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Summer Undergraduate Research Fellowship Poster Symposium

August 2, 2018
2:00 p.m. to 3:00 p.m.
Student Union Building
Copper Lounge

Program

Welcome
Introduction of Researchers & Mentors
Poster Session & Reception

Montana Tech · 1300 West Park Street · Butte, MT 59701

SURF Poster Abstracts

Electrically Conductive Ink from Multi-Walled Carbon Nanotubes, Isaac Gilfeather (*Mechanical Eng.*), *& Mentor*: Dario Prieto *(Mechanical Eng.)*

Inks and paints that are electrically conductive have great potential in numerous applications such as wearable electronics, sensors, and inkjet printed circuits. Current inks on the market are often made with metal particles in solution, which can be expensive and susceptible to oxidation, so it was preferable to use carbon particles and water as the solvent. Carbon nanotubes (CNTs) are electrically conductive but are hydrophobic. Thus the main challenge was to achieve stable aqueous suspensions. Graphene Oxide (GO) was initially used, which is hydrophilic but after low CNTs loading and large cluster formations were observed, a surfactant was selected, known as Sodium Dodecyl Sulfate (SDS), which provided stable aqueous suspensions. The ink samples were prepared by sonificating 1 mg/mL of multi-walled CNTs and varying amounts of SDS in deionized water followed by centrifuging the samples to remove any large clusters that remained. The ink samples produced had varying amounts of precipitate left over with the least amount being formed when there was a 1:10 weight ratio of CNTs to SDS. Optimizing the ratio of CNTs to SDS is a critical step in developing an ink that can compete with others already on the market.

Increasing the Effi*ciency *of a Stirling Engine Using Mechanical Resonance, Rebekah Russell *(Mechanical Eng.), & Mentor:* Peter Lucon *(Mechanical Eng.)*

The Stirling Engine, created in 1816, has seen recent resurgence due to its high efficiency potential. The engine's biggest drawback is its low power-to-weight ratio. The hypothesis to increase the engine's second law efficiency is: by utilizing mechanical resonance, the internal losses of the system can be decreased, which will raise the system efficiency. Two mathematical models were developed and used to determine the resonance system parameters incorporated into a beta-type Stirling engine. The first model was a resonant system with two degrees of freedom and two masses; it was used to determine the frequency and displacement values. The second model was a Stirling cycle pressure system. The two models were coupled through the displacement. The model parameters were iterated to increase the area inside the pressure curve, which is directly correlated to the efficiency of the system. A resonant mechanical system was designed, assembled, and tested to verify the model calculations. The models predict that the resonant system would increase the efficiency of the Stirling engine. The findings may help increase efficiency of Stirling engines, which may cause the systems to gain popularity and reduce our dependence on natural resources.

Graduate Student Poster Abstracts

Living Filtration Membranes Demonstrate Self-Healing Properties, Christina Eggensperger *(Environmental Eng.), & Mentor:* Katherine R. Zodrow *(Environmental Eng.)*

Membrane filtration has become a prevalent form of water purification due to its ability to remove contaminants of concern from various types of dirty water. Concerns with implementing membrane filtration into water treatment stem from biofouling that occurs on the membrane surface, costs associated with membrane production, and maintenance of membranes due to tears in their surfaces. A potential answer to problems that arise with conventional membrane processes is to formulate membranes that are less like traditional polymeric or ceramic filtration membranes and more like the membranes in biological organisms. Although many scientists have studied biomimetic membranes, no one has yet utilized a living biological membrane for drinking water filtration. This research aims to develop a living biological water filtration membrane. The membranes are grown in a laboratory setting with a culture of yeast and bacteria. Membrane thickness can be controlled by varying the growth conditions and times, and membranes for these experiments were approximately 1 mm in thickness. Bench-scale experiments using a dead-end filtration cell indicated the membranes have a specific flux of 4.4 g/m^2*hr^{-1}. Membranes were further characterized using confocal microscopy, contact angle goniometry, molecular weight cutoff tests, and membrane self-healing tests.

Testing the Presence and Viability of Seed Bank in the Joiner Gulch Area in Anaconda, Montana, Augustina Osabutey *(Environmental Eng. & Biological Sci.*), Pedro Marques *(Big Hole Water Shed Committee), & Mentor:* Robert Pal *(Biological Sci.)*

The Joiner Gulch area has been impacted by land-clearing and from wind-borne contamination from copper smelting occurring from the late 1880's through the 1970's. Today the land is affected by great erosive forces because of the lack of vegetation. Before restoration efforts are executed it is best to evaluate how much resiliency is left in the environment and around it. One way of doing that is to investigate the presence and the viability of the seed bank of the area. The scope of this project is to test whether there is a potential seedbank in the Joiner Gulch area that could be activated. Also, tested, were the effects of additional seed augmentation and of different amendments that have been utilized in earlier restoration projects (bio fertilizer, synthetic fertilizer, mycorrhizae) on the existing seed bank and the augmented seed material. The approach is to use a greenhouse-based seedbank test. Results show that the soils of the studied area have a significant seedbank that could be activated with the different treatments. However, the diversity of species appearing is rather low, therefore augmentation with additional species is also highly recommended.

BRIC Poster Abstracts

The Annotation of BigPaolini, Bo Rost (*BRIC) & Mentors:* Hannah Sparks, Morgan Paolini, and Marisa L. Pedulla *(Biological Sci.)*

Bacteriophages, or phages, are viruses that infect bacteria and were discovered approximately 100 years ago. Their ability to serve as antibacterial agents was appreciated almost immediately. With interest in novel therapeutic agents to combat antibiotic resistant bacteria, and to understand the diversity within the phage world, many phages are being analyzed and their genomes are being annotated. The phage BigPaolini was recently sequenced and was shown to contain a DNA genome with a length of 49601 bp, within the phage cluster A1. The genome was then annotated in an iterative process using the DNA Master, BLAST®, and Phamerator© programs. No putative tRNA genes were identified. Eighty-seven putative protein coding genes were found in BigPaolini, and functions were assigned to 32 of the encoded proteins. A predicted ribosomal frameshift was discovered at genes 23-24. The start codon for each gene was assessed and called within DNA Master by comparing the overall length of the gene and the computed Shine-Dalgarno score. The coding potential of each gene was examined using the Genemark program. The completed annotated map with putative gene functions was submitted to phagesdb.org.

The Purification and Amplification of Mycobacteriophages, "MyPhage" and "Solar Flare", Erin Fogarty (*Butte Sr. High*), *& Mentors*: Hannah Sparks, Tavi Wise and Marisa L. Pedulla (*Biological Sci.)*

Bacteriophages are viruses that infect and replicate in bacteria. They are being researched and tested to be used for medical applications. Antibiotic resistant bacterial infections are affecting people throughout the world. The purpose of this research is to study two phages specific to mycobacterium. Testing began with spot titers and plaque assays on "MyPhage" and "Solar Flare." This process was to determine the concentration of phages in each of the two phages' lysates that were provided at the beginning of the research. Plaque assays were completed multiple times to ensure sample purity, clear plaques, and similar morphologies. Spot titers were performed to calculate the number of plaque forming units per 3 microliters. Once the purification process was complete, the phages were harvested from the infected webbed plates to create the lysate with a higher titer. The results from the high titers for both phages allowed for higher lysate concentrate needed for DNA extraction.

SURF Poster Abstracts

3-D Photogrammetry for LiDAR Calibration, Jacob Clarke *(Geophysical Engineering),* & Mentors: Marvin Speece *(Geophysical Engineering*) *and* Jeremy Crowley *(MBMG)*

The use of drones and drone imaging has grown immensely in recent years. Drones can accurately and quickly map large areas such as quarries or hillsides using centimeter-level GPS control points along with a camera or LiDAR (light detection and ranging) sensor mounted to a drone. LiDAR calibration involves determining the offsets between the inertial measurement unit (IMU) and the axis of LiDAR scan rotation. In this study, we compared a photogrammetric model to a LiDAR model of 3-D printed objects to determine LiDAR calibration variables. This project focused mainly on the indoor lab work to create small scale models using a digital camera as well as a Velodyne VLP-16 LiDAR. These indoor laboratory tests were preliminary to performing large scale tests to begin LiDAR calibration. We also flew a drone over a Montana Tech campus construction lot to create a large scale photogrammetry model to calibrate the LiDAR system. We processed these photogrammetry data and printed the results using a 3-D printer to create a physical elevation model. Future goals include mounting the LiDAR on a drone with integrated computer control to allow for obstacle avoidance and real-time mapping.

Curation and Characterization of a Collection of Mycobacteriophages, Hannah E. Sparks *(Biological Sciences) & Mentor:* Marisa L. Pedulla *(Biological Sciences)*

Bacteriophages, or phages, are viruses that specifically infect and kill bacterial cells. Phages are the most numerous biological entities on Earth, with an estimated population size of 10^{31}. Discovery, purification, and characterization of phages illuminate the composition of the microbial world and provide potential applications in medicine. To combat antibiotic resistant bacteria, phages are being investigated as supplements or alternatives to antibiotics. Through Montana Tech's Biology Department's NIH-funded outreach program, over 8,000 K-12 students have collected and tested soil and water samples for phages that infect *Mycobacterium smegmatis*. Together, these students have isolated and named more than 100 phages, stored at various stages of purification at Montana Tech. To further the study of these phages, purification and amplification were carried out for eight of them. This project included growing high-titer stocks of the phages, DNA extraction, restriction enzyme digests, transmission electron microscopy, Polymerase Chain Reaction analysis, and submission of DNA to the University of Montana for sequence analysis. In addition, the collection of phages was organized electronically by utilizing Excel spreadsheets and uploading information to the database, phagesdb, sorting samples and lab notebooks, and updating the storage and labeling of the collection.

SURF Poster Abstracts

Developing a Program for Calibrating and Streaming from a Software-Defined Radio, Amanda Kolbeck *(Electrical Eng.)*, *& Mentor:* Kevin Negus *(Electrical Eng.)*

Radio transmission is a valuable tool, especially in areas where more common signals can't reach; within mines, for example. Software-defined radios (SDRs) allow faster, more direct control over transmitting and receiving signals. This project focused on a LimeSDR, an open source software-defined radio developed by Lime Microsystems (LimeSDR). A Python code was developed for writing to the LimeSDR. It focused primarily on calibration and tuning, using three known signals to test the program—double sideband, upper sideband, and lower sideband. Signals were created using I and Q samples. The LimeSDR was connected to a spectrum analyzer to observe each of the signals at different calibration points and confirm that the program was operating successfully. This research proves that an interactive Python code can be written to calibrate and tune a software-defined radio. Software-defined radios have a broad scope of capabilities, both in transmitting and receiving signals, especially given the open source framework and collaborative online environment available. This program can be expanded on to calibrate and tune signal reception, allowing communication between two or more LimeSDRs.

Digital Signage to Enhance Visitor Learning at Museums, Michael Fryer (Computer Sci., Software Eng.), Justin Bak (Software Eng.), *& Mentor*: Phillip Curtiss *(Computer Sci.)*

Museums are always looking for new ways to engage their visitors. With display technologies becoming cheaper, one such way is to have displays showing some information about the exhibit near them. However, this doesn't directly encourage the visitor to explore the topic more deeply. This project aims to bridge the gap between displaying digital content and encouraging the visitor to learn more about the topic by exploring related content. This is achieved by building a semantic web out of the content to be shown on the displays. By using a semantic web, it is possible to present different topics to the visitor based on some content they have just viewed, or what they have viewed in the past. This promotes the idea of learning by exploration by providing content to the visitor that they are interested in. Additionally, the order of the content they view is anonymously tracked and logged. This allows for analytics to be run on the data collected. The result of the analysis will aid curators in modifying the content to better suit the needs of the visitor.

Summer Research Poster Abstracts

Three Dimensional Physiological Model for in vitro Biomaterials Research, Sowmya Sudhakar (*Mechanical Eng.*), *Mentored by:* Jack Skinner and Jessica M. Andriolo *(Mechanical Eng.)*

A physiological model was designed to determine the efficacy of a biomaterial with mammalian tissues. Current 3D models face challenges of mimicking complex electrical signals between cells that are naturally occurring in living systems. Other vital characteristics including constant fluid flow, multiple cell layering, and three dimensional cell growths are also relatively primitive in-vitro. Expensive alternatives exist such as Episkin® by L'Oreal and MatTek's EpiDerm® skin models. Moreover, these models are limited to skin testing only. We have designed a physiological model that has the components of fluid flow, multiple cell type layering and three-dimensional growth combined together. Fluid flow was introduced using peristaltic pumps regulated with miniature modulators. Cell layering was achieved by growing various cell types on polymer fiber scaffolds fabricated with electrospinning. The scaffolds were then stacked together to create a multi-layer cell model.

BRIC Poster Abstracts

Using Varying Voltages to Observe Different Conditions of Denitrification in Potentiostats, Autumn Lineback (BRIC & Environmental Eng.), *& Mentors:* Daqian Jiang and Taymee Brandon *(Environmental Eng.)*

Sludge from the Waste Water Treatment Plant was used to inoculate these potentiostats. It was done so the sludge would grow a biofilm of bacteria that is unknown. These bacteria use extracellular electron transfer to denitrify the solution within the reactor. The research is in progress and contributes to a graduate student's thesis. Solutions were made and samples were collected. Measurements were made of pH, nitrate, nitrite and ammonia concentrations. This information gathered from sampling, along with future DNA extraction, will determine the type of bacteria, and their effectiveness at denitrifying the sludge. The project will continue during the academic year.

Short Range Imaging Using Ultrasonic Sensors, William Gildehaus *(Electrical Eng.), & Mentor:* Bryce Hill *(Electrical Eng.)*

Currently multiple tools, such as LIDAR and RADAR, can create 2D and 3D scans of rooms and objects. However, these tools cannot measure distances less than 10 cm because their signals travel near the speed of light. Acoustic signals can be used for short range measurements because the signals move much slower, which is easier for the sensors' detection process. This research focuses on developing the hardware and software to make distance measurements using ultrasonic signals. Many different waveforms and frequencies, ranging from 5 kHz to 42 kHz, have been or will be analyzed to determine the ideal hardware configuration. The software has been developed to perform single-point distance measurements and a microphone array has been designed to perform 2D measurements in the future. The data gathered thus far indicates the purposed ultrasonic sensors may not be the best solution due to acoustic ringing in the transmitter. Not using the ultrasonic sensors provides more flexibility for determining hardware configurations. It is recommended that more research be completed in order to reach the final goal of short range acoustic 3D imaging.

Summer Research Poster Abstracts

A Novel Portable Electrospinning Device for Functionalized Fiber Materials, Emily A. Kooistra-Manning, Lane G. Huston, Zach S. Burckhard *(Mechanical Eng.)*, & *Mentors:* Jack L. Skinner and Jessica M. Andriolo *(Mechanical Eng.)*

Electrospinning has become a valuable technique for producing micro-to-nanoscale polymeric fibers with length scales from ~1 nm to 100 µm. The utility of electrospun fibers can be subsequently increased with the ability to deposit directly onto a non-conductive/ non-energized surface. Possible uses include displays and sensors for commercial or defense applications or in biomedical application for depositing on tissue. To accurately deposit electrospun fibers onto a nonconductive surface, we developed a new electrospinning apparatus. The set up for the device includes a ring electrode at the end of a tube encapsulating the device. The tube allows air to flow over the needle and carry the fiber past the electrode onto the target surface. The entire device is portable and has been miniaturized, compared with previous designs. Fibers were deposited directly onto a nonconductive surface placed beyond the grounded electrodes. Details of the apparatus along with images and analysis

SURF Poster Abstracts

Developing a REST Framework for Medical Device Data using FHIR Standards, Tyler Fricks *(Computer Sci.)*, Kevin George *(Health Care Info.)*, Julie Miller *(Nursing)*, *& Mentors:* Phil Curtiss, *(Computer Sci.)*, Charie Faught *(Health Care Info.)*, Janet Coe *(Nursing)*, *and* Casey McGruder *(OrganTalk)*.

As healthcare technology development and use continues to expand, the need for device interoperability and appropriate information exchange has grown. The researchers aimed to show that a current medical device could be connected to a developed Electronic Health Record (EHR) using a Representational State Transfer (RESTful) framework following Fast Healthcare Interoperability Resources (FHIR) standards and stream pertinent medical data. A Welch Allyn Atlas monitor was connected to a control point device, and heart rate and electrocardiogram waveform information from a simulation mannequin was collected to demonstrate the capabilities of the framework. This collected data is sent over the network to a gateway that interprets the information and forms proper FHIR commands. These commands are sent to the FHIR queue which allows commands and requests to be serviced consecutively. Device data was collected in real time, illustrating the possibility of connecting medical devices to EHRs using FHIR standards and the capabilities that come from open source software in the medical field. Connecting EHRs to third party vendor applications can expand the reach of expert knowledge into geographically remote areas, allow for quicker transfer of data between clinicians, increase analytical trending for chronic illnesses, or alert nursing staff of imminent complications prior to the patient showing symptoms.

Design, Fabrication, and Testing of Lightweight and Durable Automotive Components from Composites, James Jeffrey (Mechanical Eng.), & Mentors: Ronda Coguill *(CAMP*), and Dario Prieto *(Mechanical Eng.)*

With a constant push towards lighter, stronger and more fuel-efficient vehicles, the use of composite materials is a proven way to achieve this goal. Composite material manufacturing is widely used in large scale manufacturing, but is a challenge for small scale operations, such as Montana Tech. The idea is construct a composite seat for the Montana Tech's Baja team that meets the requirements of the Baja SAE Collegiate Design Series. The initial design and model testing was done on SolidWorks with material testing done by CAMP at Montana Tech. The first protype was built using a wet-layup process on a foam mold. The second part will focus on the mechanical evaluation the prototype, further adjustments to the model, refabricating, and testing under real conditions. This project has shown that we can do quality small scale carbon composite manufacturing efficiently at Montana Tech.