UNIVERSITY of WASHINGTON

Undergraduate Research Symposium May 17, 2013 Mary Gates Hall

Online Proceedings

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.

POSTER SESSION 2

Commons West, Easel 31

12:45 PM to 2:15 PM

Can Electroencephalography (EEG) be a Predictor of Medication Response in Children with Autism?

Veronica Youn Kang, Junior, Biology (General)

Mentor: Sara Webb, Psychiatry & Behavioral Sciences, Seattle Children's Research Institute

Mentor: Esha Massand

Mentor: Anna Kresse, psychiatry, Seattle Children's Research Institute

Autism is a disorder characterized by deficits in social and communication skills and repetitive behaviors. Fifty-two percent of the children with autism are treated with medication for some of the common co-morbid behaviors – e.g., anxiety, aggression, and hyperactivity. However, only 49-69% of these children respond positively to the medication, and about 18-26% of these children experience side effects such as insomnia, sedation, and increased appetite. An extensive series of trial-and-error might be needed for a patient, which could be time-consuming and stressful for both the patient and parents. A reliable method is needed to predict the effectiveness of the pharmacological treatment. This study used electroencephalography (EEG) to detect early changes in the brain that we cannot yet observe in behavior. Children who are diagnosed with autism and starting a medication (e.g. stimulant, antidepressant, or atypical antipsychotics) participated in this study. EEG was recorded while the subjects participated in a social processing task, a resting task, and the Go-NoGo inhibition task. The participant's caregiver completed three questionnaires: Child and Adolescent Symptom Inventory, Aberrant Behavior Checklist, and Social Communication Questionnaire. This project analyzed the subject's change in EEG and behavioral data over three different time points (T1= before, T2= one week after, T3= one month after the start of medication). Multiple aspects of each individual's EEG signal were examined by comparing the difference from T1-T2 and T1-T3 against the null hypotheses of *no change* (or comparing change to 0). The goal of this project is to search changes in the EEG signal that is related to positive (or negative) behavioral changes in this population. This study will

provide an important first step for understanding changes in the brain in response to medications, which may provide useful information to professionals during the process of choosing the most effective medication for children with autism.

POSTER SESSION 2

MGH 241, Easel 137

12:45 PM to 2:15 PM

Tailoring the Surface Properties of Iron Oxide Nanoparticles for Biomedical Applications

Kunichika William (Kuni) Hongo, Senior, Mat Sci & Engr: Nanosci & Moleculr Engr
Mentor: Kannan Krishnan, Materials Science & Engineering
Mentor: Amit Khandhar

Iron-oxide magnetic nanoparticles (MNPs) with tuned magnetic properties can enable novel diagnostic and therapeutic technologies such as magnetic particle imaging and hyperthermia. In order to optimize the magnetic properties of MNPs, organic synthesis methods are required. However, these organic synthesis methods render the nanoparticles hydrophobic and unusable for biomedical applications. To make MNPs functional in biomedical applications whilst retaining their magnetic functionality, they must be transferred to the aqueous phase using a biocompatible polymer. In this work, MNPs will be coated using a biocompatible PEG-ylated amphiphilic polymer: poly (maleic anhydride-alt-1-octadecene) or PMAO-PEG. To ensure the PMAO-PEG is a well suited polymer coating for MNPs, various molecular weights and molar ratios of PMAO-PEG are synthesized and characterized to study the effects of PEG surface density and molecular weight on MNPs. By altering the density of the polymer used to coat and phase transfer MNPs, effects such as the solubility, circulating life, colloidal stability, dosage frequency, and proteolytic degradation rates of MNPs in the biomedical applications are studied using data obtained from Gel Permeation Chromatography (GPC) and Fourier Transform Infrared Spectroscopy (FTIR). Molecular weight distributions of the various polymers are obtained from the GPC to evaluate the conjugation success after PEG-ylation. In addition, FTIR was used to identify known and unknown materials in the samples, determine the quality and consistency of samples, and to determine the amount of components in samples.

POSTER SESSION 2

Commons West, Easel 34

12:45 PM to 2:15 PM

Mismatch Negativity and Social Adaptive Behavior in ASD

Tanner Chas (Tanner) Dixon, Junior, Neurobiology
Mentor: Sara Webb, Psychiatry & Behavioral Sciences, Seattle Children's Research Institute
Mentor: Anna Kresse, psychiatry, Seattle Children's Research Institute

Event related potentials (ERP) are electrophysiological responses of the brain measured during an electroencephalogram (EEG). The Mismatch Negativity (MMN) is an ERP component that occurs as a result of the brain detecting a deviant sound among a sequence of standards. It is represented by a negative peak in the fronto-central region of the scalp with latency 100-250 ms after onset of the abnormal stimulus. Previous studies have shown that the MMN is reduced in children with autism spectrum disorders (ASD) relative to typically developing children. It has been suggested that this indicates atypical automatic auditory processing in ASD. Other research has found abnormal MMN activity in schizophrenia patients as well. These studies have found an association between MMN activity and test measures of social function in individuals with schizophrenia. It has been theorized that impairment in auditory detection present in schizophrenia (as evidenced by a reduced MMN) may have downstream effects on certain facets of social cognition. No known work has yet been done to assess the same association in ASD. This study investigated the relationship of the MMN with social skills in individuals with ASD. In this study, EEG was recorded from children and adolescents with and without autism while they listened to auditory stimuli consisting of a standard sound ("ba") and deviant sounds ("da," "bi") to elicit an MMN. Parents reported on children's social adaptive behavior in the Vineland assessment. The aims of this study are to (1) replicate previous findings that individuals with ASD have a reduced MMN relative to typically developing individuals, and (2) explore the relationship between the MMN and social behavior in children with ASD and typical development, as measured in the Vineland. A strong association may shed light on the sensory involvement in typical social functioning.

POSTER SESSION 2

MGH 241, Easel 136

12:45 PM to 2:15 PM

Nanoimprint Lithograpy of Nanomagnetics for Biomedical Applications

Tanner Justin (Tanner) Hoecherl, Senior, Mat Sci & Engr: Nanosci & Moleculr Engr
Mentor: Kannan Krishnan, Materials Science & Engineering
Mentor: Byung Seok Kwon, MSE

Nanoimprint lithography (NIL) has become a widely used

technique in fabricating nanoparticles using a top-down approach with several advantages over bottom-up chemical methods, including being able to precisely control particle shape, size, structure, and composition. Using NIL, synthetic antiferromagnetic (SAF) nanoparticles can be fabricated using multilayer deposition techniques, imprinting, liftoff, and particle release into water with limited defects. The particles can also be coated with a functional polymer so that they can be used in a number of drug delivery systems. However, common NIL techniques often make it difficult to add functional coatings to the particles after the particles are released in water. Deposition methods for different layers, as well as using silicon molds that introduce defects and irregularity in particle size are other pitfalls that can be corrected using a new approach. The nanoparticles (˜300 nm diameter) were homogeneously patterned using a mold to etch disk-shaped nanoparticles on a silicon substrate with layers of titanium and magnetite deposited on its surface via magnetron sputtering to contribute to the antiferromagnetic properties of the particles. The fabrication process is extensive and utilizes many clean room processes, including nanoimprinting, dry etching, undercutting, multilayer deposition, liftoff, and polymer coating, though polymerization was not explored in this study. Following, release techniques were used to produce a monodisperse and homogeneously-sized sample of high moment, multilayer particles in water with high saturation magnetization and low toxicity. Final results to determine the effectiveness of the particles were determined by studying the magnetic properties of the nanoparticle solution sample in the presence of an external magnetic field. With antiferromagnetic and useful imaging properties, functional biomagnetics could become a highly useful material system. Future work in this field includes biofunctionalizing the particles to modify in-solution behavior and implementing them into various biomedical systems, depending on how small the particles can be made using NIL.

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.

Stable Marriage when You are Not Sure Who Would Make a Good Long-Term Partner

Eric Christopher Lei, Senior, Computer Science, Economics, Mathematics

Mary Gates Scholar

Mentor: Anna Karlin, Computer Science and Engineering

Can a group of men and women be paired together to guarantee no divorces or scandals? In 1962, two economists posed this question mathematically and offered a solution. A 2012 Nobel Prize went to two of the key researchers that worked on this problem. Their solution took the form of an algorithm, a systematic procedure that could be performed by a computer. The solution to the "stable marriage problem" has both interesting theoretical properties and real-world applications, such as the assignment of medical students to hospitals. In the original version of the problem, each man and woman know their preferences over all their potential partners. We are considering a variant in which they only know some of their preferences. The algorithm not only needs to figure out whom to match with whom, but also what information to gather on preferences. We present our preliminary results on efficient algorithms for this problem. This is joint work with Anna Karlin and Jamie Morgenstern.

POSTER SESSION 4

Balcony, Easel 89

4:15 PM to 5:45 PM

Impact of Black Holes in Cosmological Simulations of Galaxy Clusters

Taylor Montana (Taylor) Posey, Junior, Extended Pre-Major
Brianna Louise Diaz, Sophomore, Pre-Sciences
Mentor: John Ruan, Astronomy
Mentor: Breanna Binder, Astronomy
Mentor: Philip Rosenfield, Astronomy
Mentor: Eric Agol, Astronomy

Observations suggest that the intracluster medium in galaxy clusters is strongly influenced by supermassive black holes residing in cluster centers. We investigate the consequences a black hole can have on the thermodynamics of the gas in galaxy clusters by comparing the properties of a simulated galaxy cluster without black holes to X-ray observations of real clusters, which have black holes. For our data we used Python to manipulate a cosmological simulation made with ChaNGa, a code capable of simulating gravity, thermodynamics, and other things. Our cluster simulation includes gravity, hydrodynamics, gas cooling, star formation, and stellar feedback in a fully cosmological setting. However, this simulation lacks black hole formation, growth, and feedback, allowing us to pinpoint the effects of these processes on the cluster by comparing to observations. In our investigation, we found only minor differences in the density, temperature, and pressures of the gas between the observed and simulated galaxy clusters in the cluster outskirts. However, we found significant deviations between the simulation and observations near the cluster centers, where a large spike in star formation is present in the simulated cluster, not seen in the observations. Our results suggest that black hole formation and feedback in galaxy clusters most strongly affect the cluster in the central regions, where it can significantly decrease star

formation by heating the gas.

POSTER SESSION 4

MGH 241, Easel 167

4:15 PM to 5:45 PM

Metabolic Changes in Induced Pluripotent Stem Cells during Cardiomyocyte Differentiation

Merry Toh, Senior, Bioengineering
Mary Gates Scholar
Mentor: Anna Naumova, Radiology

Induced Pluripotent Stem cells (iPSCs) have the capability to differentiate into beating cardiomyocytes, therefore have the potential to regenerate injured heart. Structural and metabolic maturation is important to support the increase in energetic demand during the differentiation process. These metabolic and energetic requirements of iPSCs during their differentiation into iPSCs-derived cardiomyocytes (iPSC-CM) are largely unexplored. The aim of this project is to study the changes in metabolic pathways in iPSCs during differentiation processes, using state-of-the-art, extracellular flux (XF) analyzer manufactured by Seahorse Bioscience (Massachusetts, USA). IPSCs were differentiated into cardiomyocytes in 96-well plates using directed differentiation protocol. Oxidative phosphorylation and glycolysis rates were measured in plate using XF machines on different time points of differentiation. The XF machine monitors the changes in energy producing pathways by measuring the amount of oxygen consumption and the acidification rate. Our findings showed significant difference in the energetic requirements of undifferentiated and differentiated stem cells. We found that undifferentiated iPSCs have active mitochondrial metabolism reflected by high respiratory rate. During differentiation of iPSCs, their metabolism shifts to a more glycolytic pathway. Fully matured cardiomyocytes demonstrate greater metabolic flexibility characterized by quick shift of energy production from oxidative phosphorylation to glycolysis in conditions where mitochondrial respiration is impaired. To our knowledge, this is the first study to measure the changes in energy metabolism in iPSCs during differentiation into cardiomyocytes by XF analyzer. The protocol developed in this study will provide novel platform for analyzing the energetics of other cells types during differentiation processes. The results of the study will provide an insight into metabolic processes underlying cardiomyocyte differentiation of iPSCs and might be useful for establishing metabolic targets to regulate cardiogenesis and cell maturation.

POSTER SESSION 4

MGH 241, Easel 170

4:15 PM to 5:45 PM

Development of a Diffusion Tensor Imaging (DTI) Based Approach for Three-Dimensional Fiber Tracking of the Breast Ductal Network

Peixian Liu, Senior, Bioengineering
Mary Gates Scholar
Mentor: Savannah Partridge, Radiology

Diffusion tensor imaging (DTI) has been successfully used to map 3D brain structure due to its ability to characterize water diffusion rate, anisotropy, and direction. However, DTI-based 3D fiber tracking has not yet been done in human breast. The objective of this study is to develop an approach for 3D fiber tracking of the breast ductal network. In the study, an optimized DTI pulse sequence has been determined by testing on different parameter combinations. Intra-subject reproducibility has also been characterized to assess the reliability of the DTI data and post-processing methods. Lastly, 3D fiber tracking of the breast ductal network is under development using DTI measures obtained from scanning the breast of healthy volunteers. The resulting information on 3D trajectory of breast ducts can benefit the study of the anatomy and development of the breast. It may also help detect early malignancy within the ducts because of the disruption of the ductal system.