UNIVERSITY of WASHINGTON

Undergraduate Research Symposium May 17, 2013 Mary Gates Hall

Online Proceedings

POSTER SESSION 1

Commons East, Easel 49

11:00 AM to 12:30 PM

Designing a Web-Based Collaborative Translation Management System for Public Health Workers

Adrian Andrew Laurenzi, Senior, Computer Science, Biology (General)
Levinson Emerging Scholar, Mary Gates Scholar
Mentor: Katrin Kirchhoff, EE

Local and regional public health departments in the U.S. are legally required to make their services available in languages other than English. Most health departments outsource translation of health and safety information materials (e.g. websites and flyers on vaccinations, emergency preparedness, etc.). This is costly and time-consuming and makes it impossible for health departments to translate many important documents. We designed a web-based collaborative system to enable the production of multilingual health communication materials by bilingual public health workers. Our system could reduce the cost of translation and increase access to public health information for people in the U.S. with limited English proficiency. The system is based on a workflow where a source document in English is machine-translated and then revised and corrected by humans to produce a finalized translation. We designed the system for public health professionals who are bilingual domain experts but not necessarily trained translators. We initially gathered data to inform the design of our system through interviews and focus groups with local and regional public health departments. Based on the design recommendations extracted from the data, we implemented a web-based prototype collaborative translation management system. We further refined the system through an iterative design process that included informal user testing with multilingual participants. Future work will include usability studies with public health workers and the integration of additional collaborative features.

POSTER SESSION 1

Commons East, Easel 50

11:00 AM to 12:30 PM

Engineered Altruism in Bacteria for Bioprocessing of Plant Biomass

David Mao Zong, Senior, Bioengineering
Mary Gates Scholar
Mentor: Eric Klavins, Electrical Engineering
Mentor: Rob Egbert, Electrical Engineering

Consolidated bioprocessing is the creation of one engineered organism that can handle a chain of chemical reactions that take a low cost feedstock, such as plant biomass, and synthesize high value products such as biofuel or medicine. This project aims to address the first stage of consolidated bioprocessing which is the digestion of the feedstock. Our design is an *E. coli* strain that can be in one of two states: the consumer state or the altruist state. In the consumer state, the cell carries out normal function by growing and dividing. In the altruist state, the cell produces a large payload of digestive enzymes that degrades plant biomass then lyses to release the payload to the environment where it can act. The consumer cells can then utilize the products of the digestion process to grow and divide. This system is made up of three major genetic components. The first component is a plasmid that designates whether the cell is in the consumer or the altruist state. This plasmid carries a genetic toggle switch that has two operons that produce transcription factors that co-repress each other. The second component is a plasmid that handles the production of digestive enzymes coupled with a lysis gene. Expression of this plasmid is only active if the cells are in the altruist state. The third component a genomic set of enzymes that handles the digestion of cellobiose, the product of the breakdown of cellulose. Initial results demonstrate that the engineered strain is able to grow solely on cellulose and current work focuses on the optimization of the system.

POSTER SESSION 1

Commons East, Easel 77

11:00 AM to 12:30 PM

A Web Study Evaluating Low Frame Rates and Bitrates for Mobile Sign Language Video

Rafael Torres (Sunny) Rodriguez, Senior, Electrical Engineering
Mary Gates Scholar
Mentor: Eve Riskin, Electrical Engineering
Mentor: Jessica Tran, Electrical Engineering

Mobile video communication has been popularized by applications such as Skype and Facetime, but the technology suffers from resource limitations both on the device and on the cellular network. Transmitting high quality video requires high bandwidth and battery draining processing power on mobile devices. These requirements hurt the user experience by creating high data cost, reducing call time, and limiting use to high speed networks such as WiFi. My research contributes to the MobileASL (American Sign Language) project that applies video compression to solve these issues specifically for mobile sign language communication. The deaf and hard-of-hearing community can benefit immensely from a mobile video chat application as ASL is a visual form of communication. We conducted a web study investigating sign language comprehension and intelligibility of video transmitted at four low frame rates (1, 5, 10, 15 fps) and four low bitrates (15, 30, 60, 120 kbps). The purpose was to determine how much video quality can be reduced before compromising sign language comprehension and intelligibility. The study found intelligible sign language video can be transmitted at frame rates and bitrates much lower than the current recommended standard for sign language video communication (25 fps at 100 kbps or higher) without diminishing the user experience. These findings strongly suggest that the recommended international standards are too high and can be reduced while maintaining intelligibility.

SESSION 1Q

TOMORROW'S TECHNOLOGICAL SOLUTIONS AND APPROACHES FOR TODAY'S PROBLEMS

Session Moderator: Marc Dupuis, Computing and Software Systems

389 MGH

1:15 PM to 2:45 PM

* Note: Titles in order of presentation.

Perceptual Thresholds for Multi-Finger Haptic Interaction

Paul David Lambros (Paul) Bartell, Senior, Electrical Engineering

Mary Gates Scholar

Mentor: Blake Hannaford, Electrical Engineering

Mentor: H. Hawkeye King, Electrical Engineering

Force-feedback (haptic) displays are becoming increasingly common in consumer technology. Perceptual thresholds for haptic interaction are important for determining how much force output is required from a haptic display to provide detectable feedback to the user. In this presentation, I will talk about an experiment measuring force perceptual thresholds for single and multi-finger interaction with haptic targets. Using the UW Multi-Finger Haptic Display, subjects feel two targets on a virtual surface. One target produces center-attractive force when in contact with the subject's finger while the other produces no force. A thresholding algorithm presents the subject a new set of haptic targets with a smaller maximum force after correctly selecting the force-producing target twice. Eventually the subject can no longer detect a target and the max force is adjusted upward. This type of forced-choice algorithm causes the threshold force to converge to where the user successfully detects the stimulus 71% of the time. In this experiment, three new methods of presenting time-correlated haptic feedback to the subject were tested. Statistical analysis shows significantly lower minimum force thresholds for multi-finger methods providing time-correlated feedback (mean thresholds of 22.94, 21.75, 22.13 mN) when compared to the single finger and multi-finger spatially correlated methods (29.24 and 33.37 mN respectively). These results suggest a neural summation effect when haptic targets are arranged to provide time-correlated stimulation to multiple fingers at once.

SESSION 1R

SYNTHETIC BIOLOGY AND MOLECULAR BIOTECHNOLOGY

Session Moderator: Daniel Ratner, Bioengineering

022 JHN

1:15 PM to 2:45 PM

* Note: Titles in order of presentation.

An Ultrasensitive Detector Protoype in *Escherichia coli*

Rahul Francis (Rahul) Brito, Senior, Bioengineering

Washington Research Foundation Fellow

Mentor: Eric Klavins, Electrical Engineering

Mentor: Rob Egbert, Electrical Engineering

While timely and specific diagnosis can enable optimal treatment of patients, modern-day diagnostics are not optimized for the needs of low-resource settings due to: 1) low sensitivity, 2) slowness in providing results, and 3) dependence on electricity, chemical reagents, and trained clinicians, at a high cost. The result is frequent poor diagnosis, which can increase the rate of negative health outcomes such as patient mortality and evolution of drug resistant pathogens. There is therefore a pressing need for diagnostics that are sensitive, accurate, rapid, and inexpensive. The field of synthetic biology holds much promise in this area due to the ease and affordability of genomic re-engineering and replicating of single-cell organism like *Escherichia coli* and *Saccharomyces cerevisiae*. To address this need and opportunity, we have engineered a prototype detector in E. coli that utilizes two DNA-based modules to sense a low concentration of target analyte

and produce a large output response. Module 1 detects small concentrations of target analyte by switching cells from an ON to OFF state and Module 2 significantly amplifies an output signal by enabling ON cells to grow rapidly. By seeding these cells in an environment with a non-detector strain that grows faster than OFF cells but slower than ON cells, we hope to demonstrate that this genetic logic enables a detector strain that conditionally and significantly takes over the population after detection event. This approach holds much promise for a multiplexed diagnostic, as different strains of detector cells sensing a specific pathogenic marker could be co-cultured, with the result that only the cells that detect a target analyte grow. As a cell that is a diagnostic could be easily replicated and simple to use, this approach could be extremely feasible for a low-resource setting.

SESSION 2A

GRAPHS AND GEOMETRY

Session Moderator: Werner Stuetzle, Statistics
085 MGH
3:45 PM to 5:15 PM

* Note: Titles in order of presentation.

Structured Learning of Gaussian Graphical Models
Palma Alise Den Nijs (Palma) London, Senior, Mathematics, Electrical Engineering
Mary Gates Scholar
Mentor: Maryam Fazel, Electrical Engineering
Mentor: Daniela Witten, Department of Biostatistics
Mentor: Su-In Lee, Computer Science & Engineering
Mentor: Karthik Mohan

We estimate a Gaussian graphical model corresponding to a covariance matrix using machine learning techniques. A motivating application is to identify genes associated with cancer in the human genome. Suppose we have genetic data from two people, one of whom is healthy, while the other has cancer. Our goal is to identify gene expressions that differ between datasets and contribute to cancer. We model each dataset as a Gaussian graphical model, which is a network of edges and nodes. Each node represents a random variable, or gene. Each edge represents the dependence between the two variables it connects. An edge with zero value indicates the two variables are independent when conditioned on the rest of the variables. Such networks are analogously represented as inverse covariance matrices. Our goal is to use empirical genetic information from cancer patients to recover the true inverse covariance matrices. We suppose that the inverse covariance matrices have a certain structure and we set up a problem to encourage that structure. Structure refers to the relative magnitudes of matrix elements. A structure of interest is a *hub node*, which is highly connected to other nodes. These nodes play a regulatory role in gene expression and may be related to cancer. Our goal is to identify hub nodes in the difference between two inverse covariance matrices. We formulate this question as a convex optimization problem. We encourage the solution to have a certain structure by adding regularizer terms to the objective function. We recover the overall structure of the inverse matrices, while simultaneously encouraging the solution to have specific structures of interest. An alternating directions method of multipliers (ADMM) algorithm is used to solve the optimization problem. We run the algorithm on synthetic genetic data, and on real gene expression data to identify cancer related genes.

SESSION 2G

MICRO- AND NANO-MATERIALS IN ACTION

Session Moderator: John Berg, Chemical Engineering
242 MGH
3:45 PM to 5:15 PM

* Note: Titles in order of presentation.

Battery-Free Gas Sensor Nodes Utilizing Ambient Radio Frequency Energy
Chen Shi, Senior, Bioengineering, Electrical Engineering
Mary Gates Scholar
Mentor: Joshua Smith, Computer Science & Engineering, Electrical Engineering
Mentor: Aaron Parks

Gas sensors are widely used in daily life and industry. An important application of gas sensing is the monitoring of environmental factors affecting health, such as the concentration of carbon monoxide, in populated areas. However, most conventional gas sensors are powered by batteries, which need periodic replacement. The goal of this project is to integrate a Wireless Ambient Radio Power (WARP) energy harvesting platform with a new class of amperometric electrochemical gas sensors, provided by KWJ Engineering, Inc, to create novel battery-free gas sensor nodes. The WARP sensing platform, developed in Dr. Joshua Smith's group, utilizes ambient radio frequency (RF) energy from common sources such as cellular towers and TV broadcast stations, which provide a reliable and pervasive 24-hour power source. The gas sensors manufactured by KWJ Engineering possess the advantages of low power, low cost, high sensitivity, and high selectivity. Particularly, the low power requirements of the gas sensors make it possible for them to be powered by the RF energy harvested by the WARP platform. Currently the potentiostat circuit needed to properly bias the gas sensor and acquire the gas concentration is being developed. The gas sensor circuitry will be integrated with the WARP platform to produce the

battery-free RF-powered gas sensor nodes, followed by system optimization for reliable and efficient operations. With such gas sensor nodes, long-lived wireless sensor networks with zero maintenance cost could be deployed in continuous toxic gas monitoring applications, including air quality monitoring in cities and process control in industry.

POSTER SESSION 3

Commons East, Easel 69

2:30 PM to 4:00 PM

Feasibility of Transferring Gallium Phosphide to Diamond Using PDMS

Edward Payne Roberts, Junior, Mat Sci & Engr: Nanosci & Moleculr Engr

Mary Gates Scholar

Mentor: Kai-Mei Fu, Physics/ECE

Mentor: Nicole Thomas, Electrical Engineering

The overall project that I work in is to see how quantum states can be used to process information. To realize this, we utilize crystal defects in diamond that exhibit quantum properties. We then network the defects using GaP as a photonic waveguide. GaP is used because at the wavelength of the defect, it is transparent and its index of refraction is higher than diamond. My contribution to this project is to investigate the feasibility of using polydimethylsiloxane (PDMS), a material similar to rubber, as a way to transfer gallium phosphide (GaP) on to the diamond. Using PDMS allows the amount of GaP transferred to be easily scaled due to the surface area of PDMS. I will first use more widely available silicon on insulator substrates to develop a general process flow. The silicon will be patterned as 50 by 50 micrometer squares using photo-lithography and plasma etching. The squares are then transferred to a secondary substrate using a PDMS stamp. We expect then to be able to apply the processing scheme developed for silicon to the transfer of GaP onto diamond.

POSTER SESSION 3

Commons East, Easel 60

2:30 PM to 4:00 PM

Fall Detection Smart System

Chia Ning (Chia-Ning) Wang, Senior, Electrical Engineering

Bora Srecko Banjanin, Senior, Electrical Engineering

Lingrui Zhang, Senior, Electrical Engineering

Mentor: Howard Chizeck, Electrical Engineering

Mentor: Kevin Huang, Electrical Engineering

Falling remains a major cause of depression and mortality among the elderly due to both physical (e.g. hip fractures) and emotional (i.e. lack of exercise due to fear of falling) injuries. For seniors with a greater propensity to accidental fall, a common solution is to move to a nursing home, which many regard as a loss of privacy, individuality, and dignity. Remote patient monitoring using stand-alone sensors that alert medical workers when a patient has sustained a life-threatening fall presents an alternative solution that allows patients to reside in their own homes. Unfortunately, the cost of responding to false positives or failing to respond to false negatives makes it difficult to commercialize such a system. Our research focuses on creating a real-time, high accuracy, and low cost fall detection system that employs a detection algorithm based on tri-axial accelerometer and gyroscope data. We begin by adopting motion detection and inference techniques used by other research groups to better understand their advantages and limitations. Examples include tilt sensing for posture recognition, filtering and periodic signal detection for step recognition, and context sensing. We examine the accuracy of these techniques, weigh in computational cost, and explore how the techniques could complement or interfere with each other. From these results, a fall detection algorithm is created based on an amalgam of both established and novel techniques such as device self-calibration for determining threshold acceleration and angular velocity values. We then evaluate the final product against other commercially available fall detection systems.

POSTER SESSION 3

Commons East, Easel 70

2:30 PM to 4:00 PM

Measuring the Spin Relaxation Time of Donor-Bound Electrons in Indium Phosphide

Pasqual B (Pasqual) Rivera, Fifth Year, Physics: Comprehensive Physics

NASA Space Grant Scholar

Mentor: Kai-Mei Fu, Physics/ECE

Neutral donor-bound electrons and excitons in bulk semiconductors provide a system that may have interesting prospects for quantum information processing (QIP). In GaAs, the donor-bound exciton system exhibits extremely high optical homegeneity with spin relaxation times similar to that of negatively charged quantum dots. The complex excited state structure, however, makes full coherent optical control of the spin state challenging. Exhibiting a simpler excited-state structure and a higher exciton binding energy than GaAs, coherent optical control of donor-bound electron spin states in InP may be more accessible. In this work we investigate the spin relaxation properties of donor-bound electrons in InP using continous wave polarized laser spectroscopy at liquid helium temperature. Current progress towards measuring the spin relaxation time via polarization-induced optical pumping will be presented.

POSTER SESSION 3

Commons East, Easel 71

2:30 PM to 4:00 PM

Biological Sensing using Diamonds

Christopher Lee (Chris) Chen, ,
Mentor: Kai-Mei Fu, Physics/ECE
Mentor: Michael Gould, Physics

The study of defects (nitrogen-vacancy centers) in diamond may be instrumental in developing better biological sensors that optically detect tagged biological molecules without interfering with natural processes. Using nitrogen-vacancy (NV) centers, our goal is to develop highly sensitive microscopes that detect magnetic fields produced by magnetic nanotags. Since the NV center photoluminescence intensity depends on its spin state, a decrease in photoluminescence will occur when a magnetic field is applied to the NV center. We employ this property in the detection of nanotags. The applications of this research include the study of biological systems, and faster, cheaper and earlier detection of diseases. While performing optically-detected magnetic resonance in NV centers results in high-sensitivity detection of magnetic fields, a reduction in signal occurs when the NV center symmetry axis is misaligned from the instrument's externally applied magnetic field. Helmholtz coils, which produce near uniform magnetic fields, may be used to align the magnetic field to the proper orientation. Two Helmholtz coils, placed on the horizontal plane of our sample, will allow for clearer detection of photoluminescence dips as the magnetic field will be aligned to one of the NV center axis. In this work, we integrate and test Helmholtz coils in our NV based magneto-optical microscopes. This includes the development of electrostatic simulations and a search algorithm for the alignment of the magnetic field, as well as the fabrication of the coils.

POSTER SESSION 4

Commons East, Easel 74

4:15 PM to 5:45 PM

Modularizing Biology: A Novel Way of Refining Gene-Network Characterizations through Turbidostat Mixture Control and Fluorometry

Felix Ekness, ,
Mentor: Chris Takahashi, CSE
Mentor: Eric Klavins, Electrical Engineering

The field of synthetic biology aims to modularize gene-networks within microorganisms for the purpose of using them as well characterized parts in building novel, useful biological systems. Realizing this goal is vital because biology's inherent practicality holds the key to needed energy efficient technologies. As the human population increases, energy efficient technologies will become more and more a necessity. The first step in realizing this vision of adapting biology into an engineering discipline is through properly characterizing gene expression and enzyme function within engineered and natural biological systems. To do this, I have developed a turbidostat with mixture control and fluorescence sensing capabilities. A turbidostat is a continuous culture bioreactor that maintains constant culture volume and microbe density through a feedback loop between turbidity measurements and dilution with fresh media. The constant culture environment and microbe density allows the cultured microbes to reach a "steady state" where growth and all environmental conditions are kept constant. By maintaining microbes at steady state, variables that effect microbial processes are minimized, which facilitates accurate examining of gene-network dynamics. The mixture control ability of the turbidostat allows for the concentration of a given molecule within the culture environment to be modulated through time without altering any other environment variables. Through mixture control, a molecule that acts as an input to a gene-network (i.e. an inducer molecule that initializes a gene-network) can be varied in concentration through time within the culture environment. Since most gene-networks utilize fluorescent protein production as their output, the turbidostat's fluorometer (a fluorescence detector) can monitor the output of a gene-network while the input to the network is modulated. We believe that the ability of this turbidostat to look at the input-output dynamics of gene-networks under defined environmental conditions will yield enhanced behavioral understandings, aiding to the modularity of these systems.

POSTER SESSION 4

Commons East, Easel 59

4:15 PM to 5:45 PM

Developing a Model for Noise in Stochastic Gene Expression

Shane A (Shane) Colburn, ,
NASA Space Grant Scholar
Mentor: Georg Seelig, Electrical Engineering and Computer Science & Engineering
Mentor: Alex Rosenberg, Electrical Engineering

Cellular noise is the variability in a biological quantity due to randomness. It is mathematically defined as the quotient of the quantity's standard deviation and mean. Systems of genotypically identical cells may exhibit noisy gene expression—there are often differences between cells in terms of protein abundance. We are interested in developing a model to better understand this noise. Many factors contribute to gene expression noise, one of which is alternative splicing. RNA splicing is when sequences of RNA are "cut out", leaving only the regions that will be translated into protein. Alternative splicing is when pre-mRNA transcripts are spliced dif-

ferently, resulting in similar yet different specialized proteins. This is common in eukaryotes and increases protein diversity, allowing cells to take on particular functions and thereby playing a role in cellular decision making. To model the noise, we began by cloning different plasmids, each of which had two fluorescent reporter genes, citrine and mCherry. To better understand the alternative splicing mechanism, one of our plasmids contained an extra sequence of bases, an intron, in citrine. We used our two reporters to produce fluorescence readouts of correct versus incorrect splicing. We measured the fluorescence with a flow cytometer and the noise could be quantified by determining the spread and mean of the data. We hypothesize that as mRNA concentration increases, noise in expression will decrease, since variation decreases with increasing sample size. We also hypothesize that the plasmid with the intron will be noisier than that without since the alternative splicing mechanism will have a greater length sequence to splice. Alternative splicing will sometimes produce abnormal transcripts that are found to be in high concentration in cancerous cells. So in modeling the noise and gaining a better understanding of this mechanism, we may improve understanding of how cancer develops.