Summer 2010 Undergraduate Research Symposium

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University of California, Merced

Undergraduate Research and Graduate Enrichment Programs:

UC Alliance for Graduate Education and the Professoriate (UC AGEP)

AGEP is a partnership among the 10 UC Campuses. Funded by NSF, the goal is to increase the number of underrepresented minority students who acquire doctoral degrees in the Science, Technology, Engineering and Math (STEM) fields and ultimately enter the professoriate.

UC Leadership Excellence through Advance Degrees (UC LEADS)

The UC LEADS Scholars Program, funded by UC's Office of the President, is designed to educate California's future leaders by preparing promising undergraduate students coming from underrepresented or disadvantaged backgrounds for advanced education in the STEM fields.

Scholar Name	Program	Major	Faculty Mentor
Mark Bailey	AGEP	Computer Science	Stefano Carpin
Jessica Clayton	AGEP	Physics	Sayantani Gosh
James Hernandez	AGEP	Applied Mathematics	Roummel Marcia
Brandi McKuin	AGEP	Environmental Engineering	Elliot Campbell
Damian Quintanilla	AGEP	Psychology	Michael Spivey
Farm Saechao	AGEP	Chemistry	Matt Meyer
Eva Vega	AGEP	Biological Sciences	Kara McCloskey
Jesse Anaya	LEADS	Environmental Engineering	Wei-Chun Chin
Adrian Garcia	LEADS	Mechanical Engineering	Carlos Coimbra
David Larson	LEADS	Mechanical Engineering	Carlos Coimbra
Josue Lopez	LEADS	Mechanical Engineering	Gerardo Diaz
Janna Rodriguez	LEADS	Mechanical Engineering	Carlos Coimbra
Grant Vousden-Dishington	LEADS	Computer Science	Stefano Carpin

2010 Research Symposium Abstracts

Solid Oxide Fuel Cell
Josue Lopez and Gerardo Diaz, PhD, School of Engineering, University of California, Merced

As the world population increases, resources decrease and there is more waste being produced. Being able to use the waste and make usable energy, without harming the environment, would provide energy independence, and lower carbon emissions due to combustion of fossil fuels. Through a process of gasification, biomass and other types of waste can be converted into synthesis gas, which can be directly converted into power and heat by means of highly efficient electrochemical processes in a solid oxide fuel cell (SOFC). Testing a SOFC with gas mixtures present in synthesis gas, such as: Hydrogen/Carbon Monoxide at normal operating conditions of a SOFC has a large potential to generate renewable energy. The gas compositions to be tested will mimic the types of gases obtained in plasma gasification processes. The testing procedure will include: Verifying script for operations of the SOFC, verifying flow of nitrogen through system purge, sealing path of anode (inlet & outlet) with high temperature adhesive, curing the adhesive, testing with pure hydrogen, and finally testing with mixtures of hydrogen and carbon monoxide. Once the testing is done then the polarization curves are obtained, which enhances the knowledge of Solid Oxide Fuel Cells operating with fuels similar to synthesize gas (syngas) in plasma gasification systems. The results obtained in the test station can be extrapolated to much higher systems. An alternate way to make usable energy, using waste as the input, will benefit everybody by providing alternate sources, aside from fossil fuels and other commonly used fuels that pollute the environment.

Optical properties of ZnO nanowires
Jessica Clayton, Yang Liu, Jennifer Lu, Ph.D., Sayantani Ghosh, Ph.D., School of Natural Sciences, University of California, Merced

The semiconductor ZnO has gained substantial interest in the research community for its wide, direct band gap (3.37eV) and large exciton binding energy (60meV) which make it a candidate for many applications including optoelectronics, piezoelectric transducers, sensing applications, and miniaturized semiconductor lasers. While much work has been done on the fabrication of ZnO nanostructures, relatively little is known about the relationship between fabrication conditions and optical properties. Here we present a series of studies on the optical properties of ensembles of ZnO nanowires grown on Si/SiO2 substrate with randomized orientation. ZnO nanowires were characterized using SEM, room temperature photoluminescence (PL), and absorption spectra. We explore the effect of excitation wavelength and power on two commonly observed features in the PL spectra and show how this relates to the absorption spectra. We also explore the optical effects of two growth parameters: polymer coating and annealing temperature. Higher annealing temperatures showed an increase in emission intensity as well as a red-shift of the visible emission. A slight red-shift was also observed for increasing excitation wavelength. This study shows that the ratio of the intensity of UV to visible emission is not a good measure of the quality of ZnO nanowires.

Automatic Generation of Realistic, Virtual Environments from Publically Accessible Data

Mark Bailey, Stefano Carpin, PhD, School of Engineering, University of California, Merced

Simulation is essential for developing robotic control software in a time-efficient and safe manner. Realistic representations of environments where the robot will perform are also necessary. A simulation package called USARSim (Unified System for Automation and Robot Simulation) has recently been developed on top of the Unreal Tournament game engine allowing the same code used to control an actual robot to simulate it virtually, but the environments used would still have to be created manually. Therefore, the objective of this project was to create a method where environments could be created automatically using data obtained from databases which describe the geo-location and characteristics of various objects such as terrain, streets, etc. By exploiting certain features of the U.T. game engine and utilizing data from the USGS database, we developed a program which automatically generates terrain based on a particular coordinate grid. This terrain is editable within the U.T. game engine and compatible with USARSim. Furthermore, a similar program is being developed which downloads street location and orientation data from the Open Street Map project database and generates representations of streets for a particular coordinate grid. The end-goal for this project is to have a unified program which downloads data for a specific coordinate grid from various databases and automatically replicates the objects in 3D to create a more detailed and realistic environment which can be used with USARSim. However, this project has the potential to further develop as more objects are mapped out and the data is made publically available.

ARMA Time Series Model For Short-Term Wind Forecasting

Janna Rodriguez, Carlos Coimbra, PhD, School of Engineering, University of California, Merced

Recent government regulations responding to environmental concerns made alternative and clean sources of energy viable within a relatively short time. While many studies confirm that enough solar energy power could be viably produced to fulfill the world's energy demand, the most likely solution to the energy problem includes a portfolio of several resources. Among these, solar and wind are considered some of the cleanest alternatives. Wind power plays an important role in supplying energy in many regions in the United States and in the rest of the world. The most important factor in wind energy is the wind velocity, since there is a cubic relationship between velocity and power, meaning the increase in 10% (1.1x) in velocity will increase the turbine's power by 33% (1.33 = 1.1x1.1x1.1). Currently, wind energy storage is not well-developed, yet there is a direct need to know in advance how much wind energy will be available on any given day in order to allow for utility-scale scheduling and to aid power grid integration of wind turbines. Time Series models are among the most popular methods for short-term forecasting. The aim of this project is to develop an understanding of the level of accuracy of currently available wind forecasting models. We focused our research on ARMA models, which include some of the most successful forecasting methodologies for short-term forecasting. AR models (p) are capable of adequately representing behaviors in time series with zero-mean. A stationary series varies around its mean, in this case zero. Stationary models use the previous value of time series, to predict next one. The model for the project was applied during different months, and the RMSE was different depending on the data. Some months showed better forecasting results than others. The month of May was selected because it was the month that shows the average results. The same model was applied to different month and the forecasting accuracy results dropped significantly. Finally, it was found that time series could be combined with self-learning techniques such as artificial neural networks.

Kinetic Isotope Effect Study of Asymmetric Hydroamination Reaction

Farm Saechao, Hui Zhu, Matthew P. Meyer, PhD, *School of Natural Sciences, University of California, Merced*

Asymmetric hydroaminations promise a convenient and environmentally friendly route to privileged pyrollidine structures that appear frequently in pharmaceutical structures. However, the development of asymmetric hydroamination reactions has proven extremely difficult. To date, only specialized intramolecular hydroaminations using 5-aminopentenes and 5-aminopentynes have been demonstrated. Here, we propose to leverage mechanistic methods developed in our lab to probe the symmetry breaking process that gives rise to the coveted stereogenic center in a recently reported Ti-catalyzed asymmetric hydroamination. Specifically, we propose to measure ^{2}H KIEs at enantiotopic groups in 4,4-dimethyl-5-aminopentene substrate. We also propose to measure global ^{13}C KIEs for this conversion. The ^{2}H KIEs report upon the steric demands in the transition state, while the ^{13}C KIEs report upon the array of atoms necessitated by the electronic demands of the parent reaction. Together, these studies, in conjunction with computational work, should yield information that will contribute to the development of the next generation of hydroamination catalysts.

Life-Cycle Assessment Of Greenhouse Gas Emissions For Algae Biofuels

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The Energy Independence and Security Act of 2007 (EISA) establishes new renewable fuel categories and eligibility requirements. EISA sets the first U.S. mandatory lifecycle GHG reduction thresholds at 50% for biomass-based or advanced biofuel, as compared to those of average petroleum fuels used in 2005. The regulatory purpose of the lifecycle greenhouse gas emissions analysis is to determine whether renewable fuels meet the GHG thresholds. A comparative life-cycle assessment (LCA) study of a hypothetical production plant has been conducted to assess the environmental impacts associated with processing, from production to combustion, of algae biofuels. The most significant LCA burdens associated with algae cultivation are nutrients supplied to the pond, CO_2 and fertilizers, and drying of the algal biomass. Previous LCA studies may have largely underestimated the LCA GHG savings of algae biofuels by neglecting the co-products of biofuels such as wastewater treatment (WWT), biogas, fertilizer and animal feed. This model includes two different WWT effluents as sources for nitrogen and phosphorous, and examines the reduction of impacts when CO_2 and drying heat are supplied as waste from anaerobic digestion or power plant. The results show utilization of waste, such as WWT effluent as culturing medium and CO_2 and heat (provided by anaerobic digestion or power plant), are necessary if algae biodiesel is to meet the EISA lifecycle GHG reduction thresholds.

Designing a BIOLOID Framework for Embodied Learning

Grant Vousden-Dishington, Stefano Carpin, PhD, School of Engineering, University of California, Merced

Many experiments in machine learning of motor control focus solely on simulated robots for testing and validating performance due to the cost and time needed to build a suitable, but these simulations inevitably omit environmental variables that affect performance. Such experiments also traditionally specialize learning toward a particular task, effectively preventing the robot from discovering alternative solutions. This study examines how the modular BIOLOID robot can be configured and programmed using C to perform various actions and explores the theory behind reinforcement learning based on neural networks, as it applies to an eighteen degree-of-freedom, humanoid robot. Reinforcement learning methods, such as Q-Learning, are of particular interest because they can be implemented without encoding a priori information about the environment or task to be completed, an appealing trait if the learning agent has many degrees of freedom to be mastered. The combination of C programming and the BIOLOID suggest a convenient, economical way to implement motor learning experiments in an embodied platform. In addition, the shortcomings of this platform, in particular the difference in complexity of the motors and sensors, will be addressed and venues for including other hardware proposed. The software and theory that can be used with this BIOLOID provide an embodied alternative to simulations of machine learning for conducting experiments and applying machine learning to a programmable agent.

Experimental Determination of Insect Flight Aeroelastics

David Larson, Carlos Coimbra, PhD, School of Engineering, University of California, Merced

To better understand the complexities of insect flight, an advanced imaging system is designed consisting of four high speed cameras and a Nd:vanadate q-switched laser. The system has the capability of creating 3D models of flying insects recorded at 1000 frames per second, including wing structure deformation and surrounding flow field visualization. The data collected will allow a more complete understanding of the aeroelastic behavior of insect wings while in flight. Additionally, the system can perform precise analysis of the flow fields surrounding the insects in order to determine the aeroelastic forces that allow efficient flight at such small-scales.

Acellularization of Cardiac Matrix for Generation of Live Cardiac Patch

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Every twenty seconds someone in the United States suffers from a myocardial infarction (MI). A myocardial infarction occurs when blood vessels become blocked preventing oxygen to be delivered to the heart, which leads to damaged cardiac muscle. With the loss of functional tissue, the heart works harder to maintain blood flow which supplies all other tissues of the body. This compensation often leads to heart failure. A heart transplant is often the only hope for patients suffering from cardiac failure, but unfortunately there are not sufficient donors. In order to bridge this scarcity of heart donors' many groups are looking at alternative treatments for repairing injured cardiac muscle. Our lab, currently researches methods for cardiac tissue regeneration using varied substrata and stem cells. This project focuses on creating an efficient method of decellularizing porcine heart, generating a cell-free extracellular matrix in which cardiomyocytes can be seeded. The overall aim is to create a biodegradable transplantable cardiac patch for the purpose of tissue regeneration. This project was accomplished by 1.) Identifying decellularizing methods 2.) Dissecting cardiac muscle from porcine heart 3.) and subsequent decellularization of that cardiac tissue. One tested decellularizing method required cardiac tissue to be stirred in 1% SDS/PBS, followed by 1% Triton X-100, and dionized water. Decellularized tissue was ground into powder using a pestle and mortar. Variation of this method were investigated which included, lypholization prior to treatment and decellularizing. The matrices were reconstituted in both PBS and Pepsin to form scaffold, and assessed for matrix components such as Laminin, Collagen I, and Fibronectin. Decellularized scaffolds were seeded with HL-1 cells, an atrial cardiac cell line and the results indicate that decellularized ECM showed marked increase in cellular attachment and proliferation over control treated tissue culture polystyrene plates.

Effects of Engineered Nanoparticles on Marine Phytoplankton Exopolymeric Substance Assembly

Jesse M. Anaya, Wei-Chun Chin, PhD, School of Engineering, University of California, Merced

Polymer gel particles are abundant and important for many oceanic processes: sedimentation, biogeochemical cycling and particle dynamics. Phytoplankton exopolymeric substances (EPS)—composed of polysaccharide-rich anionic colloidal polymers—are released into water columns from marine phytoplankton during photosynthesis. The major portion (40~60 %) of fixed carbon in phytoplankton is released as EPS, contributing significantly to the dissolved organic carbon (DOC) pool in the ocean. This provides an abiotic mechanism to move organic molecules to sizes capable of sequestration in deep sea. Recent studies have identified that EPS can self-assemble into microgels (POC) through hydrophobic and ionic interaction mechanisms. Engineered Nanoparticles (ENs), which range in size from 1 to 100 nm, have properties different from those of bulk materials of the same chemical composition. Though widespread in use, ENs impacts on marine environments are largely unknown. Here we study the interactions of ENs and EPS from two representative phytoplankton species: *Phaeodactylum tricornutum* and *Ankistrodesmus angustus*. In this study, nanoparticles were mixed with EPS samples, and the assembly of EN-EPS was monitored using Dynamic Laser Scattering (DLS). With this technique we can measure particles sub micron in size, essentially by tracking their Brownian motion. DLS was used to reveal the average microgel size measured over fourteen days. Preliminary results suggest EN-induced changes of EPS assembly may lead to unexpected disturbance in elementary carbon cycling: their broad impacts may range from how we view the physical nature of microscale structures to shedding light on the most recent carbon cycling mechanisms of global climate change.

Enabling Solar Forecasting Research through Interactive Graphical Data
Adrian Garcia, Carlos Coimbra, PhD, School of Engineering, University of California, Merced

The issue of power intermittence needs to be addressed in order to improve market penetration of solar power technologies. Fluctuations in the amount of power produced by solar farms represent a risk to power grid stability. Implications of such variability include power scheduling and management of spinning reserves at the utility scale, and overall power grid management at the Independent System Operators (ISOs). If utility companies could accurately and reliably predict how much power output to expect from solar farms and distributed rooftop generation, a demand in clean renewable solar energy would quickly follow, thus reducing humanity's addition to fossil fuels. To help meet this goal, UC Merced Solar Forecasting Lab researchers study current solar resource and utilization data using various solar instruments, and produced power data from a 1MWe solar farm. Several instruments on campus record radiation levels across multiple wavelength spectra, cloud cover, and direct radiation from the sun. There is a need for compacting all these data into one website where any person could use the data dynamically, from any range of dates in a creative format. The website we are developing will provide such dynamic platform. This project is to be expanded to include many more regions. The process of storing and presenting the data dynamically is further explained.

Bound constrained gradient projection for sparse signal recovery
James Hernandez, Daniel Thompson, Roummel Marcia, PhD, School of Natural Sciences, University of California, Merced

This research concerns the recovery of signals and, specifically, images from noisy measurements. Such problems arise in many applications such as medical imaging, astronomy, and security surveillance where compression has become a necessity for transferring and storing signals. Signal reconstruction methods often give advantage to a priori knowledge of signal properties to ensure accurate estimates. In particular, sparsity (the number of non-zeroes in a signal) has long been recognized as a highly useful metric in these inverse problems, especially with the development of the compressed sensing framework, which suggests that sparse signals can be recovered with high accuracy with very high probability, provided certain statistical assumptions are satisfied and an appropriate optimization problem is solved. This research focuses on the so-called `2-`1 minimization problem, which balances a least-squares data fidelity `2-term with a sparsity-promoting `1-term. However, unlike most conventional compressed sensing methods, our approach imposes constraints on our estimates, since pixel intensities corresponding to images are naturally nonnegative and are bounded above. Our method for solving this minimization problem is based on gradient projection, which has been shown in literature to be highly successful in solving such problems. We present numerical results that demonstrate the effectiveness of our proposed approach.

For more information regarding the Graduate Division's UC AGEP and UC LEADS programs, please contact:

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