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Abstracts

WASHINGTON SPACE GRANT CONSORTIUM
N A S A

Cover

Clockwise from the upper right: Deven Bryant, Electrical Engineering/Physics; Keira Brooks, Senior, Astronomy/Physics; Matthew J. Ruppel, Chemistry: Mauna Edrozo, Biology.

A Rapid Test for HIV-1 p24 Protein Using a Novel Thermal-Responsive Polymer System

Carlos Eduardo Estrada Alamo, Senior, Bioengineering
Mentor: Patrick S. Stayton, Bioengineering

As the Human Immunodeficiency Virus (HIV) epidemic continues to spread, the need for practical, rapid diagnostic tests remains critical both for the control of the epidemic and for the treatment of patients. The best strategy to protect the general population and improve the healthcare outcomes for HIV patients is to intercept the virus early and to stop it from further propagation. The aim of this project is to develop a rapid HIV diagnostic test using anti-p24 antibodies linked covalently to "smart" temperature-responsive polymers. This rapid HIV test will make it possible for patients to get pre- and post-test counseling, test results, and any medical treatments that may be needed, in one visit. Conventional HIV immunoassays are time consuming due to a lack of efficient sample handling and they often require equipment in centralized laboratories. Rapid testing is less costly, results may be delivered more quickly, requires little training to implement, and may be made available in regions far from mainstream healthcare centers. However, current rapid tests, such as lateral flow assays, are not sensitive enough to detect biologically relevant concentrations of p24 due to their current limit of detection. Because lateral flow assays have flow through volume capacities, they have not been able to detect picomolar ranges of p24 without signal amplification. The project helps to alleviate this problem by using "smart" polymers to pre-concentrate patient samples prior to detection. Poly(*N*-isopropylacrylamide) (PNIPAAm) polymers will be used in this study. PNIPAAm polymers become hydrophobic at a temperature above the lower critical solution temperature. Using this property we aim to isolate and concentrate p24 antigen that may be present in patient blood samples. Upon heating, a sample treated with anti-p24-PNIPAAm conjugates will aggregate into a hydrophobic mass. The mass will be captured by membrane filtration for treatment via a standard ELISA protocol. Clinical studies will allow for effective comparisons between this and other formats currently used for diagnosis of HIV. These inexpensive, rapid point-of-care HIV assays will be made available in setting such as airports, emergency care settings, dentist and medical clinics, as well as over the counter for home care applications.

Understanding and Modeling Human Decision Making Dynamics

Tyler Beauchamp, Freshman, Pre-Engineer
Mentor: Kristi Morgansen, Aeronautics and Astronautics

Mixed teams of humans and autonomous robots (such as aerial, ground, and underwater vehicles) are becoming more and more prevalent, thanks to the increasing development and deployment of control and robotic technology. The better we can understand how humans reason and make decisions, the better control algorithms we can write. Improved control algorithms allow us to have finer control, make systems operate more efficiently, control more objects at a time, and make systems that can work concurrently with humans. As part of my research, I analyzed human decision making data from sequential two-choice tasks, in which a human has to make a repeated choice between A and B upon receiving a reward at every step. The experiment was conducted in the Neuroscience of Cognitive Control Laboratory at Princeton University. My work was to analyze the experimental data using MATLAB. I wrote programs looking for patterns and generated graphs that displayed the choices made by the different participants. Based on my results, we wrote a simple algorithm that tried to predict the guesses the humans would make and then wrote more programs to analyze the accuracy of our algorithm. After studying patterns of

outliers whose choices were not well represented by the algorithm we adapted the algorithm so that it represented more closely the decisions made by a broader range of participants. The research lab I work in uses underwater autonomous vehicles that move in a more natural, fishlike manner to test the control algorithms that we design. In the future we hope to expand our algorithm from a two-choice question test to a multiple-choice test and eventually to a non-predefined answer or real life scenario so that the algorithm we find can change the basis of control algorithms as we know them today.

Quantifying the Potential for Life on Exoplanets by Measuring Atmospheric Disequilibrium

David Bergsman, Sophomore, Chemical Engineering and Computer Science
Mentor: David Catling, Earth and Space Sciences

The degree to which the composition of a planet's atmospheric is in disequilibrium could be used as a diagnostic for life on exoplanets. Because the combination of gases such as O2 and CH4 will react and take other forms at equilibrium, their presence in an atmosphere indicates an active supplier that maintains disequilibrium. This active supplier could take the form of volcanic activity, solar radiation, tidal forces, or a biosphere. On Earth, gas release and uptake by the biosphere modulates the levels of all the bulk gases in the air, with the exception of argon. This project attempts to calculate the available free energy of various atmospheric compositions by minimizing the Gibbs free energy of these systems. It then compares these available energies to create a metric for the possibility of life. The energy minimization process is carried out computationally, using the atmospheric composition as input and providing an equilibrium composition as output. We use the Gibbs free energies of formation of the compounds at the desired temperature, which are calculated using a database of thermodynamic polynomials. Based on several simplified calculations of planetary atmospheres, we expect to see a difference in atmospheric potential energy between the Earth and Mars on the order of 102 – 104. Solar system planetary atmospheres and a range of possible concentrations applicable to hypothetical exoplanets will be explored, attempting to discern the validity of the metric while gaining a better understanding of what makes an atmosphere more indicative of biology. With this kind of metric, researchers will be able to determine if newly discovered planets have the potential for life.

Capacitive Shear Force Sensor Arrays

Aaron Bestick, Junior, Electrical Engineering
Mentor: Alexander Mamishev, Electrical Engineering
Mentor: Kishore Sundara-Rajan, Electrical Engineering

Amputees commonly suffer skin blisters and irritation at the interface between a prosthetic device and their residual limb. At present, few quantitative methods exist for the measurement and adjustment of the forces exerted at this interface. A need exists for sensing technology which can be used to measure these forces and facilitate precise adjustments of prosthetic geometry to increase wearer comfort. Our research objective was to produce a flexible, stretchable, capacitance-based shear and normal force sensing array, which could be integrated with moisture and temperature sensors into a "sensitive skin." This sensing array could then be attached inside the prosthetic socket and used to monitor and reduce factors which result in sores and discomfort.

Individual pixels of the array were composed of top and bottom plates, each containing several precisely aligned electrodes. The two plates were separated by a flexible silicone rubber. Finite element modeling was used extensively to optimize both the mechanical and electrical properties of the sensor cells to achieve the necessary sensitivity, dynamic range, and signal-to-noise ratio. Multiple cells were then attached to a flexible rubber substrate and connected using commercially available stretchable conductors to create a flexible, stretchable sensor array. A purpose built microcontroller was used to monitor the capacitance of each electrode pair in real time, multiplex the capacitance data for the entire array, and transmit it to a PC. The capacitance data was then analyzed and used to produce a continuous plot of the shear and normal force distribution over the array.Subsequent work will likely focus on integration of force, temperature, and humidity sensors into a single unit, as well as further miniaturization of sensor pixels in order to improve the spatial resolution of the array. In addition to improving the design of prosthetics and orthotics, the sensor arrays have applications in many other fields such as robotics, where the sensors could be used to give autonomous robots a human-like sense of touch, and allow them to manipulate objects with greater precision and dexterity.

Light-induced Brownian Motion

Anish Bhalerao, Senior, Astronomy
Mentor: Gerald Pollack, Bioengineering

Brownian motion, or the random movement of microscopic particles, is important in modeling random processes. Previous analyses of Brownian motion attribute the random movement of particles submerged in water to thermal interactions between the particles and water molecules and/or to quantum mechanical effects. However, such theories neglect the effect of an external light source on these particles. Our research tests the effect of various wavelengths of light on one micron carboxylate microspheres. Carboxylate microspheres have a net negative charge and exhibit standard characteristics of Brownian motion when placed in water. We exposed 100 microliters of a water and microsphere mixture to six different wavelengths of light ranging from 310 (ultraviolet) to 880 (infrared) nanometers. The results show that radiation energy decreases microsphere movement and that the decrease is directly proportional to the external energy. This work increases our understanding of the agents causing Brownian motion and serves to improve current models of random processes.

Distinguishing Quasars from Other Variable Objects Using a Statistical Model

Keira Brooks, Senior, Astronomy and Physics
Mentor: Zeljko Ivezic, Astronomy

Quasars are exciting objects whose copious optical emission comes from an accretion disk around a black hole. Due to their large distances (between approximately 800 million and 30 billion light-years away) and bright centers, quasars appear as point sources from our telescopes on Earth and in orbit. Currently spectroscopic observations are the best way to classify quasars from stars, but for upcoming large-area sky surveys, where spectra are not available, we want to implement another selection technique. New techniques will use time-domain information to separate quasars from stars, which show different variability characteristics. However, it is not yet clear how exactly variability will be used in a quantitative fashion to achieve this goal. Our project will

analyze data from the Sloan Digital Sky Survey, which provides both spectroscopy and time-domain information for a large number of objects, with the aim of quantifying the criteria for selecting quasars. Using a sample of over 60,000 variable objects, we model their light curves using both quasar and stellar light curve models. By comparing the quality of light curve best fits, we hope to be able to separate the two populations.

Performance Testing of High Power Helicon Plasma Thrusters

Deven Bryant, Junior, Electrical Engineering and Physics
Mentor: Robert Winglee, Earth and Space Sciences

Chemical propulsion systems are very inefficient, and, in some cases, impractical. More efficient propulsion methods need to be investigated in order to mitigate the high expenses seen in today's space related operations. Plasma propulsion is a promising solution because it allows for electrical energy to be converted into forward momentum. The High Power Helicon (HPH) project consists of ongoing testing and data analysis of the HPH plasma thruster. The goal is to develop new methods for improving the efficiency of the thruster. Performance measurements are taken with a B-dot Probe measuring axial magnetic perturbations and a Langmuir Probe measuring plasma density. Currently I am working on a more accurate B-dot probe than the one in use. The probe consists of a steel pipe, a 25 turn solenoid, and alumina tubing to mate the solenoid to the piping. The steel piping is bent 90 degrees at the end to accommodate for adequate radial extension of the solenoid. A high vacuum epoxy resin is used to connect the different parts as well as prevent from any unwanted out gassing. Using such probes, measurements are taken at many different points along the z axis of HPH and under various operating parameters to better understand the dynamics of the plasma exiting the HPH. From the collected data, findings show that an increase in efficiency could be achieved by adding an adjacent coil to the magnetic nozzle. Extending the magnetic nozzle is anticipated to maintain the plasma beam for a longer period of time, enabling more of the pulsed helicon wave's energy to transmit into the plasma's axial momentum. Further tests are to be conducted on the new configuration using our current probing techniques.

Studying the Change in Sea Surface Temperature Due to Typhoons in the Western Pacific Ocean

Tsung Hwa Sophia Burkhart, Sophomore, Pre-Engineering
Mentor: Ren-Chieh Lien, Applied Physics Laboratory: Ocean Physics

Typhoons, strong tropical cyclones in the western Pacific Ocean, are storms with low-pressure centers that form over warm waters. These cyclones can reduce the sea surface temperature with strong winds that mix warmer water in the upper ocean with cooler water below. By collecting data from recent typhoons and examining the change in sea surface temperature (primarily cold wakes, the decreases in sea surface temperature along typhoon tracks), we can improve our comprehension and predictions of their oceanic impacts and provide a resource to others involved in the ITOP (Impact of Typhoon on the Western Pacific Ocean) project. The ITOP project is a multi-university, international program designed to better understand the influence typhoons have on the ocean and predict the evolution of typhoons. Currently, the project is in the pilot experiment stage. Three oceanic surface-buoy moorings that transmit real-time meteorology data

to our Applied Physics Laboratory ITOP website were deployed in the western Pacific in March 2009. Daily, we monitor the positions of the moorings and the oceanic and atmospheric data on the website. As a first step, we used MATLAB and data collected from meteorology agencies to create plots of historical typhoon tracks and the resultant sea surface temperature, the change in sea surface temperature, and yearly typhoon trajectory summaries with the corresponding wind speed. Our ITOP website is updated frequently with new plots and features, becoming a necessary resource for typhoon information and the ITOP intensive observation experiment in 2010. Ultimately, we hope to analyze the cold wakes of typhoons. By making plots with MATLAB, the duration of the cooler water and the sea surface temperature anomaly along typhoon paths will be studied. This analysis will help in understanding the mechanisms for oceanic temperature change around a typhoon trajectory and be useful to ITOP project researchers preparing for the field experiment.

Modeling Human Decision Making in Sequential Two-Choice Tasks

Gagandeep Dhillon, Senior, Mechanical Engineering
Mentor: Kristi Morgansen, Aeronautics and Astronautics

Decision making is an essential part of human life, and the ability to make decisions without user input has become a desired function in many of today's robots. A new project in the Nonlinear Dynamics and Control Lab looks to understand human decision making when faced with a two-choice task. The work is a joint research effort among psychologists, engineers, and applied mathematicians to capture human data and then, through analysis, create computer algorithms that mimic the observed human behaviors. One of the goals is to develop a new method to capture, model, represent, and understand human behavior in tactical military scenarios which involve autonomous and semi-autonomous vehicles. The human test data is gathered from individuals who play a game where they choose either "A" or "B" which results in a different "reward" calculated from various functions which take into account current and past decisions. The test subjects are not aware of how the reward is calculated, but try to earn the maximum possible reward for each decision they make. My research role consists of the analysis of the data to implement computer algorithms in the MATLAB data processing language, and then comparing the hypothesized results with the data collected from humans. Our hypothesis is that an individual will continue to make the same decision as long as their reward increases, otherwise they will switch. Early analysis has shown low correlation in some of the experiments, so we are looking into other parameters that may also need to be satisfied, such as an increase in the reward from one decision to the next.

Correcting Temperature Effects in Scintillators Used to Detect X-Rays

Sy Donovan-Smith, Freshman, Physics
Mentor: Michael McCarthy, Earth and Space Sciences

The purpose of my research is to better understand the mechanisms in nature that cause electrons to be dumped out of the Earth's radiation belt. With a better understanding of the mechanism causing this phenomenon, we may be able to predict the time and location of high concentrations of radiation, therefore avoiding radiation damage to satellites and spacecraft traveling through the radiation belt. We can see the patterns in which these electrons fall into the atmosphere by

observing the x-rays they emit using sensors on high-altitude balloons. When x-rays hit the sensors, a scintillator gives off a flash of light, which is then converted into electrical energy; unfortunately, the scintillating material is inconsistent, giving off different amounts of light at different temperatures. The data does not always fit its ideal simple linear model, resulting in "peaks" in the data. My task is to subject the x-ray detector to various radioactive materials of known energies at different known temperatures and to record its response. Using this data, I can detect the points at which the measured results differ from the proper results, calculate the energy levels at which they occur, and cancel out the discrepancies in the sensor. With the sensors working properly, we will be able to learn about the patterns of radioactive electron fallout in the upper atmosphere.

Meristemoid Gene Expressions in Cell Development and Proliferation of Arabidopsis

Mauna Edrozo, Sophomore, Biology
Mentor: Keiko Torii, Biology

Regulatory genes coordinate the proliferation of plant cells such as pavement cells and stomata. Interlocking epidermal cells called pavement cells protect the plant body from external dehydrating forces. On the other hand, stomata, pores found on the epidermis, manage air and water flow in and out of the plants. Stomata develop from meristemoid mother cells (MMC), a subset of protodermal cells that undergo asymmetric division to initiate cell differentiation from meristemoids (stomata precursor cells with stem cell like states) to stomata. To understand the intercellular communication and gene interactions that oversee stomatal development, we use *Arabidopsis thaliana*, a small rapidly developing flowering plant related to canola cabbage as a model organism. Specifically we seek to elucidate genes that are expressed in meristemoids. We used a microarray, profiling gene expressions in *Arabidopsis*, to locate possible meristemoid-specific genes. We then use three approaches to discover the effect the genes have on meristemoids. Knockout, the first approach, eliminates the target genes through mutations generated by T-DNA transformations. Overexpression, a reverse of the knockout approach, highly expresses the candidate genes. Lastly, GFP fusion attaches a fluorescent protein to the candidate protein, allowing us to detect where the promoter and gene are active. We hope to discover the specific functions of the candidate meristemoid-expressed genes. Consequently, these approaches will help us see whether and/or how gene interactions occurring during stomatal development may resemble other cell proliferation since meristemoids maintain their stem cell like states. This in turn can have implications for stem cell research that will hopefully lead us to better understand the differentiation and division process that meristemoids and stem cells undergo in attaining their cell-identities.

Deep Tissue Stimulation using Intense Focused Ultrasound (iFU) for Localizing Painful Tissue

Josephine Garcia, Junior, Biochemistry
Abigail McClintic, Junior, Environmental Health and French
Mentor: Pierre Mourad, Neurological Surgery

In the medical field, pain can be challenging to localize and properly diagnose. Many current pain diagnostic techniques are invasive and most are designed to diagnose only specific problems. For example, to test for painful degenerative discs in the back, a physician will use long needles to inject saline in the candidate disc to identify if it is the source of pain. Besides being invasive, this method can only test discs as sources of pain, which are just one of many potentially painful structures in the back. A new type of test is needed: one that is non-invasive, versatile, and still specific in its diagnosis. The goal of our project is to test and develop a new clinical device which uses iFU (Intense Focused Ultrasound) to non-invasively localize pain. iFU is different from diagnostic imaging ultrasound in that it is far more powerful and directs all of its energy to a small focal point (about the size of a grain of rice), which creates mechanical and thermal stimulation in tissue at that spot alone. To show that iFU can stimulate a deep tissue injury, we will artificially create a peripheral neuroma in rats and use our device to stimulate the neuroma. Because the neuroma specifically causes deep pain, palpating the neuroma transcutaneously with iFU is anticipated to evoke a withdrawal response, while palpating a control section of tissue will generate no response at that same intensity. In this way we correlate the source of deep pain to a particular depth and area, demonstrating that iFU can be used to non-invasively stimulate and thereby localize and diagnose deep pain. In the future, iFU will be coupled with imaging ultrasound and used in similar fashion on humans with undiagnosed pain problems to better localize and diagnose their pain.

Adapting Seagliders to Autonomously Record and Monitor Marine Mammal Acoustics

Mariah Gentry, Freshman, Applied Physics
Mentor: Neil Bogue, Applied Physics Laboratory

Seagliders are autonomous underwater vehicles that collect a wide range of data, including salinity and temperature. Seagliders provide the optimum environment for attaching acoustic monitoring devices, as the gliders are quiet when underway with no external devices. The goal of Passive Acoustic Autonomous Monitoring, PAAM, is to create an attachable device with accompanying software to record the sounds of Beaked Whales with a testing emphasis on the Orca. The equipment must be autonomous, low powered, and able to record at high sample rates, as the Seagliders are out at sea for extensive testing. A preliminary board has already been configured for the Seaglider and experimentation has begun. A digital sound library allows bench testing in preparation for field studies. Based on early stage results, the board successfully records sound and can deliver back to a base station computer during lab testing. The ability to monitor Beaked Whales will help researches understand the vocalizations and behavior patterns that are unique to marine mammals. Utilization of the study could also aid in giving early warning to naval operations of whale proximity. The PAAM project will continue with bench testing, showing field test results, and producing recordings. The employment of the autonomous recording and monitoring device will open the doors for future research, allowing Seagliders to act as true vehicles of multi-disciplinary study.

Thermal Breakdown of Boulders Due to Stresses Induced by the Sun

Kari Nursheina Hankins, Freshman, Physics and Engineering
Mentor: Bernard Hallet, Earth and Space Sciences
Mentor: Peter Mackenzie, Civil and Environmental Engineering

Despite nearly a century of debate over the efficacy of solar heating on cracking rocks, insulation has recently been recognized as the likely cause of non-tectonic rock fractures in a variety of environments. The mechanism(s) by which heating and cooling of rocks could result in fracture are still strongly debated, but no study has attempted to quantify the state of stress due to surface heating and cooling associated with recurrent solar exposure. Thus, we want to understand the fundamental physics of, and thermal/moisture conditions required for, cracks to form in rocks due to re-current exposure to the sun. The complementary numerical simulation of the 3-D state of stress and crack growth in exposed rocks will significantly contribute to future studies of mechanical weathering and landscape evolution. We believe that directional solar heating can induce stresses in boulders sufficient to induce cracks and subsequent mechanical breakdown. Moreover, the earth's rotation and the related changing insulation are responsible for the observed directional preference of cracks. To test our hypothesis, we analyze a series of representative boulders of different size and shape for thermal stresses using a coupled thermo-mechanical numeric modeling based on the Finite Element Method. We anticipate that depending on the size of the boulder, thermal stresses can only occur near the surface (large boulders), on the surface or interior (medium), or not at all (pebbles). Furthermore, depending on the shape of the boulder, there will be a north-south orientation of cracks (spherical boulders), or orientation originating from directed insulation or the specific shape of the boulder (elongated). Our numerical results promise to help understand processes and rates of rock fracturing that control rock breakdown, sediment production, and landscape evolution not only on earth, but also on the Moon and Mars. Finally, directional heating is an unexplored mechanism for the degradation of stone and cement structures and monuments. Hence, this project has potential to pave the way to a productive line of applied, interdisciplinary research on solar-degradation of man-made structures.

Quantum Effects in Photosynthesis

Jennifer Hanson, Senior, Computer Science and Engineering and Chemistry
Mentor: Dave Bacon, Computer Science and Engineering and Physics

Quantum theory determines the structure of the Periodic Table of elements and the nature of the covalent chemical bond, but how important are quantum effects in the world of biology? Recently evidence of strong quantum-like behavior has been experimentally observed in the Fenna-Matthews-Olson (FMO) protein complex, which is partially responsible for energy transfer during photosynthesis. Theoretical studies suggest that this quantum effect, called quantum coherence, is responsible for an increase in the efficiency of the energy transfer through the FMO complex. Understanding how biology can extract energy from light with such great efficiency is of vital importance and carries great societal impact, such as in the development of highly efficient solar cells. The theory that efficiency depends on quantum effects suggests that quantum mechanics will play an important role in building better devices for harvesting energy from light. Our research asks: How will adding new, quantum coherent terms to the energy transfer efficiency equations in the FMO complex affect efficiency? Our research utilizes an approach devised from methods used by the quantum computing community. In particular we are exploring an approach involving quantum random walks. These walks allow us to study energy transfer in the purely classical protein complex but now in the presence of the phonon bath dephasing, trapping, and exciton loss, all of which destroy quantum coherence. The research

involves determining the relevant equations of motion in the Lindblad master equation form with the extra terms corresponding to external quantum coherent stimulation. We will then integrate these master equations using QSD, a set of C++ libraries developed for studying quantum trajectories. The end result will be a simulation application with the capability to test different hypothesis about the effect of coherent stimulation in the FMO complex, a result which could then lead to suggestion of novel experiments on these systems.

Analyzing Properties of the Saturnian Satellite Phoebe Using Spectroscopic Data from the Cassini Orbiter

Emily Hollenbeck, Junior, Pre-Engineering
Mentor: Gary Hansen, Earth and Space Science

The study of neighboring planets can lend additional insight into our solar system's history and properties, a general goal of the currently active Cassini Mission that has been collecting data about the Saturnian system since 2004. Our efforts in processing this data concentrate on Phoebe, a Saturnian moon of particular interest due to its distinctive features. Phoebe is a very dark object, and travels in a retrograde (opposite) orbit, characteristics contrary to the dozens of other moons around Saturn. These irregularities suggest Phoebe is a captured object, trapped by Saturn's gravitational pull, possibly originating from the Kuiper Belt of the outer solar system. As the Kuiper Belt contains remnants from the Solar System's formation, studying Phoebe provides the opportunity to gain knowledge about a possibly primordial object. The particular data we are using to study Phoebe comes from the Visual and Infrared Mapping Spectrometer (VIMS) aboard the Cassini Orbiter. This instrument records spectroscopic information in data "cubes," with two dimensions of the data corresponding to the layout of the object, and the third dimension corresponding to its reflectance at different wavelengths in the electromagnetic spectrum between 0.35 and 5.2 microns. Processing this data includes calibration, interpolation, and averaging to smooth the noise in the spectrum, and water ice modeling, assuming a liner relationship between the spectrum of completely dark areas (organics and other materials) and bright areas (water ice). One overall goal of this process is to produce a map of water ice grain size and location on Phoebe, as this can provide knowledge about its history and physical composition. Over time, Phoebe has been hit by objects that leave craters in the dark materials coating its surface, exposing a mixture of rock and water ice below. Therefore, understanding the location and amount of water ice on Phoebe allows assumptions to be made about the history of these collisions and what materials lie underneath. Additionally, knowledge about grain size lends insight into previous thermal processes and impacts. The amount of water ice on Phoebe's surface is expected to be small due to information from previous models at lower resolutions, while our higher resolution models are expected to provide more detailed information. Eventually, we hope to also map the CO_2 on Phoebe to gain more information about this unique object possibly original to the formation of the solar system.

Computational Study of Nonlinear Optic Phenylpolyene-based Chromophores

Jane Hung, Sophomore, Chemistry and Mathematics
Mentor: Xiaosong Li, Chemistry

Highly efficient nonlinear optic (NLO) chromophores may be developed as material for electro-optic devices and nanotechnology. Chromophore efficiency improves with the increase of the

second-order polarizability (□). We use computational methods to study the effect on □ of electron donating and electron accepting groups substituted on phenylpolyene-based donor—□-conjugation bridge—acceptor chromophores. Several accepting groups (SCH3, O=CCH3, CN) and donating groups (OCH3, ???) were investigated on different positions along the conjugation bridge. It has been found that □ increases for accepting groups close to the donor end of the chromophore and, to a lesser extent, for donating groups close to the accepting end. The largest □ values are shown to be due to relatively large dipole moment changes. We are further researching more deeply the causes behind large □ values.

The Effect of Fiber Orientation on the Fracture Toughness and Failure Mode of Composite Bonded Joints

Kelsi Hurley, Senior, Materials Science and Engineering
Mentor: Brian Flinn, Materials Science and Engineering

Composites are advantageous for use in high performance applications because of their superior strength to weight ratios. Lighter, high-strength components contribute to higher fuel efficiencies for aerospace vehicles and are also very desirable for structural applications. Continuous components are preferred; however, part size and geometry often prevent such parts from being manufactured. Mechanical fastening is likely to damage composite substrates, thus it is important to adhesively bond these materials. Bond quality is often assessed using fracture toughness, with a large fracture toughness value being indicative of high bond quality. For predictability, it is also desirable to create bonded joints in which failure occurs entirely within the adhesive, rather than at the laminate-adhesive interface or within the laminate itself. The behavior of unidirectional fiber composites is fairly well understood; however, most applications involve complex loading conditions that require composites with multiple fiber orientations. The purpose of this project was to determine the effect of fiber orientation on the mode I fracture toughness and the failure mode of carbon fiber reinforced plastic (CFRP) composites comprised of weaved preimpregnated lamina (prepreg). This was accomplished by testing double cantilever beam (DCB) specimens laid up with varying fiber orientations. Interlaminar fracture toughness was determined by testing specimens with no adhesive, while the fracture toughness of bonded specimens was determined by testing identical laminates secondarily bonded with film adhesive. Scanning electron microscope (SEM) fractography was used to determine the mode of failure that occurred in the bonded specimens.

Making the OneBusAway Transit Tool for the Android Phone Accessible for Blind and Deaf-Blind People

William Johnson, Junior, Computer Science
Mentor: Richard Ladner, Computer Science and Engineering

In recent years, the mobile phone has become a powerful and versatile platform for computing. An iPhone or Android phone now has all the capabilities of a telephone, web-browser, camera, GPS device, mp3 player, and compass. The MobileAccessibility project aims to use these capabilities, coupled with online web-services, to create mobile applications that are usable and useful for blind, deaf-blind, and low-vision users. At present, a number of mobile assistive devices for blind people exist, and our goal is to replace most of these with a single multi-purpose

mobile phone. The current work focuses on developing a blind- and deaf-blind-accessible version of OneBusAway, a tool developed at the UW that provides real-time bus arrival times and other useful information for the King County Metro transit system. OneBusAway exists in several forms: an online website, a dial-in telephone service, and applications for iPhone, Nokia, and Android mobile phones. I implement an accessible version of the application for the Android phone, a free open-source platform for mobile devices spearheaded by Google. We factor in input from blind and deaf-blind users about the usability of mobile phones and the transit system in general, and the various versions of OneBusAway specifically, as well as specific methods for communication with the user, such as large print, synthesized speech, alert sounds, and vibration patterns for output, and touchscreen gestures, accelerometer-based gestures, and the keyboard for user input. A fully accessible version of OneBusAway will enable disabled people to use the King County transit system seamlessly, especially if accessibility is factored into further work to integrate OneBusAway with Transit's existing tools. Furthermore, the successful creation of a complex, useful, accessible application for Android demonstrates the potential for further work in MobileAccessibility, and the results of usability studies will provide useful guidelines for further accessible mobile applications.

Dietary Curcumin as a Neuroprotective Agent
Derek Khorsand, Senior, Biochemistry
Mentor: Leo Pallanck, Genome Sciences

Neurodegenerative disorders affect over 50 million Americans every year. Although their prevalence might suggest otherwise, most of the nearly 600 cataloged neurodegenerative disorders are poorly understood. Currently, studies have implicated curcumin, the main component in the spice turmeric, as a possible treatment for several illnesses, including Alzheimer's disease. In this study, we investigate the effects of dietary curcumin on *drosophila melanogaster* models of both Alzheimer's disease (AD) and Parkinson's disease (PD). Both models are analyzed for phenotype rescue; AD progression is quantified by assessing the longevity defect noted in amyloid-beta Alzheimer's drosophila models, while PD development is analyzed for both the longevity defect and climbing defect. The detection of a possible neuroprotective effect in curcumin could lead to its use in a potential therapeutic treatment for both Alzheimer's and Parkinson's disease.

Interpolating Ice Layer Data from Mars in Order to Investigate the Possibility of Past Earth-like Ice Flow.
Benjamin King, Junior, Earth and Space Science
Mentor: Dale Winebrenner, Applied Physics Laboratory: Earth and Space Sciences

While ice on Mars has been the focus of much academic interest, little is known about its formation and behaviors. By analyzing the layers in the ice, scientists can compare it to ice here on Earth. The objective of this project is to ascertain whether Martian ice has or has not flowed in a manner like that of glaciers on Earth.The area of focus is Gemina Lingula, a lobe of ice attached to the northern polar ice cap of Mars at roughly 0° east, also known as the Titania Lobe. The surface topography of Gemina Lingula fits current ice flow models surprisingly well, but that alone is not enough to confirm ice flow. In order to confirm the flow or lack of flow in the ice,

data tracks are needed that run at least 45° off from the placement of most available data tracks. Such data can be inferred from a three-dimensional model of the layers. By interpolating Shallow Radar (SHARAD) data tracks obtained from the Planetary Data System (PDS) to form such a three-dimensional model of the layers, we can supplement the few tracks of data that already align with current putative flow lines. The englacial stratigraphy of Gemina Lingula will be compared to radar data from terrestrial glaciers in order to determine the possible differences and similarities between the characteristics of terrestrial and Martian ice.

Tracing Radar Layers in Ice on Mars to Seek Evidence for Past Ice Flow

Ryan Knott, Sophomore, Earth and Space Sciences
Mentor: Dale Winebrenner, Applied Physics Laboratory: Earth and Space Sciences

Since the discovery of water ice in the Martian North Polar Layered Deposit (NPLD), investigations have been undertaken to better understand the history of Mars' ice caps. One of the current investigations involves the use of ice-penetrating radar that can identify layers within the ice. With the data from NASA's Shallow Radar (SHARAD) instrument on the Mars Reconnaissance Orbiter (MRO), layers in the ice of the NPLD can be identified and followed to other locations in the NPLD. The principle section of the NPLD being considered for past ice flow is Gemina Lingula (also known as Titania Lobe), which bears a significant resemblance to glaciers on Earth. By following the layers in the ice of Titania Lobe along lines of apparent past ice flows discovered from past research, evidence can be gained to explore the hypothesis that Mars at some time in the past had glaciers that flowed like those on Earth. The tracing process involves gathering data from the Planetary Data System (PDS) and using the computer software MATLAB to follow the ice layers from one point on the lobe to another. The data from the ice traces provide information about how the NPLD developed and further our understanding about Mars' past climate in general. With greater knowledge about Mars' past climate and the formation of the ice layers in the NPLD, scientists can compare the differences in the histories of large bodies of ice on Earth and on Mars.

Nest Characteristics and Size Heritability between Parent and Offspring Magellanic Penguins (*Spheniscus Magellanicus*)

Laura Koehn, Junior, Biology (Ecology, Evolution, and Conservation) and ACMS
Mentor: P. Dee Boersma, Biology

Fitness is a measure of both reproductive success and survival of offspring. Although difficult to measure, fitness has components that can be quantified such as breeding location and physical traits. Size should be an important fitness parameter, so we are examining the heritability of bill and flipper size between parent Magellanic penguins (*Spheniscus magellanicus*) and their offspring. We are also determining the distance the offspring settles from the natal nest (parent nest). We predict that males are more likely to recruit close to parents because having a nest site is an important determinant of male reproductive success while females can always find a male with a nest in this population where breeding males outnumber breeding females. Using a database of over 56,000 Magellanic penguins banded in Punta Tombo, Argentina since 1983, we have approximately 7,300 parent-chick pairs. From those 7,300 pairs, 329 offspring have been re-sighted as adults. We have 10 grandparent-parent-adult offspring genealogies. Magellanic

penguins reach breeding age at 4 to 14 years of age and can live more than 25 years in the wild so having 10 genealogies of 3 generations is impressive. Of the 329 chicks that were seen as adults in the colony, 85 were breeding in nests. We examined the distances males and females bred from their natal nest. The mean distance for female nests from their natal nests was 221.5 meters (s = 277.8 m, n = 20) and the mean distance for male nests from their natal nests was 129.7 meters (s = 218.1 m, n = 34). Log transforming the individual distances, a two-tailed *t*-test (t = 2.0, P = 0.08, n = 54) showed males and females settled at similar distances from where they hatched. As we probe how these penguins with their relatives differ in size and location from the rest of the population and other questions about what makes them successful, we gain insight into what makes a penguin fit.

Synthesis, Characterization, and Reactivity of Rhodium(I) Catalysts for the Hydrogenation of 5-hydroxyfurfural (HMF)

Elizabeth Korsmo, senior, Chemistry
Mentor: Karen Goldberg, Chemistry
Mentor: Abby O'Connor, Chemistry

Sustainable replacements for petroleum products remain an elusive goal for researchers. One promising route towards renewable production of fuels and chemicals utilizes 5-hydroxymethylfurfural (HMF) as a precursor for these sought-after products because HMF can be synthesized from fructose and, more recently, glucose, which are renewable resources. Catalysts, agents which facilitate reactions but are not themselves consumed in the reactions, play important roles in many steps of these processes. Catalysts can drive reactions towards desired products or facilitate reactions such that they may be carried out under milder conditions (lower temperatures and pressures) than is otherwise possible. An avenue being explored by members of the Goldberg group involves the hydrogenation of HMF by rhodium catalysts. These catalysts are of the form $Rh(R_2)(R')_2$, where R_2 is a bidentate ligand such as 1,5-cyclooctadiene (COD) or acetylacetone (acac) and R' is a bulky phenyl phosphine. My work, has focused on synthesizing $(acac)Rh(PPh_3)_2$, a homogeneous catalyst, and examining the reactivity of this complex with H_2O, H_2, and other molecules in order to better understand the manner in which the catalyst functions during hydrogenation. A new focus of this project is to use a heterogeneous rhodium catalyst for the hydrogenation of HMF. We plan to support the $(acac)Rh(R_2')_2$ complex to silica by tethering the complex through a siloxy linkage on the phosphine ligand. The synthesis of the siloxy derivative 2 and initial reactivity studies will be described .

Expression and Function of Cone Pigment Genes Using Knock-in/Knock-out Mice

Leah Landsem, Senior, Biochemistry
Mentor: Maureen Neitz, Opthamology

A variant of the human red cone photopigment, termed LVAVA, is associated with an extreme form of nearsightedness and with cone-rod dystrophy. Genetically engineered mice in which the endogenous mouse green cone photopigment gene was replaced by either the human LVAVA variant, or a control normal human red pigment gene (termed LIAIS) were created in order to test the hypothesis that the LVAVA variant causes abnormalities in cone photoreceptor structure and function. Histological analysis was performed on 3-month-old mice with the LVAVA variant and

the LIAS variant. Cone function in both lines of mice was evaluated using the electroretinogram (ERG). Mice express two different photopigments in most of their cones, a UV-sensitive pigment and, in the engineered mice, the LIAIS or LVAVA variant. In contrast, humans express only one per cone. To avoid potential problems of interpretation stemming from coexpression, the LVAVA and LIAIS lines of mice were bred to a UV-pigment knockout line to generate mice that have only the human red cone LVAVA variant or only the LIAIS variant. The polymerase chain reaction was used to genotype mice to identify mice that lack the UV photopigment gene and the endogenous mouse green cone photopigment gene, and that have the human LVAVA red pigment gene variant. Preliminary results suggest that at 3 months of age, there is no detectable difference in the morphology of the cone photoreceptors in the LIAIS control versus LVAVA mice; however, the electroretinogram shows diminished function for the LVAVA cones compared to the LIAIS cones. Mice with genotypes indicating that they have a UV-pigment knockout and the LVAVA red pigment variant have been identified. In future experiments, histological analysis and ERGs will be performed on these mice and compared to results of the LIAIS variant in mice that lack the UV pigment gene.

Damage Resistance of Carbon Composites

Natalie Larson, Freshman, Aeronautics and Astronautics
Mentor: Paolo Feraboli, Aeronautics and Astronautics

As engineering with advanced composite materials has become more commonplace and cost effective in today's aerospace and automotive industries, the damage resistance of such materials has become of greater concern. Such damage consists of lightning strikes, compression, and shear forces on the composite. A typical aircraft made of aluminum, a highly conductive single-layered material, behaves differently in extreme conditions (lightning, impact forces) than the newly developing structures made of carbon composites, multilayered materials with low conductivity. The research is aimed at investigating the damage resistance of carbon composites under lightning, compression, and shear loads. To test the lightning strike behavior of the composite, the material is placed between the two electrodes of a 40kV capacitor and a simulated lightning arc is passed through the specimens as oscilloscopes record the current at different locations on the panel. The samples are then photographed, C-scanned for internal damages, and microscopically examined. To test the compression behavior of the composite, a panel of the material is placed in a fixture which is then put into the Instron tension/compression fatigue test frame. Force is exerted on the top edge of the panel until the material fails. The force at which the carbon composite fractures is recorded and the specimen is photographed and analyzed. To test the shear force behavior of the composite, a panel is placed in a fixture so that one end of the panel is in a fixed position while the opposite end of the panel is pulled upward by the Instron tension/compression fatigue test frame. The force at which the panel fails is recorded and the panel is photographed and analyzed for damage. Through the above tests, a stronger understanding of the damage resistance characteristics of carbon composites will be obtained.

Triggering and Development of the February 26, 2008 Auroral Intensification Event Using 3D Multi-Fluid Simulations

Tia Lerud, Senior, Applied and Computational Mathematical Science, Statistics
Mentor: Erika Harnett, Earth and Space Sciences

The effects of space weather can be disruptive and expensive since they can adversely affect satellites, astronauts, power supply networks, radio wave communications, and more. Harmful space weather presents itself as magnetic storms, on a large scale, and magnetic substorms, on the smaller scale. In this context, "substorm" refers to the process that leads to auroral intensification. The physics of both types of magnetic storms is not yet fully understood. The focus of this project is to understand the triggering mechanisms and development of magnetic substorms by using multi-fluid simulations to model a particularly interesting event on February 26, 2008, for which there is relevant satellite data taken by the "Time History of Events and Macroscale Interactions during Substorms" (THEMIS) satellite group. We expect that this project will provide further support for a paradigm that takes features from two competing models, the Near Earth Neutral Line (NENL) model and the Current Disruption (CD) model. This research will assist in developing a comprehensive model for the onset and progression of magnetic substorms which is a critical step toward bringing the space weather field to a point where reliable prediction is possible.

Ab Initio Ehrenfest Dynamics with Addition of a Magnetic-Dipole Perturbation to the Core Hamiltonian

Alex Lindsay, Senior, Chemical Engineering
Mentor: Xiaosong Li, Chemistry

With the development of laser technology in recent decades, photochemistry has emerged as an essential tool in synthetic chemistry. Using electromagnetic (EM) radiation, chemists access electronic states and subsequent synthetic pathways unavailable with thermal methods. As experimental capability has improved, prediction of molecular behavior in EM fields has become critical in divining synthetic directions. Until recently, these predictive methods considered only an electric-dipole perturbation to the core Hamiltonian. This approximation improves computational efficiency and is accurate insofar that the ratio between the electric-dipole perturbation and higher order interactions is of magnitude $a_0/\square << 1$. However, a more exact solution to the EM problem requires the inclusion of magnetic-dipole and electric-quadrupole terms. The goal of this project is to develop and incorporate magnetic field interactions into an efficient *ab initio* Ehrenfest dynamics routine. The routine (Li *et al.*, 2005, pg. 123) makes use of three increasingly small time-steps, which update the energy gradient, nuclear positions, and electron density respectively. The unitary transformation used to propagate the density matrix is computed at the mid-point of each $\square t_e$ step, taking into account linear changes in both the electric and magnetic fields. Addition of the magnetic-dipole perturbation term will allow more accurate analysis of electronic transitions and construction of potential energy surfaces (PES) in various model systems. In turn, the increased understanding of molecular excitations will give experimentalists support in efforts to selectively cleave bonds and control synthetic pathways via electromagnetic radiation.

New Oxide Nanomaterials for Spintronics and Solar Catalysis

Brittney Livingston, Senior, Chemistry
Mentor: Daniel Gamelin, Chemistry

Spintronics or spin-based electronics involves utilizing electron spin rather than charge in hopes of creating faster, smaller and better processing devices with decreased power consumption. The development of ferromagnetic semicondutors to create a spin-polarized current of electrons has recently gained interest because of the possibility of many potential applications in a variety of fields including spintronics and solar catalysis. These diluted magnetic semiconductor quantum dots (DMS-QDs) show promise for making spintronics a reality, but future technologies hinder on overcoming the difficulty of creating room temperature ferromagnetism and increasing the electron spin dephasing time. Of particular interest to this project is determining and understanding the effect that the variation of concentration of several transition metal dopants will have on the semiconductor. Previous research has shown promise using TM^{2+} dopants in colloidal ZnO nanoparticles will make this a viable source for creating DMS-QDs. This project first involves the synthesis of TM^{2+} doped ZnO nanoparticles by the hydrolysis and condensation of a zinc acetate solution in dimethylsulfoxide (DMSO). Secondly this project focuses on the analysis of synthesized DMS-QDs through various forms of spectroscopy and magnetism such as absorption spectroscopy and electron paramagnetic resonance (EPR). A number of DMS-QDs have been created through the successful synthesis of doped ZnO nanoparticles where the dopant has included Mg, Mn and Cd at varied concentration levels. Once synthetic and analytical techniques are perfected this project will help contribute to making spintronics a possibility, with future applications in processing devices, quantum computing and solar catalysis.

Diagnosing Problems of an Agitation Platform for Self-Assembly Systems

Michael Lunceford, Freshman, Electrical Engineering
Mentor: Karl Bohringer, Electrical Engineering

Designing a self-assembly system that will not require a robotic gripper to place parts individually would result in a more efficient means of assembling small parts, such as microstructures or biomedical implants. Such a system would be for use in the Micro Electro Mechanical Systems (MEMS) lab, where microscopic devices are built with tools and techniques derived from the microelectronics industry. A few years ago, a platform was designed by students working with Professor Bohringer in the lab to agitate microcomponents in a controlled way by vibrating in 3 different directions. This system would cause parts to move until falling into slots on a substrate placed on the platform. The vibration of the platform is caused by using Piezo Actuators, components that vibrate at a specific frequency and amplitude, of which there was one for each direction. These actuators are controlled by an electric signal, originally from a function generator, which has been amplified. After being used a few times, the platform malfunctioned. The purpose of the current research is to test aspects of its design that could be the source of the problem. Once the platform is functional, we will provide a summary with instructions on its use, as well as a Labview interface to facilitate its use. Part of this process has entailed reading previous documentation and contacting the students that designed the “shaker table” to clarify discrepancies between the original design and the actual product. In the lab, components of the platform will be tested to determine whether or not they are performing accurately. After the platform appears to be moving correctly, the sensors will be checked. If they are giving an incorrect reading, they will be replaced, so the platform can be controlled using a program outlined in a Labview interface. Ultimately, once these sensors are operational, the platform should be fully functional for use in MEMS experiments.

Correlating Cell Growth and Naproxen Degradation with Microorganisms Capable of Degrading Naproxen in Wastewater

Wayne McNeal Jr., Senior, Civil and Environmental Engineering
Mentor: John Ferguson, Civil and Environmental Engineering

Trace-level contaminants originating from pharmaceuticals and personal care products (PPCP) represent a new class of contaminants which are suspected to cause adverse impacts to aquatic life. These compounds often enter aquatic systems through sewers systems and wastewater treatment plants. The identification of organisms capable of degrading PPCP will contribute greatly to the design and implementation of new processes for the removal of PPCP during wastewater treatment. Naproxen is one of many PPCP that are studied. Activated sludge from West Point Wastewater Treatment Plant was enriched for microorganisms capable of degrading Naproxen. These enrichments were transferred and isolated while Naproxen degradation was monitored. Enrichments showing active degradation will be plated on solid defined media, and colonies capable of degrading Naproxen will be selected. These colonies will be identified using DNA sequencing. On-going work will include monitoring growth of biomass while monitoring degradation and various starting concentrations of Naproxen for degradation.

Collaborative Webtools for Astronomers

Katherine Mitchell, Sophomore, Computer Engineering
Mentor: Jeffrey Gardner, Physics

Theorists in the field of astronomy rely on several different types of sky data in vast quantities in order to hypothesize about the nature of our universe, its formation, its fate, and so forth. To facilitate the formation of these ideas, our project aims to develop a web widget that processes publicly available astronomical data into a tool that images several views of the sky. The possible views would include those of star locations, infrared rays, x-rays, and other astronomical elements. The widget will utilize technology similar to that of Google Earth. An important aspect of this project, in addition to development of this imaging technology, is to formulate a scheme for two or more users on different computers to be able to use the tool collaboratively. Upon completion, the technology we are developing will be easily generalizable to other fields, as it is essentially just a tool that reads scientific data and produces an image based on it; this could be utilized by any discipline of science in which observational data is difficult to visualize.

Thermal Conductivity of Martian Soil Analogue

Joseph A Moody, Junior, Physics
Mentor: Stephen Wood, Earth and Space Sciences

Previous research (Wood and Griffiths, 2007) has demonstrated that the collapse of the Martian atmosphere during periods of low obliquity can lead to subsurface warming. This warming is caused by lowered thermal conductivity of porous regolith at low (Martian) pressures, effectively blocking geothermal heat flux and resulting in the rise of subsurface temperatures. This temperature rise could result in periods of liquid water at depths close to the surface. Previous measurements of Martian soil analog (glass beads of varying sizes) have been undertaken; however, the data is sparse and has the largest uncertainty at the pressures expected during low obliquity (< 100 Pa). A vacuum chamber capable of achieving a medium vacuum will be used to

make the needed measurements; pumping will be provided by both a diaphragm pump and a turbo molecular pump. Glass beads will be placed in a Teflon sample cup with outer dimensions of 20 mm by 40 mm by 15 mm, with a half cylinder volume (positioned lengthwise) removed for the sample. A 40 AWG platinum wire will be run through the length of the sample and connected to a constant current source. Monitoring the resistance will enable measurement of temperature changes thus allowing for thermal conductivity values to be obtained as a function of pressure and particle size. In addition, for similar measurements to be made under low temperatures and with the presence of ice, a separate sample cup system will be designed for larger samples to be used in the Mars Atmospheric Chamber at the University of Washington, Seattle.

The Effect of Carbon Dioxide and Bicarbonate on Algal Growth and Lipid Production for Use in Biofuels

Matthew Munch, Senior, Biochemistry
Mentor: Rose Ann Cattolico, Biology

Due to the increasing demand for clean, alternative fuel sources, considerable attention has been shifted toward algae biofuels. Algae biofuels have many advantages over crop based biofuels, such as a large increase in oil produced per acre and the wide range of environments and water conditions in which algae can grow. Competition between crops grown for food and crops grown for fuel is also eliminated. In order to make biofuels from algae commercially viable, the algae must be grown quickly while also containing a large percentage of lipids. It has been shown in many species of algae that supplementation with carbon dioxide can lead to increased growth and biomass production due to its major role in photosynthesis. We are investigating the effect of carbon dioxide on the growth and lipid production of a particular strain of alga selected for its high lipid content. Algae were grown in flasks under constant conditions while various amounts of CO_2 were introduced into the growth medium. CO_2 gas was bubbled into the media at specific intervals during the course of the experiment while in some flasks, sodium bicarbonate was used as a potential CO_2 source. Growth was monitored over the course of an experiment and cell samples were taken, frozen, and prepared for lipid analysis using gas chromatography/mass spectrometry. We hypothesized that increased growth and lipid production would occur with the introduction of additional amounts of CO_2.

Heavy Ion Plasma Magnetic and Atmospheric Interactions between Saturn and Titan

Theodore Newell, Junior, Electrical Engineering
Mentor: Erika Harnett, Earth and Space Sciences
Mentor: Darci Snowden, Earth and Space Sciences

Titan, the largest moon of Saturn, features an atmosphere similar enough to that of prehistoric Earth to yield useful astrobiological comparisons between the two solar bodies. Titan has an orbit that places it near the magnetopause of Saturn, which is the boundary between the magnetosphere (where the magnetic field of Saturn is the prevalent magnetic force) and the Interplanetary Magnetic Field (IMF). This orbital location may affect both the shape of Saturn's magnetopause and the loss rate of the thick atmosphere of Titan during increased solar wind pressure. A three-dimensional multi-fluid simulation of the ionized plasmas around Saturn is run with and without

Titan on the dayside of Saturn during a pulse of higher-pressure solar wind and IMF. The simulation data is visualized to allow comparisons of the magnetic field and the velocities, densities, and temperatures of the three major ion plasma groups around Titan and Saturn. Analysis focuses on the heavy ion plasmas from Titan accumulating near the magnetopause. The results are expected to indicate that Titan loses enough heavy ions in these conditions to decrease the impact of the IMF and solar wind on Saturn. It will be shown that this reduced impact is the result of the heavy ion plasmas corotating with Saturn and counteracting the compression of the magnetosphere by the increased IMF and solar wind. The effect of this interaction on the atmosphere of Titan will show an ion loss rate large enough to have significantly altered its atmosphere throughout the multibillion-year lifespan of Titan to date. Understanding the effect of Titan on the magnetosphere of Saturn will provide important information about the moon-planet interaction, and can be compared with measured data from the Cassini probe now orbiting Saturn. The determined loss rate of Titan's atmosphere will allow a more meaningful comparison with the atmosphere of Earth.

Investigating the Optimal Distribution of Feedback Controls in Biochemical Networks

Bennett Ng, Sophomore, Bioengineering
Mentor: Herbert Sauro, Bioengineering

Biochemical networks can be described in terms of their elementary chemical reactions. Modeling of the specific reaction mechanisms within a given network allows us to predict and analyze how the network will respond to changing conditions. This knowledge can lead to finer manipulation of biochemical networks. From a biochemical industry perspective, this could translate to increased production rates of products such as biofuels, while from a research perspective this could expose primary targets for inhibition or promotion of malignant or benevolent networks, respectively. Biochemical networks are configured with feedback controls which allow them to respond to external fluctuations (such as increased output demand). These controls function by suppressing or enhancing enzyme activities, thereby regulating a specific reaction rate. Neighboring reactions will adjust to compensate for the altered flux, until the network reaches a new steady state. In networks of any significant complexity, it is difficult to pinpoint the influence of any one feedback control on the network as a whole. The aim of this project is to analyze the network flux influence of specific feedback controls, and determine which control has the greatest flux influence in various biochemical networks. Our methods involve the use of the roadRunner biochemical network simulation library (sysBio, Seattle, WA). We will be using the library to analyze a large sample (20,000+) of instances of specific biochemical networks. Each instance will feature randomized chemical rate constants for each reaction in the network, with a fixed overall network equilibrium constant. We will simulate each network and record the flux control coefficients (sensitivities) of each reaction in the network. We will then compile our results and analyze the distribution of flux control coefficients vs. reaction. This will allow us to pinpoint which reaction(s) in a network exhibit the greatest influence on overall network flux.

Examining K-12 Teacher Understanding of Limits in the Context of Kinematics

Alexis Olsho, Senior, Physics
Mentor: Peter Shaffer, Physics

The Physics Education Group (PEG) in the Physics Department at the University of Washington is involved in research, curriculum development, and instruction aimed at improving student learning in physics. Part of the work involves helping prepare K-12 teachers of physics and physical science. To this end, the group is developing an inquiry-based curriculum, *Physics by Inquiry (PbI)*, designed to strengthen subject matter background in physics and physical science. This summer, I will be working in the 2009 NSF Summer Institute for Inservice Teachers, an intensive 5-week program for K-12 teachers that uses the *PbI* curriculum. I am investigating participant conceptual understanding of mathematical limits primarily in the context of kinematics; other contexts may include electric circuits, geometric optics, and properties of matter. The project includes a detailed examination of pretests from previous summers. These have indicated that many K-12 teachers are unable to use limiting procedures when presented with information in non-graphical form. Using pretests and post-tests administered to the 2009 participants, as well as post-tests from previous years, we hope to gain insight into participant understanding both before and after the Summer Institute. An in-depth analysis of participant responses throughout the summer will help assess the effectiveness of the *PbI* curriculum in kinematics in general, with a particular focus on the teaching of limit concepts in the context of velocity and acceleration. A detailed analysis of the prevalence of various types of errors will give us deeper understanding of the difficulties that participants face when learning the material, guide the further development curriculum, and contribute to the existing research base on the subject.

The Modeling of Varying Astrophysical Phenomena with Related Computer Simulations: The Case of HD209458

Julian Picard, Freshman, Earth and Space Sciences
Mentor: Erika Harnett, Earth and Space Sciences

With the recent increases in computing power, the field of space physics has been able to greatly increase the rate at which information can be collected about a given system. Computer simulations of astrophysical phenomena can collect both a deeper level and wider scope of data than could direct observation with conventional telescopes and satellites. The intent of this project is to show that similar astronomical systems can be modeled by a common simulation. Two systems are to be explored using the related simulation program: Jupiter and its moon Io within the boundaries of our own solar system, and the system of star HD 209458 and its closely orbiting planet HD 209458b, “Osirius”, in the Pegasus constellation. While it would appear that the two situations differ vastly, they are in fact notably similar. Within each system, the ratio of the radius of the large body to the orbit radius of the small body reveals this similarity: The ratio within the extrasolar system is 0.11, and that of Jupiter and Io is 0.16. Using data collected by the Galileo satellite, enough is known to create a highly accurate model of Jupiter and Io. A model of the extrasolar system will be created using data gathered remotely about the star and planet, as well as properties that can be inferred because of the similarity between HD 209458 and the Sun. The first results are expected to show the validity of the simulation program for each of the two systems being examined.

Increasing the Power and Efficiency of a High Power Helicon (HPH) Plasma Thruster

Nathan Precup, Junior, Aeronautics & Astronautics
Mentor: Robert Winglee, Earth and Space Sciences

Improving the efficiency and power of experimental plasma thrusters brings the time closer when these thrusters are used on spacecraft as a primary means of propulsion, providing efficient thrust that far outperforms conventional chemical thrusters. It is therefore the goal of the Advanced Propulsion Lab to improve the performance of its High Power Helicon 2 (HPH2) thruster. Electromagnets are used to direct the plasma as it is propelled out of the thruster. The charged particles in the plasma travel along the field lines formed by these electromagnets. The objective is to create another electromagnetic nozzle for the HPH2 to channel the plasma into a tighter beam that travels farther downstream before diverging. A program was written with labview software to simulate magnetic fields based on the number of coil turns of the electromagnet, radius of the coil, and electric current flowing in the coil, and was used to simulate the properties of the electromagnets already used on the thruster. The program was also used to model the field after the addition of another nozzle, showing the effects of design changes before the nozzle is constructed. Based on the capabilities of a newly constructed power supply for the nozzle and data from the program, a nozzle will be designed to achieve a desired magnetic field strength. Installing the new electromagnetic nozzle farther downstream will encourage the plasma to continue in a straight path, improving the specific impulse of the thruster. Data will be collected to quantify the improvement after the nozzle is installed.

Optimizing the Passive Mechanical Properties of a Novel Microporous and Microchanneled Fibrin Scaffold for Cardiac Tissue Engineering

Gabrielle Robinson, Senior, Bioengineering
Mentor: Michael Regnier, Bioengineering

The increasing occurrence of cardiac damaging events in the United States has led to a dire need for new methods to regenerate wounded heart tissue. The surgical implantation of engineered tissue grown on cell delivery devices is one proposed method for cardiac repair. A promising example of one such device is the novel microporous and microchanneled fibrin scaffold being developed by the Heart and Muscle Mechanics Lab at the University of Washington. This scaffold has been shown to direct proper cardiomyocyte alignment and promote cell adhesion to the scaffold material. However, it has yet to be determined whether the scaffold can be engineered to have optimal mechanical properties for cardiac tissue engineering. It is our goal to optimize the passive mechanical properties of these fibrin scaffolds for this application by investigating parameters such as scaffold stiffness and rate of degradation. Because fibrin is a tunable polymer, slight variations in the way the scaffolds are constructed can affect their material properties. In order to determine which method of construction provides the most viable tissue engineering scaffolds, a selection of fibrin scaffolds are being made by varying parameters in the fibrin polymerization and scaffold preparation processes. The mechanical properties of these scaffolds are then assessed using stress-strain analysis, D-dimer assays to quantify fibrin degradation, and scanning electron microscopy techniques. Of the parameters being varied, the concentration of fibrinogen (fibrin monomer), the extent of fibrin cross-linking, and the length of acetone exposure are expected to have the greatest influence on the mechanical properties of the scaffolds. Both scaffold stiffness and degradation time are expected to increase with increases in these factors. Optimizing the passive mechanical properties of these fibrin scaffolds will further

the development of a novel scaffold for cardiac tissue engineering and help prepare them for use in future *in vitro* studies.

Studies Toward the Activation of C-H bonds with Pt(II) Complexes

Matthew J. Ruppel, Senior, Chemistry
Mentor: Karen I. Goldberg, Chemistry
Mentor: Kyle A. Grice, Chemistry

The carbon-hydrogen (C-H) chemical bond in alkanes is notable for its lack of reactivity, meaning many compounds, such as methane, have few useful chemical applications. Much research has been conducted towards functionalizing these compounds, thereby increasing their value for use in the chemical and energy industries by allowing for a low energy, low cost conversion of alkanes to basic chemicals. The study of transition metal catalysts has made great strides towards achieving this goal. In the 1970's, Alexander Shilov found that four-coordinate platinum(II) complexes were capable of activating and functionalizing methane into methanol in a process now known as the Shilov cycle. This cycle has three main steps: (1) The C-H bond is activated, broken by the Pt(II) complex, and the carbon is bound to the platinum center, followed by (2) the oxidation of platinum from Pt(II) to Pt(IV). Finally, (3) the platinum-carbon group is functionalized and released, regenerating the Pt(II) catalyst. This process is hampered by catalyst decomposition and use of an expensive Pt(IV) complex as an oxidant. Current studies in this field are working towards more stable catalysts for C-H activation. My work in conjunction with Kyle Grice, a graduate student in the Goldberg lab, is directed towards developing platinum complexes that can activate C-H bonds and be stable in the presence of oxidants. Towards this goal, I have conducted a series of reactions with a platinum complex containing a phosphorus-nitrogen ligand, similar to one studied by Kyle Grice, but with a nitrogen in the backbone in place of a carbon. Reaction information was obtained by ^{1}H and ^{31}P NMR experiments. These studies have revealed that my complex can activate C-H bonds when heated, chemistry which is not observed in the analogous carbon-containing complex. This underscores the participation of the ligand in this reaction. I have characterized the intermediates and products and this research will now focus on delineating this new route by which platinum complexes can activate C-H bonds.

Audio Augmentation of Tactile Images to Provide Greater Accessibility

Josh Scotland, Junior, Computer Science and Engineering
Mentor: Richard Ladner, Computer Science and Engineering

Tactile graphics are figures and diagrams designed to be accessible in a tactile form to blind students. Currently, there are two important issues associated with tactile images that must be resolved to further increase the accessibility of tactile images for all blind students. The first issue is the limitation on the amount of textual information that can be provided by tactile images. Due to the large size of Braille characters in comparison to the Roman characters we read, text from figures transcribed into Braille must often be shortened or even removed entirely before the tactile image can be finished. The second issue has to do with the percentage of blind students that are literate with Braille. Astoundingly, less than ten percent of the blind population in the United States can read Braille. Therefore, it is critical to design tactile images that are accessible by students that are not Braille literate. Both of the accessibility issues described can be resolved

through the employment of digital pens. Rather than being encoded to Braille, all textual information can be converted to audio using a text-to-speech program. The digital pen will play these audio files when a specific marker on the tactile graphic is tapped by the pen's tip. The marker will tell the pen's infrared camera which audio file to play using a Dot Positioning System in which each audio file is mapped to a unique dot pattern position. Consequently, having textual information in an audio format will allow for the complete removal of Braille from the tactile graphic. Not only can a greater amount of information be provided about a tactile image, but the audio format will give all blind students access to the image.

Application of Human Decision Making to Control Algorithms for Autonomous Underwater Vehicles

Alex Shuler, Sophomore, Aeronautics and Astronautics
Mentor: Kristi Morgansen, Aeronautics and Astronautics

Is it possible for computers to analyze and make a decision for a given dilemma like a human would? Autonomous vehicles will need to be able to predict a human's next move in order for human and autonomous vehicles to cooperate effectively in the future. Our research is studying the human decision making process at its basic level. The experiment (conducted by neuro and cognitive scientists at Princeton University) consisted of a human faced with a choice of A or B. Based on their choice, a reward was calculated from a function of the percentage of A chosen in the previous twenty questions. This reward is then relayed back to the participant for consideration of their next decision. The human is unaware of the method used to calculate the reward. The study was designed so the subjects had the least amount of information possible for their decisions. Six Different reward functions were used and our goal was to write an algorithm that can predict the human's next decision based on their past choices and the rewards they received because of those choices. So far, the human's way of decision making seems to vary significantly from one reward function to the other. Our hypothesis was that the human's choice would change only if the previous reward was less than that of the reward before it. This simple algorithm predicts the human's choice with some reward functions with only a 10% difference but is more than 50% incorrect with other reward functions. Our goal is to find an algorithm that can predict all of the human's choice with at least 85% accuracy. An algorithm that could mimic human decision making at a basic level can be applied to more complex situations where autonomous vehicles cooperate or even replace manned vehicles. One potential test bed for mixed teams of humans and robots is the autonomous vehicles in our lab. Our robotic fish will one day need to be able to decide and act on their own in environments like the Ocean where data communication is limited.

Designing and Implementing Flexible Shear and Pressure Sensor Arrays

John Thomson, Senior, Electrical Engineering
Mentor: Alexander Mamishev PhD, Electrical Engineering
Mentor: Kishore Sundara-Rajan, Electrical Engineering

Amputees often suffer from blisters and sores caused by their prosthetics. One of the causes of this problem lies in their residual limbs changing shape throughout the day, forming pressure points that didn't exist when the prosthetic was first fitted. This consequence of interfacing with a

dynamic system like a human limb results in the long term use of a prosthetic leading to discomfort and even infection. The purpose of our research was to develop a new flexible sensor capable of quantifying normal and lateral components of the interfacial forces between a residual limb and its prosthetic. Equipping doctors with this technology will provide an expanded understanding of the dynamics of this interface. Such understanding will allow researchers to design new prosthetics improving user comfort and enabling healthy prolonged use. The key concept of this technology involved the integration of non-flexible 1x1 cm^2 sensors into a grid attached to a flexible conductor substrate. These individual sensors were composed of a silicon elastomer sandwiched between two printed circuit boards. By evaluating the changes electrical field distribution between the printed plates on the two boards, normal and lateral forces applied on the individual sensor were measured. My contribution to the project focused on manufacturing process design and implementation. Working with Aaron Bestick, I have refined the methods used in fabrication while building new iterations of the sensor array for testing. Our goal for this project is to optimize and scale our sensor array. Our proof of concept goal is to build a large flexible grid, useful for gleaning information about foot pressure profiles. Such a sensor would provide useful information for diagnosing chronic foot problems such as those often seen with type 2 diabetics.

Creating and Characterizing a Functional Model for Superoxide Reductase

Justin Watson, Junior, Chemistry, Applied and Computational Math Sciences
Mentor: Julie A. Kovacs, Bioinorganic Chemistry

Superoxide is a cytotoxic species that is created as a byproduct of cellular respiration. Many organisms have evolved means of neutralizing superoxide, from Superoxide Reductase (SOR) in anaerobic and microaerophilic bacteria to Superoxide Dismutase in aerobic life forms. The goal of our research is to create and characterize a ligand system capable of mimicking the reactivity of SOR. Synthesizing a functional model for SOR will provide information about the features that define the enzymes. function. This area of study is of interest because SOR has structural similarities to cytochrome P450 (P450), a metalloenzyme found in the human body that is responsible for many metabolic functions. Understanding how the subtle structural and electronic differences between SOR and P450 influence reactivity will provide insight into what governs the different functions of these structurally similar enzymes. The structure of the ligand being created is based off of the structural and electronic properties of the amino acids binding to the iron center in the enzyme.s active site. We will be investigating how the structural and electronic properties of the ligand influences the reactivity of the model complex. Starting with propylene diamine, steric bulk will be provided to the ligand by the nucleophilic addition of two quinoline groups to one of the amino groups, while the other amine will be condensed with 3-mercapto-3-methyl-2-butanone to add a thiolate group to the ligand. The quinoline components, in addition to providing steric bulk, will mimic the aromatic histidine nitrogens bound to the iron in the enzyme; the thiol will imitate the presence of the cysteinate sulfur. When completed, the ligand will bind to the metal ion in five places, leaving a sixth site open for binding to superoxide. It is expected that the reduction of superoxide to hydrogen peroxide will occur at the available site, following a pathway similar to that of SOR. We hope to be able to find, isolate, and characterize any intermediates of this reaction pathway using crystallography and spectrophotometry.

Predicting Typhoon-Induced Cold Wake on the Western Pacific Ocean

Stephany Wei, Junior, Civil and Environmental Engineering
Mentor: Ren-Chieh Lien, Ocean Physics (OPD)

Every year, countries around the Western Pacific Ocean experience catastrophes from flooding, severe wind, and land slide as a result of the unexpected typhoons. Research on predicting the dynamics of typhoons is crucial to the welfare of a wide population. Cold Wake is a phenomenon of typhoon that describes the decrease of sea surface temperature (SST) caused by a typhoon passing and mixing the ocean water. Our goal is to measure cold wake response from typhoons that have passed and develop a system to predict properties of cold wakes and typhoons in the future. Properties include how much temperature would change across and along the typhoon path, how much time the ocean would take to recover from the temperature drop, the mechanism of the typhoon-ocean interaction, and the dynamics of the cold wake. We have developed programs using MATLAB to gather information of all the typhoons in the current year and previous years from databases archived in meteorology agencies. One of our programs produces animations that show the time evolution of the typhoon path, SST, SST anomaly, and typhoon intensity, which allow us to see cold wake pools appearing and disappearing next to a proceeding typhoon. For the cold wake spots shown in the animations, we are developing other MATLAB programs to analyze the time evolution of temperature drop along and across. We aim to understand the pattern of how the SST responds to typhoons and recovers, and the spatial structure and temporal evolution of oceanic response. Based on the analysis we will make later, we hope to develop a system to predict cold wake response caused by typhoons. From there, the first step of knowing more about the typhoons will be taken and more tragedies can be avoided in the future.

A Verification of Rapid Electrochemical Oxidation as a Method for Accelerated fuel Cell Aging

Grant Williamson Sophomore, Chemical Engineering
Mentors: Dan Schwartz, Joe Fairweather

Fuel cells offer a green power option for transportation and other mobile energy needs. They convert fuel to energy more efficiently than combustion, but removing water produced in the cell is critically important. Water build-up diminishes oxygen flow, reducing efficiency. This build-up increases with aging. We hypothesize that rapid electrochemical oxidation can accelerate this aging process, speeding up research on aging changes. This can be tested by comparing a sample that was rapidly electrochemically oxidized to one that was aged in a cell for two thousand hours, using cyclic voltammetry for surface group comparison and capillary pressure measurements for wetting comparison. Our procedure was dictated by limited material. The aged and fresh materials each had only one sample large enough to capillary pressure test and only four smaller samples. Comparing the capillary pressure measurements required equally oxidized samples. Since we only had one large fresh sample, we needed to find the correct oxidation voltage before oxidizing it. To do so, we oxidized the small fresh samples in 1 M H_2SO_4 at voltages of +1.2, 1.4 and 1.6 V vs. a standard hydrogen electrode for one week and then compared the small fresh samples to the small aged sample through cyclic voltammetry to see which voltage corresponded to normal aging. We oxidized the large fresh sample at that voltage and then compared the large samples through cyclic voltammetry and capillary pressure testing. We have preliminary results that indicate that each part of our procedure works separately. Our cyclic voltammetry shows the surface groups that are necessary to compare samples' oxidation levels. Also, after rapid

electrochemical oxidation of +1.2-1.6 volts, we have shown similar materials to absorb water, whereas before oxidation the water beaded. The capillary pressure measurements taken subsequently show that a +1.6 V weeklong oxidation causes the material to become much more hydrophilic. Eventually, our results will indicate whether rapid electrochemical oxidation creates the same changes in surface chemistry and wetting as normal aging.

Mapping Subsurface 'Hot Spots' on Mars Using THEMIS Thermal Infrared Radiance Data

Rebecca Wu, Sophomore, Astronomy
Mentor: Joshua Bandfield, Earth and Space Sciences

Liquid water cannot currently exist on the surface of Mars because of its low surface temperature and atmospheric pressure, but subsurface liquid water could exist near a location of subsurface volcanic or hydrothermal activity, creating an environment that might potentially house Martian life. Finding subsurface heat sources using solely surface temperature data is ineffective, though, because the diverse physical properties of the Martian surface make even nighttime temperatures highly variable. The Thermal Emission Imaging System (THEMIS) on the Mars Odyssey spacecraft, which measures the surface radiance at 9 different wavelengths in the infrared spectrum at a spatial sampling of 100 meters per pixel, can be used to better detect subsurface volcanic or hydrothermal heat sources. Because variation in temperature has different effects on the radiance values at different wavelengths, surfaces with a small contribution (<~1% surface area) of temperature irregularities can be more accurately detected by comparing the radiance values of each pixel at band 9 (12.57 microns) and band 4 (8.56 microns) with the values expected of an isothermal surface. Pixels of interest correspond to locations on the Martian surface that can be mapped using the Java Mission-planning and Analysis for Remote Sensing (JMARS) program in order to determine its local geological context, and are then further examined using high resolution visible images. Thus far, research of this sort has not detected any geothermal or hydrothermal activity, but this type of analysis can continue to be improved and used in order to search for locations of thermal anomalies as small as 10 meters across. This process can also be used to provide insight into more general Martian surface properties and geologic processes.

Using VLF Emissions to Study Lightning-Ionosphere Energy Coupling

Matt Yelin, Junior, Earth and Space Sciences
Mentor: Robert Holzworth, Earth and Space Sciences

Lightning is among the most powerful naturally occurring phenomena on Earth and can affect everything from spacecraft launches to phone calls. The goal of the World Wide Lightning Location Network (WWLLN) is to study and better understand lightning. A particular focus of the Network is the effect of lightning on the Earth's ionosphere, the upper level of Earth's atmosphere that has been ionized by the solar wind. The network is able to track when and where lightning strikes using an array of antennas around the world that pick up on the Very Low Frequency (VLF) emissions that lightning gives off when it strikes. Due to the very long wavelength of VLF emissions, relatively few antennas are needed to give adequate coverage of the entire globe. Currently roughly 40 antennas cover the entire world, and are able to detect about 10% of all strikes that occur globally. One of the main short term goals of the project is to

increase the detection efficiency of the network. The most straightforward and effective way of doing this is to simply deploy more antennas. In order for a strike to register, it must be detected by 5 separate stations, and there are a huge number of strikes that are only detected by 4 or less. Therefore, by simply setting up 10-15 more stations, in the right places, a huge gain in detection efficiency can be achieved. WWLLN data is also being used to develop models for how lightning strikes affect the ionosphere. Since it is the only worldwide network that gathers information in real time it is particularly useful for developing global models of lightning-ionosphere interactions. Most models developed up to this point have not had this kind of data to work with, so they are more based on the interactions involved with a single stroke of lightning. By increasing the detection efficiency and further improving our models, we hope to better understand lightning effects on the ionosphere and its potential consequences for our everyday lives.

Using Feedback Distortion to Improve Motor Rehabilitation

Ada Zhang, Senior, Bioengineering & Music
Mentor: Yoky Matsuoka, Department of Computer Science and Engineering
Mentor: Reinhold Scherer, Department of Computer Science and Engineering
Mentor: Sujata Pradhan, Department of Rehabilitation Medicine

In the United States, nearly 800,000 people suffer from stroke every year. Approximately 25% of these patients demonstrate learned nonuse: a tendency to use affected limbs below the level of the individual's true capability. As a result, rehabilitation therapies for these patients is often less effective. To overcome the psychological barriers experienced by such patients, we are exploring the use of visual feedback distortion. The principle behind visual feedback distortion can be summarized by, "what you see is not what you do." That is, the visual feedback a patient receives about his movement is distorted from reality through a virtual environment. Previous research has shown that individuals rely more on visual feedback than on kinesthetic feedback. Therefore, as patients follow the virtual visual cue, they may unknowingly exceed their self-imposed maximal capability by 20%. For patients to trust the visual representation, they must not notice the distortion. To prevent their discovery of the distortion, we are researching the minimal force and position distortion that can be reliably perceived by these patients. This value is called the Just Noticeable Difference (JND). Our lab is interested in improving rehabilitation for motor control of the hand. We are currently focusing on the movement of the index finger about the metacarpophalangeal (MCP) joint and a pinching motion between the index finger and thumb. Using MATLAB, we have created visual representations of the force and position of a haptic robot that is attached to a patient's finger. Preliminary results suggest that visual feedback distortion improves rehabilitation for patients with learned nonuse. To support these results, we plan to implement this setup in a hospital to increase sample size. Furthermore, by comparing the movement of these patients with that of healthy people, we aim to identify useful parameters to distort in order to reestablish normal movement.