendicular to the water flow direction. While blade mounting geometry has implications for parasitic drag, lift-induced drag, and blade lift generation, which strongly influence turbine performance, little research has been published on this topic. The impact of blade mounting geometry on turbine performance was evaluated by comparing the power conversion efficiency of ten two-bladed turbines with varying mounting geometries in a recirculating water flume. Each turbine was also tested without blades to evaluate interactions between blades and mounting geometry. A servomotor rotated the test turbine at constant angular velocity and two six-axis load cells were used to measure the torque produced by the turbine rotor. Six tests were performed with connecting struts at each end of the blades. Cross sectional geometry (rectangular, rounded, and foil) and thickness were varied (chord length held equal to the blade). Three tests were also performed with solid disks of varying radii mounted to each end of the blade. Finally, one test was performed with a single foil strut mounted at the center of blade span. Complete performance curves at four Reynolds numbers were generated for each mounting geometry by varying the free stream velocity. At the highest Reynolds number, the thin foil strut performed with greatest efficiency, followed by the thin rounded strut and thick foil strut. The smallest disk, thin rectangular strut, and thick rounded strut performed similarly. Strut and disk drag was analytically modeled and compared with experimental data to characterize power loss from each mounting geometry. These results offer insight into cross-flow turbine design for optimal efficiency and encourage investigation of additional mounting geometries such as winglets or curved mounting interfaces.

POSTER SESSION 3

Balcony, Easel 100
2:30 PM to 4:00 PM

NDVI Imaging of Submerged Aquatic Vegetation
Carter Kraus, Junior, Aeronautics & Astronautics
Orion Mackenzie (Orion) Black Brown, Junior, Mechanical Engineering
Mentor: Rick Rupan, Oceanography
Mentor: Fritz Stahr

Chlorophyll concentration is an indicator of plant health, but is challenging to quantify. As a result, normalized difference vegetation index (NDVI) imaging was developed to help solve this problem by making use of of chlorophyll's varying reflectance of light waves. This is a proven and powerful tool for observing terrestrial vegetation, allowing for efficient monitoring of living plant populations worldwide. However, no research had been published regarding the use of NDVI for submerged aquatic vegetation, thus our team sought to apply the technique to an aquatic environment, specifically seagrass beds in Queensland, Australia. Seagrass provides both nutrition and habitat for marine life, as well as carbon dioxide storage. The ability to monitor seagrass ecosystems is essential to understand and, in turn, preserve them. We saw NDVI imaging as a potential improvement to current seagrass monitoring methods and conducted experiments to find what issues this technique has in the underwater environment. After testing many aspects of NDVI imaging on in-situ seagrass beds and other test environments, we ultimately found it was not a viable option. This is largely due to basic optical transmission characteristics of water.

Poster Session 3

Commons East, Easel 78

2:30 PM to 4:00 PM

Growth of Nickel Sulfate Hexahydrate Crystals in a Magnetic Field

Kim-Lien Vu, Sophomore, Chemical Engineering, Edmonds Community College
Shannay Kammann, Sophomore, Mechanical Engineering, Edmonds Community College
Zumrat Makhkamova, Senior, Chemical Engineering , Edmonds Community College
Erica Toikka, Sophomore, Bioengineering, Biology, Nursing, Edmonds Community College
Lauren Valdez, Junior, Computer Science Engineering, Edmonds Community College
Mentor: Tom Fleming, Department of Physics, Edmonds Community College

Nickel sulfate hexahydrate (NiSO4.6H2O) is an important industrial compound most commonly used in the nickel-plating industry. Approximately 40,000 tons are produced and consumed each year by manufacturers requiring corrosion-resistant components ranging from consumer electronics to medical devices and aerospace engineering. Freitas et. al. found that zinc sulfate heptahydrate crystal growth increased by 38% under a magnetic field of 0.3-0.7T compared to crystallization under earth's magnetic field alone, whereas Lundager et. al. have presented evidence that paramagnetic materials such as CuSO4.5H2O do not exhibit such magnetically-induced increases in crystal growth rate. We present here our progress on confirmatory experiments aimed at fitting Nyvlt theory of cumulative crystal weight fraction M(L) and average growth rate G in batch synthesis of diamagnetic ZnSO4.7H2O and paramagnetic NiSO4.6H2O under external, uniform, homogeneous magnetic fields $0.0T<B<1.0T$. Our study will examine the differences in the growth rate of paramagnetic and diamagnetic sulfate crystals under the influence of a manipulated magnetic field. Recrystallization is a method of purification during the synthesis process of many compounds. If recrystallization can be improved to increase percent yield by influencing the magnetic field surrounding the compound, it may be a profitable method for drug manufacturers to consider.

Poster Session 3

Commons East, Easel 77

2:30 PM to 4:00 PM

Improved Cooling Efficiency and Cost-Effectiveness of Bitter-Type Solenoid

Peter Yuthachack, Freshman, Chemical Engineering, Edmonds Community College
Collin Rhodes, Sophomore, Mechanical Engineering, Edmonds Community College
Duy Nguyen, Sophomore, Chemical Engineering, Physics, Mathematics, Edmonds Community College
Minpyo Kim, Sophomore, Mechanical Engineering, Edmonds Community College
Mentor: Tom Fleming, Department of Physics, Edmonds Community College
Mentor: Billy D. Jones, Edmonds Community College

High-powered electromagnets are used in many different fields of science such as quantum physics and synthesis chemistry. Some projects require a very strong magnetic field to work. This magnet will allow students the freedom to design complex projects that utilize a strong magnetic field However, they are generally quite expensive and only available for use at well-funded research facilities and universities. Thus, we present our research in the design and construction of a cost-effective electromagnet capable of producing a highly-uniform magnetic field that can be used to further undergraduate research at Edmonds Community College. Our principal focus is on the reduction of engineering, fabrication and maintenance costs through a novel radial-flow cooling system which can be easily 3D-printed using high-temperature plastics in conjunction with a solid Bitter-plate solenoid design, requiring far less intricate and less expensive machining processes than conventional staggered-channel Bitter-plate designs. In order to make meaningful comparisons of generated field and thermal profiles with other published designs, our design maintains general shape and structural congruence to a design by Sabulsky, et. al., yet differing significantly in the design of the cooling system.