Undergraduate Research Symposium May 19, 2017 Mary Gates Hall

Online Proceedings

POSTER SESSION 1

Commons East, Easel 48

11:00 AM to 1:00 PM

APOGEE/Kepler Overlap Yields Orbital Solutions for a Variety of Eclipsing Binaries

Aleezah Ali, Sophomore, Physics: Comprehensive Physics, Astronomy
Mentor: Diana Windemuth, Astronomy
Mentor: Eric Agol, Astronomy
Mentor: Meredith Rawls, Astronomy

Eclipsing binaries (EBs) are systems in which two stars orbit and pass in front of each other. They are important astrophysical tools utilized in this project to directly measure the fundamental properties of stars, such as their masses, and radii. We create a sample of ˜50 bright EB targets based on high-quality photometry from the Kepler Satellite and spectroscopy from the Apache Point Observatory Galactic Evolution Experiment (APOGEE). Here, we present mass, radius, and orbital solutions for a subset of these EBs. For each system, we extract radial velocities (RVs), the speed at which each star in the system is moving away from the observer, from the APOGEE spectra. Then, we combine the RV with Kepler light curve (LC) information to simultaneously model the system light and line-of-sight speed as a function of time. Because our model has high dimensions with 18 free parameters, we first solve for the LC and RV solutions separately, and then simultaneously solve them. We use a least-squares optimization method to determine the best fit solution and quantify the uncertainties in model parameters running Monte Carlo Markov Chain (MCMC) simulations. The model parameters that we find will further our understanding of fundamental stellar properties and evolution.

POSTER SESSION 1

Commons West, Easel 23

11:00 AM to 1:00 PM

Automatic Characterization of User Errors in Spirometry

Andrew Zhao Luo, Senior, Computer Science, Bioengineering
Mary Gates Scholar
Mentor: Eric Whitmire, Computer Science and Engineering
Mentor: Shwetak Patel, Computer Science & Engineering

Spirometry is among the most common tests for characterizing pulmonary function and plays a critical role in detecting and improving outcomes related to chronic lung disease. During a spriometry maneuver, a patient rapidly exhales into a machine which records the total volume and flow of air over time. However, patient error in performing the spirometry maneuver, such as by coughing or taking multiple breaths, can lead to clinically misleading results. As a result, spirometry must take place under the supervision of a trained specialist who can detect and correct patient errors. To reduce the need of specialists to coach patients during spirometry, we demonstrate the ability to automatically detect four common patient errors. Applying machine learning techniques on features derived from spirometry data, we were able to automatically classify errors from spirometry data with an F-score between 0.784 and 0.907. Our work provides the first step toward reducing the need for trained individuals to administer spirometry tests by demonstrating the ability to automatically detect specific errors and provide appropriate patient feedback. This will increase the availability of spirometry, especially in low resource and telemedicine contexts.

SESSION 1B

TECHNIQUES FOR IMPROVING QUALITY OF MEDICAL CARE

Session Moderator: Eric Seibel, Mechanical Engineering

MGH 228

12:30 PM to 2:15 PM

* Note: Titles in order of presentation.

Improving Accuracy of At-Home, Preventative Oral Health Care through Customized Teeth Models

Hae In (Angel) Lee, Junior, Computer Engineering
Mentor: Eric Seibel, Mechanical Engineering

Recent technology introduced by Phillips Sonicare attempts

to address the challenge of improving at-home, preventative oral health care for children by providing users encouragement and guidance on how and where to brush based on rough estimations that are visually represented to the client on a general, perfect teeth model. Although this innovation is a step towards empowering individuals to improve their oral health from information outside dental clinics, there are limitations to the actual improvement that can be made due to its implementation. By combining and creating new tools that will work with advanced intraoral cameras, I intend to take the next step in improving at-home, preventative care through a design that will be more personal and accurate than any existing one. More specifically, my goal is to develop software that can create personalized teeth models, representative of the user's teeth. Through a series of manipulating a perfect, 3D animated teeth model from Animium, I examine the object files, which are 3D model files, treating them as text files and observe how they change for a specific edit through a 3D model editor such as Autodesk 3ds Max. These observations are used to create general algorithms for a specific edit which is combined into a program that can generate personalized teeth models, such as missing or crooked teeth. With a more personal model, the users are more accurately guided to a specific lesion on their teeth, resulting in more effective application of medicinal therapies and optical monitoring of healing.

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 East, Easel 59

1:00 PM to 2:30 PM

Characterization and Photostability of a Red Fluorescent Standard

Jasmine Yu Graham, Senior, Bioengineering
Mary Gates Scholar
Mentor: Eric Seibel, Mechanical Engineering
Mentor: Leonard Nelson, Mechanical Engineering

Protoporphyrin IX (PpIX) is a red fluorescent metabolic byproduct of oral bacteria and serves as an indicator of early and late stage caries. PpIX has a strong absorption band centered at 405 nm and exhibits an emission range from 615 to 710 nm. Spectroscopic and imaging devices targeted at PpIX require a fluorescent standard for calibrating their detection sensitivity. However, PpIX lacks photostability and an alternate molecule is needed to represent the excitation and emission fluorescence characteristics of PpIX. Evaluation of instrument performance over time is especially important for long range clinical studies examining changes in fluorescence in response to disease therapies. The scanning fiber endoscope (SFE) is an optical imaging system currently used in clinical dental research to quantitatively monitor the fluorescence of PpIX. Water based solutions of PpIX are unstable and led us to develop a dye-in-polymer standard that offers photostability, portability, and uniform fluorescence. Organic europium complexes model the fluorescence spectrum of PpIX closely, with a similar red emission range from 615 to 710 nm. Preliminary photobleaching experiments using a 405 nm laser illuminating a europium dye embedded in a polyurethane polymer demonstrated that it offers significantly better photostability than PpIX, exhibiting a 3-4% drop in europium fluorescence after one hour of continuous laser excitation. Under similar laser illumination conditions another PpIX phantom molecule, octaethylporphyrin (OEP), suffered a $>$20% drop in fluorescence after only 3 minutes of excitation. The photodegradation curve over time for europium was evaluated using the same 405 nm laser and LED excitation sources used for measuring the pH dependence of PpIX fluorescence in oral biofilms. Dye-in-polymer europium materials were also exposed to elevated temperatures in addition to laser illumination to further assess their suitability as fluorescence standards.

POSTER SESSION 2

Commons East, Easel 58

1:00 PM to 2:30 PM

Surface Imaging System for Needle Biopsy to Detect its Adequacy and Rapid Cancer Lesion through Milli-Fluidic Device

Roujia Wang, Senior, Bioengineering
Levinson Emerging Scholar, Mary Gates Scholar, UW Honors Program
Mentor: Eric Seibel, Mechanical Engineering

Core needle biopsy (CNB) is used as a minimally invasive method to diagnose prostate and other cancers. However, this method still has limitations of getting non-diagnostic and inadequate CNBs due to sampling error. Thus extra CNBs are often taken and other time-consuming tests looking at surface cellularity such as histological evaluation on tissue smears are done to reduce probability of this error, which leads to needless pain and cost. Therefore, we propose to design a rapid-on-site evaluation system by imaging the outer surface of needle biopsy samples. This system generates a whole surface image of CNBs that contain cellularity information as a quicker and more informative adequacy testing of CNBs. This proposed project aims to develop cost-efficient imaging for obtaining sub-cellular and structural information from CNBs at the point-of-care. There are three phases: Design of System, Development Image Stitching Algorithm, and Integration, testing, and generating surface image. Phase I aims to determine the optimal optical imaging system and developing a staining protocol for CNBs. Phase II is developing an image stitching algorithm that takes in images from Phase I. Phase III will integrate I and II and generate a whole surface image of CNBs to provide morphological features for clinicians so that they can determine the adequacy of biopsy and needs for additional biopsies. The main criterion of this design is to perform evaluation within 20 minutes while still maintain intactness of specimen. If the design is successful a commercial device will speed the process by 10x (<2 minutes), while maximizing use of CNBs and reducing the number of biopsies taken to minimize suffering of patients. It may also accelerate diagnosis speed for prostate cancer. Importantly, this design can be applied to other types of cancer diagnosis, such as remote radiology clinics where a pathologist is typically not available.

SESSION 2L

WATER, WASTE, AND MONKEYS

Session Moderator: Stevan Harrell, Anthropology

MGH 284

3:30 PM to 5:15 PM

* Note: Titles in order of presentation.

Detecting and Measuring the Concentration of Zinc in Water Using *Saccharomyces cerevisiae*

Lauren Nicole Goetsch, Junior, Extended Pre-Engineering
Hieu Ngoc Do, Junior, Pre Engineering
NASA Space Grant Scholar
Pezhman Khorasani, Junior, Electrical Engineering
Caleb Ellington, Junior, Bioengineering
Mentor: Eric Klavins, Electrical Engineering

Zinc pollution is a large problem in underdeveloped countries with mining industries. Leaching of brass and galvanized iron can add substantial amounts of zinc into water resources. Furthermore, high zinc concentration is usually indicative of lead and cadmium, which, when once accumulated in the human body, can negatively affect the immune system. Currently, there are no rapid, inexpensive methods to determine the concentration of zinc in water. The sample is usually sent to a lab and analyzed using sophisticated and prohibitively expensive instruments. Our goal is to create an affordable and easy-to-use diagnostic tool using Saccharomyces cerevisiae—a yeast commonly used in industry. By designing a gene circuit that connects a zinc-sensitive promoter for Green Fluorescent Protein (GFP), we hope to engineer a strain of yeast that will give a green fluorescent output of different intensities when grown in different concentrations of zinc. After building and testing different strains of yeasts– each using a different zinc sensitive promoter, we found that there was no significant variation in GFP output between different concentrations of zinc and between different yeast strains. In addition, after comparing the results with a wild-type control, we also found that our recombinant strains are not much better at detecting zinc than the wild type strain. For the next steps of this project, we will continue to build gene circuits involving other zinc sensitive genes. Once a few genes are identified as being suitable for our purposes, we will focus on amplifying and fine-tuning GFP expression as well as replacing the GFP with that a color output that can be detected by the naked eye.

POSTER SESSION 3

Commons West, Easel 12

2:30 PM to 4:00 PM

Prioritizing Gender Equality: Clinton's Symbolic Status and Reactions to the 2016 Presidential Election

Alexander Giovanni (Alex) Preston, Senior, Psychology
Mary Gates Scholar, UW Honors Program
Mentor: Cheryl Kaiser, Psychology
Mentor: Eric Gomez, Psychology

Entering the 2016 presidential election, Hillary Clinton stood poised to become the United States' first woman president. An electoral win would have assigned Clinton status as a

symbolic first, or a figure who comes to represent social change by becoming the first member of a social group to assume some position from which members of this group have been excluded. Drawn from previous literature on symbolic victories for social movements, our initial hypothesis predicted that a Clinton win would influence Americans to be less concerned with gender inequality and to think that future steps to promote equality were less important. Given Clinton's defeat, however, we modified our hypothesis to be that gender inequality would become more salient and Americans would prioritize reducing this inequality more, compared to before the election. Within-subjects shifts in these attitudes were measured by administering self-report surveys before and after Election Day 2016. While participants' perceptions of broad societal gender equality conditions did not change, participants' support for specific policies aimed at remedying inequalities increased following Clinton's defeat. We offer potential theoretical and contextual explanations for these findings. Additionally, we explore how individual differences contribute to these primary effects. Our findings suggest a window of opportunity to organize collective action around gender equality issues.

POSTER SESSION 4

Commons West, Easel 19

4:00 PM to 6:00 PM

Transgenic Yeast Biosensor: A Novel Detection Method for Copper Contamination

Alan Cavido (alan) Cabrera, Senior, Bioengineering
Kyle Christian (Kyle) Schuppe, Senior, Anthropology: Medical Anth & Global Hlth, Biochemistry
Mentor: Eric Klavins, Electrical Engineering
Mentor: Daniel Lachance, Molecular Engineering

According to the World Health Organization, an estimated, 780 million people do not have access to clean water sources. Disasters are another potential cause of disruption to the supply of clean water. When the safety of a water source is unknown, a cost effective method to determine water safety is necessary to reduce unsafe water related disease and death. Prior synthetic biology research has been conducted utilizing transgenic yeast as a biosensor for heavy metal detection, such as using plasmids expressing Green Fluorescent Protein (GFP) which are promoted by heavy metal binding transcription factors. While able to detect copper ions in a dose dependent fashion, the relative instability of the plasmid, reporters which are difficult to detect in situ, and limited targeting to copper and silver ions make the efficacy of the designs impractical. Using modern methods of plasmid integration and the modulation of the copper sensitive pCUP1 promoter expression we sought to produce a stable and more sensitive biosensor for the detection of copper ions in water. We successfully integrated the genetic cassette pCUP1-yeGFP into the yeast genome and produced a viable biosensor for the detection of aqueous copper. We tested this yeast strain via a cytometer after exposure to copper of varying concentrations at varied time intervals. The results showed a dose response curve that positively correlated with copper concentration in a semi-linear fashion, which indicated the pCUP1-yeGFP transgene was a viable sensitive reporter for the detection of copper. Currently, variable constitutive promoters are being altered to increase copper detection sensitivity by modulation of the expression of the metal binding transcription factor Ace1. The team is currently exploring the effect of Ace1 upregulation on the sensitivity of copper sensing. After investigating sensitivity modulation, an exploration of practical field detectable reporters, such as violacein, will be undertaken.

POSTER SESSION 4

Commons West, Easel 28

4:00 PM to 6:00 PM

Hyaluronic Acid Coated Polyblend Nanofibers for Promotion of Gliobastoma Migration

Jialu Sun, Senior, Mat Sci & Engr: Nanosci & Moleculr Engr
Mary Gates Scholar, UW Honors Program
Mentor: Miqin Zhang, Materials Science & Engineering
Mentor: Ariane Erickson, Material Science and Engineering

Complications and mortality from glioblastoma multiforme (GBM) are often the result of tumor metastasis and thus, understanding the underlying mechanisms in glioma cell migration to help minimize tumor diffusion is of vital importance. Previously in our lab, aligned co-polymer blend chitosan-polycaprolactone (C-PCL) nanofibers have been shown to promote a migratory phenotype and an upregulation of invasion-related genes in GBM cells after 24 hours of culture. Here, we aim to further investigate the effects of nanofiber chemistry on the migratory and invasive character of GBM cells by coating C-PCL nanofibers with hyaluronic acid (HA), a major component of the brain extracellular matrix (ECM). Human U-87 MG GBM cells, a model glioma cell line, were used to study the GBM behavior on the nanofibers. Proliferation assays to determine the biocompatibility of the nanofiber platforms with and without HA were evaluated followed by cell morphology analysis to evaluate elongation and alignment. Overnight migration studies were conducted to determine if migration profiles on the nanofiber platforms were similar to those reported *in vivo*. Drug resistance and invasion-related genes were assessed to determine if culture on HA-coated C-PCL nanofibers could increase malignancy in GBM. Finally, flow cytometry was used to pinpoint the population of cells expressing a more invasive phenotype and thus provide an idea if HA-coated C-PCL nanofibers were a suitable *in vitro* platform for developing high-throughput

anti-invasion cancer therapies.

POSTER SESSION 4

Commons West, Easel 17

4:00 PM to 6:00 PM

Cytopendix: A Millifluidic Chemostat

Garrett S. (Garrett) Newman, Senior, Electrical Engineering
Abby Xu, Senior, Electrical Engineering
Mentor: Eric Klavins, Electrical Engineering

The characterization of a genetically modified strain of yeast is a tedious and laborious process, which in standard cases, may require upwards of one hundred twenty hours of regular attendance to a single characterization experiment. This is common when developing a novel genetic circuit with several distinct parameters and states. The state-of-the-art method involves loading the yeast strain into a proprietary lab-on-a-chip to perform the strain characterization. Our method, however, improves upon the state-of-the-art method by being cheaper, more flexible, and more integrated into existing lab equipment. We employ a CNC-milled polycarbonate microfluidic chamber with mix, temperature, and inducer and sampling controls. This chamber connects directly to a flow cytometer while running, affording real-time, fully automated strain characterization. We have found this apparatus, the affectionately-titled Cytopendix, to be suitable for sustaining yeast cultures and permitting real-time chamber sampling with the flow cytometer. The nature of its simple design and the speed of CNC milling has granted us significantly shorter design iteration periods than current lab-on-a-chip methods. Furthermore, its mixing, temperature, and sampling controls are robust and easy to reprogram. We encountered particular difficulty in accurately dispensing discrete sample volumes, but we have discussed viable and actionable solutions to this problem. Through a multitude of design iterations, we have vastly improved the functionality, usability, and reliability of the system and expect it to develop into a significant improvement over the state-of-the-art methods in this field. The Cytopendix has, overall, proved to bear significant potential as a flexible and extensible instrument for fully automated yeast strain characterization.

POSTER SESSION 4

Commons West, Easel 18

4:00 PM to 6:00 PM

Yeast Biosensor with Estrogen-Detecting CRISPR Transcription Factor for Low-cost Water Quality Screening

Riley Maeliann (Riley) Stockard, Junior, Bioengineering
Mary Gates Scholar, UW Honors Program
Nadia Young (Nadia) Popovici, Junior, Pre-Sciences
Miranda Nicole Howe, Sophomore, Pre Engineering
Mentor: Eric Klavins, Electrical Engineering

Exposure to abnormally high levels of estrogenic compounds can trigger dramatic developmental and sexual deformities in fish and wildlife. For instance, bisphenol A (BPA), found in plastics, is a common pollutant that threatens the natural environment and human consumers by acting as an endocrine disrupter. However, testing for these estrogenic chemicals requires samples to be processed at a laboratory with expensive equipment. Cell biosensors that are engineered to detect pollutants and produce a visual response are a low-cost, tunable, and highly sensitive alternative. Here, we show our work to expand access to estrogenic pollution detection by genetically engineering *Saccharomyces cerevisiae*, brewer's yeast, to produce green fluorescent protein (GFP) until it detects ß-estradiol, a human estrogen. Our biosensor expresses a CRISPR transcription factor (CTF) which includes an estrogen receptor and *mxi1* repression domain, coupled with a guide RNA that targets the promoter for GFP. We observed with a cytometer that upon ß-estradiol induction, the CTF-expressing yeast demonstrated heightened GFP expression and larger, possibly un-dividing cells. We hypothesize that our CTF is reducing cell growth and division rates, thus increasing the concentration of GFP molecules per cell, and show our work to investigate this prediction. In the future, we plan to tune the sensor to repress fluorescence only when reaching a hazardous concentration of ß-estradiol. In addition, we will measure our biosensor's ability to detect similar estrogens such as BPA, in the hopes that it can function as a universal estrogenic sensor.

POSTER SESSION 4

Commons West, Easel 16

4:00 PM to 6:00 PM

Detecting Auxin Using an IAA17-ADE2 Fusion Protein in *Saccharomyces cerevisiae*

Gabriel Beuchat, Junior, Biology (Molecular, Cellular & Developmental)
Xavaar Chayton Quaranto, Freshman, Pre Engineering
Undergraduate Research Conference Travel Awardee
Mentor: Eric Klavins, Electrical Engineering

We have evaluated the viability of a system for detecting auxin with a yeast culture using the red buildup of P-ribosylformyl glycinamidine as a reporter that can be used to reliably identify auxin in water without the need for advanced

equipment. To accomplish this we have fused an IAA17 protein to an ADE2 enzyme with a linker that preserves function, then transformed that into a yeast strain that lacks native ADE2 and has an Fbox AFB2. We plated these on adenine deficient agar with various concentrations of auxin to test for sensitivity. As controls, we plated basic strains w303a and w303alpha and found that the ADE2-lacking w303alpha still needs a little bit of adenine or it will not grow at all. We tested two different types of media, YPD and SC with minimal adenine concentration, both of these have just enough adenine to keep the yeast alive but still induce the red color. We conclude that the method of detecting auxin via the degradation of an IAA17 tagged protein is a viable strategy, but that using ADE2 as our target enzyme presents complications when considering the ultimate goal of our project. The reporter is not simple to use as a very specific concentration of supplemental adenine is required to allow growth but still induce the ADE pathway. To mix this media would require high-precision equipment usually available only in a lab. This problem can be solved by changing the reporter to allow the yeast to be functional in any media, which will be our next project.