NYU POLYTECHNIC SCHOOL OF ENGINEERING*



SUMMER RESEARCH PROGRAM UNDERGRADUATE ABSTRACTS 2013

NEW YORK UNIVERSITY

*Formerly Polytechnic Institute of New York University. Merger complete January 2014.



SUMMER RESEARCH PROGRAM UNDERGRADUATE ABSTRACTS

SEVENTH ANNUAL UNDERGRADUATE SUMMER RESEARCH PROGRAM

INTRODUCTION

NYU-Poly's Undergraduate Summer Research Program provides a unique opportunity for NYU-Poly, NYU College of Arts and Science, and NYU Abu Dhabi students to engage in research over the course of the summer. This program offers students far more than the traditional classroom experience; it allows them to work alongside faculty mentors on cutting-edge research projects. Close interaction with faculty and research staff promotes an educational experience that advances the i^2e model of invention, innovation and entrepreneurship. Undergraduate students are afforded the opportunity to conduct research as paid interns during this 10-week period. The program aims to enhance and broaden student's knowledge base by applying classroom learning to solve practical and contemporary problems and to better prepare them for lifelong learning.

Summer 2013 marked the seventh year of the Undergraduate Summer Research Program. Since its inception, 293 students have participated in and 166 faculty members have contributed to the program. This year also marked the first year in which NYU's Center for Urban Science and Progress (CUSP) took part in the program. In addition to their work in labs, students attended seminars on presentation skills, resume and cover letter writing, graduate schools admissions and gene patenting. Additionally, students presented their work-in-progress to other members of the research cohort at a special luncheon dedicated to practicing presentation skills and fostering inter-group collaboration on current and future projects.

The program was an initiative of Professor Erich Kunhardt and Associate Provost Kurt Becker, who have played a vital role in making the program possible since its creation. NYU-Poly's faculty participation in this program was essential, as was the financial support provided by faculty mentors and NYU-Poly's Board of Trustees. The gifts from several alumni donors have also propelled the program's success. I would like to thank Dr. Joseph G. Lombardino '58Chem, James J. Oussani, Jr. '77ME, and Dr. Harry C. Wechsler '48CM, for their generous support of this year's program. Additionally, this year marked the second year of the George Juul Thompson Undergraduate ECE Research Fellowship. Six of this summer's researchers were graciously supported by this fellowship made possible by Ms. Dede Thompson Bartlett whose father, Mr. George Juul Thompson, was a graduate of the Polytechnic Institute of Brooklyn in 1930. Donors' gifts allow us to engage more student researchers, faculty mentors, and further strengthen this truly unique summer experience. I would also like to acknowledge Coordinator's Sara-Lee Ramsawak and Meagan Watson who ensure the programs daily operations run seamlessly.

The abstracts published in this volume are representative of the poster presentations given at the symposium celebrating the accomplishments of the undergraduate researchers during the New Student Networking Expo on August 28, 2013.

I congratulate all of the student researchers who participated in the 2013 Summer Undergraduate Research Program and look forward to future summers of intellectual and scholarly activities.

Iraj Kalkhoran



Associate Provost and Dean of Undergraduate Academics

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APPLIED PHYSICS

APPLICATIONS OF A "QUANTUM MECHANICS PHYSICS ENGINE" FOR EXAMINING PARTICLE SCATTERING AND EXCITATIONS

Quantum mechanics is the theory which deals with the behaviour of matter on small scales. In particular it dictates that all objects can be described as solutions to the Schrödinger equation which reads $i\hbar \frac{\delta\psi}{\delta t}=H\psi$, where H is the Hamiltonian operator. In nearly all cases of interest an exact analytical solution is not possible. Thus to gain any understanding of many quantum mechanical systems a computational approach is required. Our goal is to develop a "Quantum Mechanics Physics Engine" to allow us to examine systems of importance. Our program will simulate the quantum mechanical behaviour of a particle in one and two dimensions. We will apply this program to examine the scattering of particles off of various barriers and to examine methods of manipulating quantum systems into and out of excited states.

The algorithm used to run our quantum mechanical engine is the leapfrog method, in both one and two dimensions. In certain simpler cases, the spectral method is also used because of its more rapid rate of calculation.

CENTER FOR URBAN SCIENCE AND PROGRESS

SURVEYING EXISTING, LOW-COST, MOBILE ENVIRONMENTAL SENSORS FROM A CITIZEN SCIENCE PERSPECTIVE

Environmental sensing is a broad, analytical field that studies the ambience at various sites through the continuous or intermittent acquisition of specific parameters by sensor systems. Previously, such tasks were performed by high-cost monitoring stations primarily owned and operated by the EPA and other government agencies. However, over recent years, the advancement of mobile computing and the accessibility of DIY sensor kits have facilitated an emergence of environmental sensing projects centered on citizen-science-based approaches.

Citizen-science projects such as Air Probe and CitiSense were developed as mobile sensing devices equipped with low-cost DIY gas sensors that monitor air quality through the collection of carbon monoxide, nitrogen oxide and volatile organic compound (VOC) concentration readings. Designed in similar fashions, MoboSens and WaterBot share common approaches in data collection. Both projects enable anyone to test for water quality parameters such as salinity and dissolved nitrogen concentration at local watersheds using easily attainable/DIY devices. Many of these citizen science projects utilize the vast capabilities of today's smartphones as programmable tools, wireless transmission apparatuses and embedded sensor platforms to gather and send data.

CUSP, NYU's Center for Urban Science and Progress, promotes citizen-based approaches in the collection and analysis of people's urban environment. The objective is to consolidate the many environmental citizen-science projects and sensors using a wiki as a collaborative database. The wiki comprises mainly of detailed sensor specifications, protocol information and calibration procedures on both DIY and professional-grade sensors, allowing for cross comparisons. Additionally, it will feature consumer reports based on accuracy, set-up, possible applications, etc.

CHEMICAL AND BIOMOLECULAR ENGINEERING



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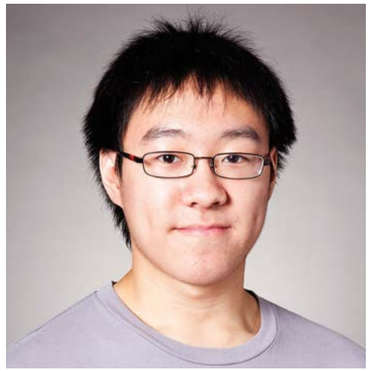
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THERMOSTABILITY, STRUCTURE AND ACTIVITY ANALYSIS OF ASPERGILLUS ORYZAE CUTINASE

Cutinases are α/ß hydrolases secreted by fungal phytopathogens that enable them to penetrate the protective surface cutin layer of plants. Apart from hydrolyzing cutin ester bonds, the hydrolytic activity of cutinases has been exploited for a broad range of reactions including hydrolysis of soluble and insoluble esters and polymer synthesis. With regards to their application to polymers, cutinases have great potential for polyester recycling and polymer (polyesters or polymers with ester side chains) surface modification. Enzymes with greater thermostability are desirable for their application on polymer substrates. The goal of the current project is to study the thermostability of cutinase from Aspergillus oryzae (AoC), elucidating its thermal deactivation pathway and examining its activity on polymeric substrates. AoC was expressed in Klebsiella pastoris and the enzyme was purified using immobilized metal ion chromatography. The preliminary stability studies based on circular dichroism (CD) analysis, dynamic light scattering (DLS) analysis and residual activity analysis have revealed that aggregation plays an important role in deactivation of the enzyme. Interestingly, when AoC is expressed in a different yeast strain, pichi pastoris, it exhibits decreased aggregation and decreased stability compared to the AoC expressed in klebciella pastoris. These differences can be attributed to differences in posttranslational modification in different strains. The effect of aggregation of an enzyme on its activity towards a polymeric substrate and its stability will continue to be studied.



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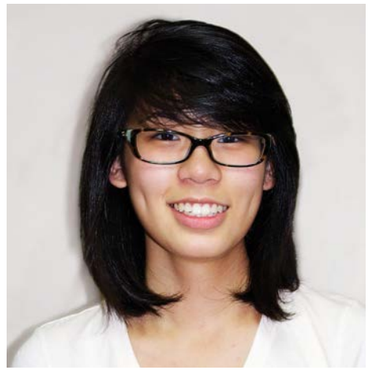
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MODIFIED CELLULOSE NANOCRYSTALS FOR USE IN BIOBASED THERMOPLASTICS

Biobased polymers such as polylactic acid are increasingly used to displace petroleum-based polymers. The renewable and degradable properties allow them to be created through a greener approach. Biobased polymers have many drawbacks: low tensile strength, chemical resilience, high gas permeability, and low heat deflection temperature. Glass fibers have been used to reinforce polymers (fiberglass), but the potential health effects are unknown. Cellulose nanocrystals (CNCs) could replace glass fibers due to a high aspect ratio (length/diameter) and nanoscale. The inherent properties of CNCs can result in a nano-effect for reinforcement—meaning multiple parameters are improved instead of some gains and decreases that are typically observed with macro-composites. Cellulose is the most abundant biopolymer in the world, being widely found in plants and bacteria. Ramie is a fibrous plant and due to its naturally high aspect ratio was the source of cellulose. Purified ramie underwent acid hydrolysis to isolate the CNCs. Dispersion of hydrophilic CNCs into hydrophobic polymer matrices is difficult due to poor compatibility. To achieve better dispersion the surface of the CNCs was modified through Fischer esterification to increase compatibility and interfacial interactions. Acrylic acid was used as a hydrophobic modifier and citric acid to impart anionic charge for hydrophobic cationic polymer wrapping. CNCs were freeze-dried and analyses done by a Fourier transform infrared spectroscopy. To confirm Fischer esterification took place, two bands between 1100-1300 cm-1 and one in the 1700 cm-1 were present which represents the ester linkage. Future plans involve dispersing the CNCs into a biobased polymer via solvent casting and checking for improvement.



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NON-PHOTOCHEMICAL LASER-INDUCED NUCLEATION OF SUPERSATURATED POTASSIUM CHLORIDE SOLUTION SUSPENDED IN POLYMER MATRICES

The initial stage of crystallization—nucleation—is the result of random clustering of solute molecules, making it difficult to predict when and where a crystal will form. In an effort to study the early stages of nucleation, Garetz et al accidentally discovered that when exposed to a high-powered near-infrared laser, certain supersaturated solutions would nucleate without absorption of laser light. This process was named non-photochemical laser-induced nucleation (NPLIN). Later studies have shown that NPLIN is possible in supersaturated solutions of potassium chloride in an agarose gel matrix. Utilizing gels as a medium promotes crystal growth by forming larger, single crystals with fewer defects and different morphologies.

We conducted experiments using a 532 nm green laser beam instead of a near-infrared beam and observed nucleation around boreholes in the agarose gel. We concluded that the crystals formed as a result of the formation of boreholes rather than NPLIN. Although the agarose gel appeared to be colorless and transparent, we hypothesized that the gel was absorbing some of the laser light, drilling holes as the high-powered laser beam passed through the gel. To determine the cause of the undesirable boreholes, we obtained the ultraviolet-visible light spectrum of agarose, which confirmed that agarose absorbs green light. In order to ensure that drilling does not occur after exposure to the laser, we are looking for and preparing hydrogel materials that do not absorb green light. Further research will focus on devising other experiments by varying the degrees of supersaturation and the concentration of the polymer.



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Student researchers are working with Professor Bruce Garetz to study nucleation—the initial stage of crystallization.



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EFFECTS ON AMYLOID BETA TOXICITY IN THE PRESENCE OF CHARGED SEVEN RESIDUE PEPTIDES

Amyloid Beta (Abeta) is a peptide of 36-43 amino acids whose pathology is closely linked to Alzheimer's disease. The peptide's aggregation propensity is a direct link and primary component to the formation of amyloid plaques (insoluble fibrous protein aggregates) found in Alzheimer's patients. It has been hypothesized that the toxicity of Abeta is the result of oligomeric molecular complexes. Studies have shown that small peptide fragments of Abeta (as small as 5 amino acids in length) have been effective in altering its toxicity in vitro. The small peptide KLVFF is a known ligand that will bind to the Abeta in isolation. Using this information, our aim was to study the effects of Amyloid Beta toxicity when exposed to the charged peptides KLVFWAK and ELVFWAE. These peptides were expected to show similar binding affinity to Abeta as KLVFF did. They also contained charged ends: the positive KLVFWAK (K being positively charged) and negative ELVFWAE (E being negatively charged). Using Thioflavin-T fluorescence, a dye known to bind to amyloid fibrils, the aggregation propensity of Abeta was measured when incubated with the above mentioned seven residue peptides. The results found that Abeta's aggregation propensity was accelerated in the presence of either charged peptide. The accelerated aggregation of Abeta may be favorable to our studies since it could also mean that it reduces the time in which the peptide exists in its toxic oligomeric state.



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THE STABILITY CHANGE OF BETA AMYLOID 40 IN THE PRESENCE OF ALPHA SYNUCLEIN

For over a century, experts in the medical field have been looking for cures for a widespread disease, the Alzheimer disease. Common among the elders, Alzheimer disease is a dementia known to affect an individual's memory and speaking ability. It is characterized by the shrinkage of cerebral cortex due to loss of neurons. Lately, scientific research has identified the cause of the disease to be the misfolding of a protein named beta amyloid. It is found out that the aggregation of the protein from its monomeric state to oligomers and fibrils is associated with the development of the disease. Beta amyloid is produced from the cleavage of amyloid precursor protein, an internal membrane protein commonly present in many tissues, especially in the synapse neurons. By controlling the aggregation due to abnormal folding of beta amyloid, we expect to control the development of the disease. There are many ways to control a protein's stability, temperature, pH, mixing with other chemicals, etc. In this project, monomeric beta amyloid is co-incubated with another protein called alpha synuclein. Just like beta amyloid, alpha synuclein is present in synapse neurons and is responsible for the neurodegenerative disease Parkinson's disease. While co-incubating the two proteins, samples are taken out at different time points to gather data about the aggregation of the proteins.



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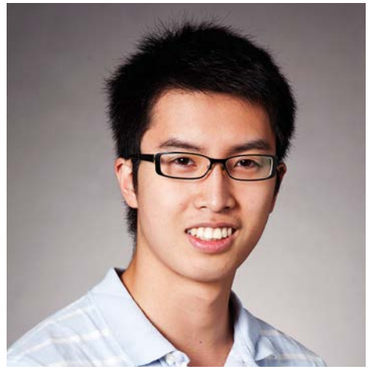
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HIGHLY STABLE SURFACE BIOMODIFICATION FOR DNA DIAGNOSTICS

DNA microarrays and biosensors have been used as diagnostic tools in various bioanalytical applications, from pathogen identification to guiding cancer diagnosis and intervention. However, many aspects of the hybridization process at the heart of these technologies are still not well understood, making optimization difficult. These complications are primarily introduced by molecular crowding and interactions that arise in the interfacial environment in which the surface-immobilized "probe" DNA hybridizes with sample "target" nucleic acids from solution. In order to gain a better fundamental understanding of surface hybridization, an electrochemical method was developed in which ferrocene-labeled target DNA is used to study hybridization on a surface as a function of temperature. This allows thermodynamics of surface hybridization to be rigorously established from melting curve analysis. Use of this method requires very stable immobilization chemistry for the probe DNA. Immobilization starts with the polishing of a gold electrode surface to clean it. Next, it is coated with a layer of poly(mercaptopropyl)methylsiloxane (PMPMS) polymer as an "anchor layer," which is then crosslinked with tris-(2-maleimidoethyl)amine (TMEA). Crosslinking stabilizes the PMPMS film on the electrode, as well as provides reactive groups for attachment of the probe DNA. Only if this surface chemistry is sufficiently well developed can precise melting curves be determined. In these experiments, a temperature range from 41°C to 70°C was used to determine melting curves. It was also used to expose the probe DNA to extreme temperatures to demonstrate the stability of the polymer crosslinking on the surface and reversibility of the melting process. The results of these experiments will be compared with similar results in which a different crosslinker, 1,11-bis(maleimido)triethyleneglycol (BM(PEG)3), was used. From these studies we seek to develop the most effective route to constraining the molecular organization of probe layers and thus advance fundamental studies of DNA surface hybridization.



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NANO-VOLUME HYBRIDIZATION REACTOR DESIGN TO ANALYZE DNA HYBRIDIZATION

Microarray is a technique used to compare the degree of genetic similarity between pools of DNA sequences through DNA hybridization. The study of DNA sequences through DNA hybridization has led to breakthroughs in the diagnostics of genetic diseases, treatment of diseases, as well as in many other fields of science. Our current method of studying the thermodynamics of DNA hybridization uses a method called TIRF (Total Internal Reflection Fluorescence) microscopy. TIRF microscopy uses the reflection of a laser beam within a microscope slide with probe-DNAs immobilized to produce an evanescent electromagnetic field which excites the labeled target-DNA which is hybridized with probe-DNA on the surface. The intensity level emitted by these specimens correlates to the level of hybridization and the fluorescence of the hybridized DNA in the cell can be captured using a camera.

However, there are limitations and uncertainties in the data collected from this method of analysis. To improve upon this method used, a design to incorporate an electrochemical means to the photographic method of Fluorescence microscopy was made implementing a nano-volume reaction cell. In the proposed design, a nano-droplet of a DNA solution is prepared in a microscope slide and instead of the camera, laser, and filters placed on the bottom of the design, an electrochemical sensor is attached thus, moving the camera, laser and filters above the nano-droplet. The proposed design allows for both an electrochemical and photographic means to analyze the hybridization of DNA in the cell which improves the reliability and certainty of the results and data collected.



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PC12 NEURONAL DIFFERENTIATION VIA ELECTRICAL STIMULATION ON GOLD SURFACES

PC12, a secondary cell line derived from a neuroendocrine tumor on the adrenal medulla of an irradiated rat, has shown to be an effective research model for sympathetic neuronal differentiation. PC12 cells have been cultured on conductive surfaces to model neuronal response to electric signal in the nervous system. Here, the joint impact of growth factor and electrical stimulation on PC12 cells in vitro was evaluated. In this model, PC12 cells were cultured in electrode array wells containing gold film electrodes delineated with an insulating film. After inducing differentiation with nerve growth factor, the cells were subjected to constant current stimulation (1V for 15 min) every four days. Neurite outgrowth and morphology changes were monitored, with growth speed and length and of the neurites measured relative to PC12 cells plated on collagen-coated surfaces under comparable conditions. Single cell response to electric signals can be further evaluated for eventual application of these findings in nerve regeneration.



▲ Omar Yassin experiments with polymers to study optimal conditions for Mammalian cell life.



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ELECTRIC FIELD EFFECT OF CONDUCTIVE POLYMER NANODOMAINS ON MAMMALIAN FIBROBLAST CELLS

Mammalian fibroblast cells, which are responsible for cellular structure in humans, are widely used in stem cell research because they are actively manipulated. When a cell is able to change roles, functioning differently than its predisposed genotype entails, it is differentiated. Cell differentiation may be controlled by many environmental factors, one of which being electrical stimulation. Conductive polymers (CPs) like polyaniline (PANI) have been altered to exhibit electrical properties similar to semiconductors and metals by means of doping, or introducing impurities to pure compounds. CPs may be used to induce differentiation of mammalian cells due to electrolytic contact with cell membrane substrates which signal cascades that alter gene expression. Mammalian cell life may subsequently be prolonged.

In this experiment, solutions of the doped conductive polymer polyaniline-dinonylnaphthalene (PANI-DNNSA) and the thermoplastic copolymer ethylene-vinyl acetate of 18 wt.% (EVA18) were mixed in different ratios. The polymers phase separated via spinodal decomposition while evaporated onto Pyrex petri dishes. Controlled evaporation allowed the polymer mixtures to form conductive thin-film nanodomains which are environments that affect cell activity. The nanodomain ratios of EVA18 and PANI-DNNSA (respectively) were 50:50, 75:25, 85:15, and 90:10. Mammalian fibroblasts were cultured on each of the nanodomains with a bare, fifth dish as a control. The growth of all cell domains were monitored weekly using a standard optical microscope for 5 weeks. Comparisons were made between each nanodomain to justify which ratio supported the best living conditions for the cells. Future trials may be done to improve the resilience of the nanodomains, and develop methods to increase cell lifespan.



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EFFECT OF LONE PAIR ON THE STABILITY OF HETEROCYCLIC MOLECULES

Lone pair interactions are responsible for an extensive number of effects, especially those dealing with molecular stability, inter/intra-molecular interactions, and reactivity. Perhaps one of the most celebrated lone pair effect is the anomeric effect, which explains why the conformation of α-D-glycopyranose is more stable than β-D-glycopyranose. Lone pair interactions are difficult to study experimentally and, as a result, their nature is not completely understood; however, their behavior is easily analyzed using quantum theory. In this account, lone pair interactions arising from nitrogen containing organic cyclic systems are studied using the quantum chemistry software Spartan '10 and Gaussian '09 on NYU's high performance computers. Thermochemical and NMR properties are calculated on increasingly complex gas and solution phase cyclic systems using the B3LYP and M062X ab initio DFT functionals with a variety of high level of theory basis sets. Ultimately, this account seeks insight on the effect of nitrogen's lone pair in the stability of reserpine, an indole alkaloid, by simplifying reserpine into smaller fragments. These fragments and their isomers are extensively analyzed to determine relative energy, enthalpy, and free energy stabilities in order to account for the experimental fact that reserpine spontaneously epimerizes at the secondary nitrogen ring junction to form iso-reserpine, the more stable epimer, upon the addition of acid. Furthermore, NMR properties, such as, chemical shift and coupling constants, are calculated on the reserpine and iso-reserpine molecules. Lastly, thermochemical properties of both X-ray crystal structures are calculated to determine the lattice energies for a more detailed analysis of the lone pair effects. The analysis of this work will examine the effect of stability due to the nitrogen lone pair in organic cyclic molecules.



ALEX CHEW

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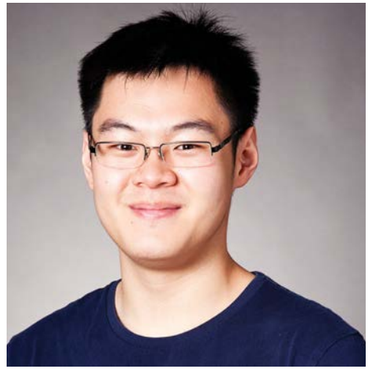
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CHEMICAL SHIFT CALCULATIONS USING AB INITIO METHODS

The NMR spectrum of a molecule can give invaluable structural information. With the new Gaussian 09 software package, computing chemical shifts using theoretical chemistry have become increasingly popular. However, one of the most reliable functional, second-order Moller-Plesset perturbation theory (MP2), requires a large computational cost and is impractical for larger molecules. It appears that the new hybrid density functional theory methods give comparable accuracy, but at a lower computational cost. Twenty-four hybrid density functional theory methods were tested to compute accurate proton and carbon chemical shifts for small organic molecules. The basis set chosen for these calculations include the Pople double and triple zetas families, and the Dunning families. The addition of polarization functions for the basis sets increase the accuracy of chemical shift values more than the addition of diffuse functions. The Gauge Invariant Atomic Orbitals (GIAO) was selected over the Continuous Set of Gauge Transformations (CSGT) due its accuracy and higher consistency of converging. The accepted optimization B3LYP/6-31G* level was used for reliable ground-state geometries of the molecules. In addition, The Self Consistant Reaction Field (SCRF) Chloroform solvent was used to account for the solute-solvent interactions. Root mean square deviations (RMSD) and linear scaling are the statistical tools used to determine the accuracy of the functionals. Our goal is to determine the most accurate hybrid DFT method and basis set in order to compute the chemical shift spectrum of larger molecules such as reserpine and isoreserpine.



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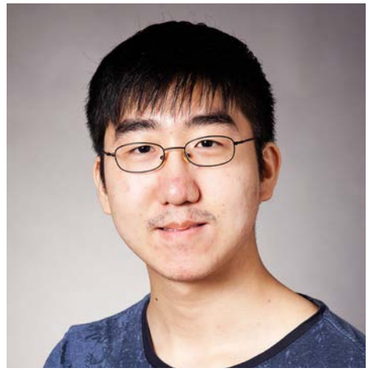
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CHARACTERIZATION OF A SUPERCHARGED MUTANT OF THE CARTILAGE OLIGOMERIC MATRIX PROTEIN FOR THE PURPOSE OF TANDEM DRUG/GENE DELIVERY

For diseases such as cancer that develop resistance to available treatments there is a need for a dual delivery vehicle for: 1) small molecule therapeutics to attenuate disease proliferation and; 2) nucleic acids to alter disease programming at the genetic level. The goal of this project is to characterize an engineered protein that non-covalently binds to the negatively charged phosphate groups of nucleic acids while retaining the inherent small molecule binding ability of the wild-type protein. The engineered protein (CSP) was derived from the N-terminal coiled-coil pentamer domain of the Cartilage Oligomeric Matrix Protein (COMPcc) which was mutated to display positively charged arginine residues at solvent exposed sites. This elicits a stronger non-covalent interaction with both plasmid DNA and siRNA at lower weight/weight ratios as compared to COMPcc. Circular dichroism spectra showed that the structural integrity of COMP was maintained after site-directed mutations to CSP. The hydrophobic pore of COMPcc was also believed to be retained in the CSP mutant. Interestingly, curcumin, a small hydrophobic molecule with anti-tumor properties, was also been shown to interact with CSP. Recent drug binding studies showed that CSP had similar drug loading capacities as compared to COMPcc further suggesting that the hydrophobic pore of the pentamer was retained. We are currently working on an enhancing the encapsulation method for small therapeutics as well as optimizing conditions for nucleic acid-binding for future use in both in vitro and in vivo studies.



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MULTIFUNCTIONAL STIMULI-RESPONSIVE PROTEIN POLYMER-GOLD NANOPARTICLE HYBRIDS FOR SMALL MOLECULE DELIVERY

Stimuli-responsive, multifunctional proteins capable of self-assembling and forming defined, nanometer-scale structures have been closely studied for their potential in therapeutics, particularly in drug delivery vehicles and tissue regeneration systems. In a previous study, a library of protein diblock copolymers – EnC and CEn -derived from naturally occurring self-assembling domains (SADs) elastin (E) and the coiled-coil domain of the Cartilage Oligomeric Matrix Protein (C) were generated, where n represents the number of elastin repeats. In order to control the encapsulation and delivery of drug molecules, we have templated gold nanoparticles (GNPs). GNPs exhibit surface plasmon resonance enabling the conversion of light energy into thermal energy. These GNPs act as an additional “trigger” to induce self-assembly of the protein, which is dependent on the E domain. Out of the engineered protein diblock library, E1C and CE1 have been chosen to template the GNPs due to their high inverse transition temperature (38.0°C and 59.0°C, respectively) and stability beyond in vivo conditions. The block orientation affects GNP templation, thermo-responsiveness and overall small molecule binding and release of the GNP-protein polymer composite. In particular, GNP templation leads to a slightly less ordered structure for both protein types via circular dichroism (CD) studies as well as an increase in inverse transition temperature, demonstrated via UV/vis absorbance data. Both Protein-GNP polymer complexes demonstrate improved binding to the small molecule and unique antitumor, antiamyloid, and antihypertrophic agent curcumin, making them suitable for potential use in drug delivery.

CIVIL AND URBAN ENGINEERING



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OPTICAL IMAGING OF HIGH PH DEPENDENT DEGRADATION IN CEMENT BASED MATERIALS

In the United States, the bridges, roads amongst others are deteriorating. In the recent American Society of Civil Engineers report, the grade point average for infrastructure was “D”. A large extent of the material deterioration comes from the chemical reactions occurring within the concrete materials which also cause premature effects). It is important for concrete technologists to have a way to investigate the amount of pH within the concrete being used. The goal of this research is to bring about a direct manner of measuring the pH value by using sensor molecules which allow both in situ and lab personnel to use the surface of the concrete sample cross-section as a platform to apply the sensor molecule polymer solution that will allow for light source to be used within a spectrophotometer that will measure light intensity by colors (Red, Green and Blue) that will in turn get converted into absorption numbers that will later provide for the specific pH value on a certain point on the sample. The concrete was cured for a period of two weeks before it was used in the development of this experiment. It was then split into several portions in order to be used in the set-up. The ideal concrete portion would be the one that has a flat surface, that way the light source waves would penetrate the sample and bounce out evenly. Iterations on the accuracy of this experiment are still taking place in the Department of Civil Engineering Optical Sensing Laboratory.



▲ Carlos Santana and his PhD mentor, Engui Liu



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COMPUTER SCIENCE AND ENGINEERING

BRINGING iOS TO SEATTLE

Seattle is a free and community-driven platform for networking and distributed systems research. It operates on resources donated by users and institutions across the world, and currently features more than 20,000 computers and mobile devices. The scalable global distribution of the Seattle network provides the ability to use it in application contexts that include cloud computing, peer-to-peer networking, mobile computing, and distributed systems.

Seattle is ideal for students, researchers, and companies that want to prototype and test code on test beds that have varying scale, diversity, and topologies. The same code may easily be run on a variety of operating systems, architectures, and network environments in order to understand the performance and dynamics of a distributed system.

Seattle runs on end-user systems in a safe and contained manner, with support for several platforms. Users install and run Seattle with minimal impact on system security and performance. Sandboxes are established on the user's device to limit the consumption of resources such as CPU, memory, storage space, and network bandwidth. Programs are only allowed to operate inside of a sandbox, ensuring that other files and programs on the device are kept private and safe. This allows researchers and students to safely run code without impacting performance or security.

So far, Seattle was released for Windows, Mac OS X, Linux, and Android. The goal of this summer research project is to write an iOS version for Seattle and deploy it to the iOS App Store. This was not possible until recently, when iPhone, iPod, and iPad apps were allowed to be written in languages other than Objective-C, Apple's own programming language.



▲ Seattle makes the power of Cloud Computing available to everyone. It's free, community driven, open source, and provides access to computers worldwide. Working with Prof. Justin Cappos, Lucas Gregolin Dias worked to create an iOS version of the software to deploy on iPhones and iPads.



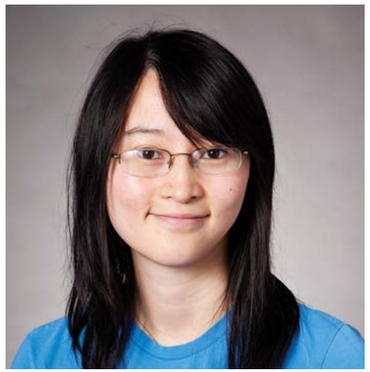
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DESIGNING HARDWARE USING HIGH-LEVEL PROGRAMMING LANGUAGES

Applications run faster on hardware due to the parallelism and higher speed provided by hardware (as compared to the sequential processing by software). Any application can be executed quicker in hardware if a custom chip was designed for it. However, this is not practical, given today's technology. But reconfigurable chips, known as Field Programmable Gate Array (FPGA) chips, are promising. After programming an FPGA chip, the chip emulates the circuit designed so what is needed is converting applications to hardware quickly. Typical ways to design hardware today, writing Hardware Description Language (HDL) programs and drawing schematic diagrams, are complex, hard to learn and time consuming. An alternative approach is writing programs in high-level programming (software) languages, such as C, C++, MATLAB and LabVIEW and then converting them to hardware by means of sophisticated tools. These tools can generate not only transistor layout circuits for custom chips, but also special files to program FPGA chips, allowing us to re-configure an FPGA chip for an application.

For our research, we used LabVIEW, Xilinx ISE, and the National Instrument (NI) Digital Electronics (DE) FPGA Prototyping Board along with C++, VHDL, and schematic designs to develop applications as software, as hardware or partially as software and partially as hardware. One of our projects is the development of the tic-tac-toe game that runs on the PC as software and also runs on the FPGA chip as hardware. Another project is the development of the EMY CPU (a simplified version of the MIPS microprocessor used for Computer Architecture classes) that runs applications on the PC and on the FPGA chip. Both of these projects show the ability to run applications on the PC, on the FPGA chip, or using a combination of both the PC and the FPGA chip. We also compared the amount of hardware used by the different versions of each of these projects. We can show that it is faster to develop hardware using high-level programming languages at the expense of more hardware demand on FPGA chips.



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THE UPDATE FRAMEWORK

A typical Windows computer has about two-dozen software updaters, each handling security in their own way. The Update Framework (TUF) is a library that can be used to universally secure updaters, with little or no customization.

To accomplish this, TUF acts as a sort of man-in-the-middle, intercepting package updaters' requests for updated files and only passing the files on to the updater if TUF deems it secure. Judgments as to the security of the package are determined by utilizing several small files on the repository, called metadata files, which hold a few extra pieces of information. There are four required metadata files: root, targets, release and timestamp. Each metadata file is required to be signed by a certain number of different keys, as specified by the key's "signature threshold." By distributing responsibilities, signers' keys can be easily revoked if they are no longer trusted.

Root specifies the other roles-the keys that are trusted, as well as the minimum number that are required. Targets lists the hashes and sizes of the files that are to be downloaded. Release, similarly, lists the hashes and sizes of the metadata files. Finally, timestamp lists the hashes and size of release; this is the first line of defense, because if release does not match timestamp's description, none of the other data is downloaded, as it is clearly compromised. Thusly, timestamp is frequently resigned and rechecked using an online key, so as to quickly alert clients to a possible attack.



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EXPLORATIONS IN ARTIFICIAL INTELLIGENCE PROGRAMMING

Artificial intelligence is loosely defined as the impression of intelligence in a man-made device. Applications of A.I. available today demonstrate the broad utility of this concept, but leave much to be desired. Present design focuses on so-called "weak" intelligence. This approach uses specially designed logical rules to make decisions and take actions that appear to imply reasoning or comprehension, but are in fact perfunctory responses. This contrasts with "strong" A.I. which, if successfully developed, would possess intellectual capacity similar to humans. This would vastly increase the viability of using A.I. to accomplish complex tasks. The goal of this project was to explore and implement theories which could form the base for future strong A.I. development.

The "intelligent agents" produced were given the task of solving a simple maze. This maze consisted of a 15x15 grid of "tiles" which could be marked as traversable, already traversed, or the goal tile. In the early stages of research, two weak A.I. agents were developed based on common searching algorithms: depth-first and breadth-first search. The depth-first search based agent explored the path it had chosen until it had no possible moves remaining before backtracking to the most recent intersection. The breadth-first search based agent explored all paths it encountered simultaneously, resulting in a more thorough but often overreaching search. The next agent favored paths similar to those it had already taken and, unlike the previous two, relied on an internal representation of the state of the maze when calculating its next move. The final agent was developed with emphasis on thought process, and altered its actions based on values representing mental properties such as focus, confidence, and emotion. This strategy has great potential for application to further reaching strong A.I. development.



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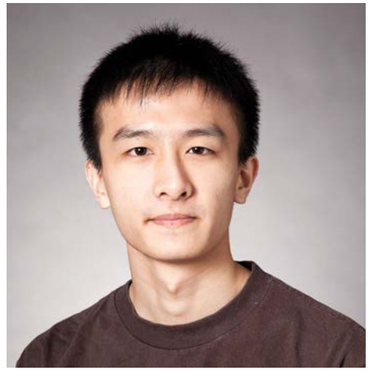
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ELECTRICAL AND COMPUTER ENGINEERING

MEDICAL DEVICES FOR SEIZURE DETECTION

Epilepsy is one of the most prevalent neurological disorders in the world, affecting over 70 million people around the globe. It manifests itself in humans as seizures caused by a brain malfunctions and as much as 5% of the world's population has experienced at least one seizure in their lifetime. It is imperative that a patient receives medical attention as soon as possible to prevent possibly life-threatening injuries to themselves or others. Until recently, seizures could only be detected after the fact. However, by monitoring electrical signals from the brain, a printed circuit board (PCB) was developed to aid medical professionals in detecting seizures before they occurred. The board serves as an intermediary between doctors and the patient's brain. Brain signals will be obtained from a surgically placed electrode array. For testing however, such signals are artificially generated to mimic a seizure. The array would transfer eight analog electrical signals from the brain to the PCB. The signals themselves are incredibly small, within the microvolt (μV) range, and must be amplified many times or they will be indistinguishable from electromagnetic and thermal noise in the environment. Amplification also allows the full resolution of an Analog to Digital Converter (ADC) to be used when transferring the signal to a seizure detection firmware algorithm. Samples of the analog waveforms and the results of the detection algorithm are transmitted via a radio frequency (RF) transfer protocol to a receiving board where they can be displayed on a graphical user interface for doctors and other medical professionals. The board was designed under rigid constraints, limiting the size and power consumption in the interest of the patient's safety and a prototype board was eventually fabricated.



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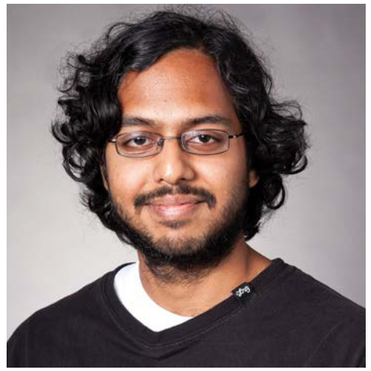
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MODELING AND COMPUTATION OF TRANSFORMER INRUSH CURRENTS

Transformer inrush current is the current across the transformer for the first period in which voltage is applied. This current is studied because when a voltage source is applied, a large peak of current is seen across the transformer. After the first period, the current reduces significantly into a steady-state. Therefore, we study this inrush current to understand it and possibly reduce the effects of it. Additionally, we study the phase hop. Phase hop is when the voltage source is switched off at half period and turned on again. Essentially eliminated half a waveform, we see two peaks of inrush current. However, the second peak is around two times the first peak. This is due to residual flux left over from the first peak of inrush current.

In the lab, we tested the effects of a gap in the transformer on the inrush currents. Using both simulations and measurements from real transformers, we were able to show that a larger gap in the transformers resulted in a reduced phase hop. We used software such as Maxwell and EMTP to simulate different gap sizes and compared them. From these, we performed measurements in the lab with various transformers and obtained relatively similar results. Additionally, we mathematically found a way to approximate the peak inrush current and phase hop of a transformer given its parameters. With these developments, further studies may show how to eliminate the phase hop further so power systems will not be impacted so greatly by such large current.



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UNMANNED AERIAL VEHICLE

Quadrotor UAV's (Unmanned Aerial Vehicles) are four-propeller platforms that offer many potential benefits to various end users due to their mobility and maneuverability. Due to their vantage point, they can be used as mobile surveying and tracking platforms, and thus lend themselves to a variety of civilian and military/law enforcement uses.

One caveat of the maneuverability of such vehicles is that they are inherently unstable, and conventional designs may be rendered uncontrollable by the loss of even a single propeller. Additionally, the use of commercial off-the-shelf electronics means that reliability of every component must be validated, and fail-safes and backups must be developed to cope with failures. Finally, the power consumption of a quadrotor with reasonable payload capacity may be quite high, reducing flight times: thus, efficiency (both electrical and mechanical) is paramount.

The objective of this project is to integrate a lightweight commercially-available quadrotor frame, brushless motors and controller electronics with a custom-developed autopilot unit, and further develop safety functions, along with homing and tracking capabilities to exploit the vehicle's vantage point. The controller developed for the vehicle is thus designed to be robust and tolerant of multiple failures, and is evaluated both in MATLAB and hardware-in-the-loop tests before final implementation in hardware. The hardware platform is a versatile embedded processing board, with dual processors and a variety of inertial, magnetic and pressure sensors built-in.



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GAIT AND POSTURE CONTROL FOR HIGH-PAYLOAD QUADRUPED ROBOT

This project focuses on the development of dynamic gaiting control algorithms for a quadrupedal robot with a large payload relative to its joint loading capacity. In particular, this study focuses on improving the trajectory and posture control algorithms currently running on a target legged platform. Ideally, this platform is to be outfitted to move quickly on flat-land terrain without sacrificing peripheral hardware or overall runtime.

The target platform for this study is an in-house designed quadrupedal platform, named "GreenFoot," with decentralized joint feedback and a large relative battery and onboard device payload. This platform will be utilized in the future for the development of rough terrain path-planning algorithms. The platform's upper-level sensory array includes a laser range finder (LIDAR) and two high definition cameras, processed by an on-board, upper-level computer. Having these mechanisms on-board makes the platform fairly top-heavy and thus more difficult to stabilize during walk cycles that employ exclusively pattern-driven, feed-forward gait generation and posture control methods.

To study the effects of dynamic joint loading during conventional four-legged gaiting cycles, a dynamical model of the GreenFoot platform has been generated using the Open Dynamics Engine (ODE) C++ API. The ODE simulation has been used to test potential gaiting and posture control methods, as well as to study dynamic joint loading during a variety of motion situations. The output of these simulations will be utilized to target joint overloading and thus guiding improvements to the platform's gait-generation and posture control algorithms. This study will also provide resolve on potential hardware considerations that must be made on the GreenFoot platform to ensure scenario adaptability in future projects.



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IMPROVED EEG DATA VISUALIZATION

Modern technology allows for unprecedented amounts of data to be recorded, from google search histories to dinosaur genomes. The information contains a wealth of insights but is increasingly difficult to manually process. In this work, innovative methods are developed for examining micro intracranial EEG datasets. The data contains seizure and non seizure dynamics that can be used to better understand how seizures begin, progress, and end naturally. However, this high resolution data, recorded at almost 300 Hz from 360 electrodes, is difficult to sift through for important patterns. Novel data visualization techniques allow the researcher to better understand the data by arranging it in accessible ways. This work improves an existing method by adding several new features. These features enable the user to quickly navigate to a specific data point and easily navigate its contextual datasets. Future work seeks to delve deeper into the data, illuminating new aspects that will lead to innovative anti epileptic therapies.



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MATHEMATICS

ANALYSIS OF MATHEMATICAL MODELS OF CZOCHRALSKI TYPE GROWTH PROCESSES

Mathematical modeling of industrial processes is an indispensible tool often necessary for the prediction of unforeseeable events and effects of various changes of controllable parameters in a process. The Czochralski method, first invented in 1916, has been proven as the most effective way to produce high purity crystal ingots in the silicon industry today. Our research surveys several models of the Czochralski process and attempts to generate a deeper understanding of the process through a combination of mathematical analysis and numerical computations of the various models. Mathematical models of the Czochralski process can be very complex. To simplify our analysis and focus our attention on the more fundamental aspects of the process we reduce the model by taking into consideration special cases and making simplifying assumptions on certain controllable parameters such as temperature and rotational speed. The models surveyed are represented by systems of partial differential equations. We will focus on the differential content of these equations. The differential equations are discretized and compared to the continuous models. We attempt to give an interpretation of the Czochralski process when a discretize model is used. The possibility of chaos is also studied in the discrete model.

DYNAMICS OF BPS EQUATIONS MODELING KINK SOLITONS IN A MONOPOLE CONFINEMENT PROBLEM

The objective of this paper is to model kinks solitons constructed in the recent study of Chen, Li, and Yang of a monopole confinement problem in N = 2 supersymmetric QCD. The model will describe two quarks that interpolate pairs of confined monopole vacua through 2 strings. It will satisfy the confinement property, which states that the force between quarks will never decrease with the increase of distance.

In order to model the kink soliton, we will use the Euler-Lagrange equation on a functional that describes the kink energy of the system in terms of the monopole moduli space coordinates. The Euler-Lagrange equation will help us find a lower bound for the energy, as well as a set of second order differential equations for which that stationary point is satisfied.

We will then use the Bogomol'nyi-Prasad-Sommerfield, or BPS, bound in order to find the lower bound of the kink energy which will occur when certain first order differential equations that are satisfied. As shown by Chen, Li, and Yang, the solution pair to the Euler-Lagrange equations will also be a solution to the BPS equations.

We will discretize the first order differential equations and investigate the behavior of this system. We will model the system using various methods, check if chaos appears, and finally, see if the discrete model converges to the continuous solution that was presented in Chen, Li, and Yang's paper.



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A FLOWER-POT INTERPRETATION OF NUTRITION IN TUMOR GROWTH

The application of mathematical concepts to cancer biology is an exciting field full of challenges. The objective of our research is to attempt to simulate and reinterpret tumor growth using a "Flower-Pot Model" proposed by Shnerb and studied by Yang and others. The "Flower-Pot Model" is used to predict the growth of vegetation when being supplied with water. We re-interpret the flower-pot model in terms of the mass of a tumor and a nutritional source. The dynamical analysis of the flower-pot model indicates two final states, one being a vegetation state and the other being a desert state. The equilibrium points are globally stable, meaning that convergence is independent of the initial conditions. Synonymously, our interpretation of the "Flower-Pot Model" in terms of tumor and nutrition can result in two different states, tumor state or sinkage-state. When an abundant nutrition supply is available this model predicts that the tumor will grow and result in a tumor state. On the other hand, when the tumor biomass is lacking in nutrition the tumor will result in sinkage-state. In practice, it is the simple models that are used to form the foundation of applied biological modeling. In this respect, our research direction focuses on using a well understood model and applying it to tumor growth. Our mathematical model will help us identify two things, one being the mass of the tumor and the other being the time when chemotherapy should be applied to the tumor.



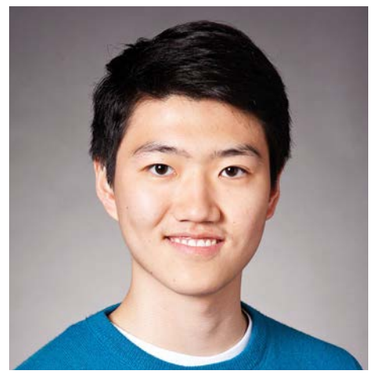
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NONLINEAR DYNAMICS IN MODELS OF OSCILLATORY CHEMICAL REACTIONS

Chemical oscillations occur when the chemical system is far from equilibrium and the concentrations of the intermediates start to fluctuate. The nature of oscillations in chemical systems has fascinated many people and has captivated them towards their exploration primarily in the 1900s. In this paper we will mathematically analyze different types of oscillating reactions through nonlinear mass action dynamic laws or rate equations and will discuss the work previously done on them.

We shall present the differential equations and rate constants that describe such models; starting with basic models such as Lotka-Volterra, and continuing with models associated with the Belousov-Zhabotinskii reaction such as the Oregonator.

We then study the dynamics of the continuous models and in some special instances a derived discrete model. We pay particular attention towards the “black box” model. In all instances, the models describing the oscillating chemical reactions are systems of first order ordinary differential equations. We focus our study on the qualitative properties of these systems. We classify the systems as chaotic or not and numerically study its chaotic dynamics. Finally, we will discuss other relatively new oscillating reactions that are worth noting.



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MEMS ACTUATOR ANALYSIS

Microeltromechanical systems (MEMS) are of great and increasing importance in current and future technologies. MEMS devices are used for a variety of applications including inkjet printers and accelerometers, which are used in a plethora of consumer electronic devices. These delicate systems need to be carefully modeled mathematically to ensure that they do not collapse during the fabrication process or any later time. Here we analyze two undamped parallel plate electrostatic actuators. Electrostatic actuators are used in MEMS applications as switching mechanisms. The first of these that will be considered is a micro-scale electrostatic actuator ruled by electrostatic and elastic forces. The second of these that will be considered is a nano-scale electrostatic actuator. On the nano-scale there is an additional force that needs to be considered- the Casimir force. The Casimir force is a quantum effect that arises from the quantized states of virtual photons that exist in quantum vacuum fluctuations, and is only noticeable for practical purposes on very small distance scales. Due to the arrangement of the system being considered, the Casimir force is attractive between the plates. Insights gained from the analysis of the simple micro scale actuator will be applied to the more complex analysis of the nano scale actuator. The goal of this analysis is to create a framework that will successfully describe the dynamics of motion of undamped parallel plate electrostatic actuators with the Casimir force in consideration.



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COMPUTER ANIMATION OF A CONVEX BODY AND OTHER CONVEX BODIES NATURALLY ASSOCIATED WITH THE BODY

The geometric measurements of convex bodies are a major contributor in many areas of mathematics and thus have become a study of its own. As the convex body changes shape, the change in measurements allow for a generalization of when the body reaches its maximal and minimal values on particular quantities naturally associated with the body. In order to create a visual representation of the changes described, animations are created to visually analyze the change in the bodies and measurements, and to test the validity of known theorems and conjectures.

Particular shapes of interest include the Lp Ball and the Ellipse where their two and three dimensional equations are as follows:

L_p Ball:

2 *Dimensions*:
$$(|x|^p + |y|^p)^{\frac{1}{p}} = 1$$

3 *Dimensions*:
$$(|x|^p + |y|^p + |z|^p)^{\frac{1}{p}} = 1$$

Ellipse:

2 *Dimensions*:
$$\sqrt{a^2x^2 + \frac{y^2}{a^2}} = 1$$

3 *Dimensions*:
$$\sqrt{a^2x^2 + a^2y^2 + \frac{z^2}{a^4}} = 1$$

As the shapes change form due to the amendments in the value of (p) from one to infinity in the case of the Lp Ball, and value of (a) from zero to infinity in the case of the Ellipse, the area and perimeter of the shape are numerically calculated when working in two dimensions. In three dimensions, the volume and surface area are instead calculated. With these two quantities accounted for, the validity of the Isoperimetric Inequality is tested in two and three dimensions where the general inequality is as follows:

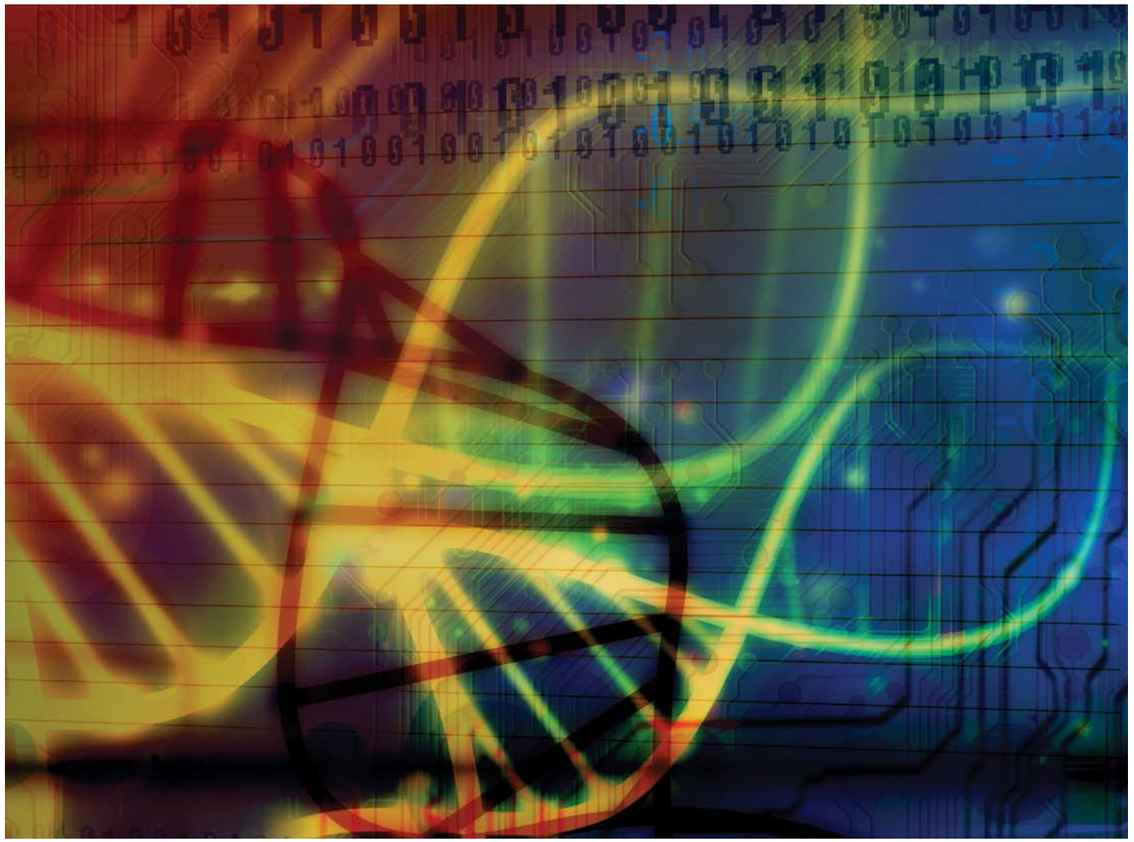
$$\frac{(V_n)^{n-1}}{(A_n)^n} \leq \frac{\Gamma(\frac{n}{2}+1)}{(n\sqrt{\pi})^n}$$

Where V_n and A_n represent the n-dimensional volume and surface area respectively, n represents the dimension, and $\Gamma(x)$ represents the gamma function.

MAHALANOBIS-TAGUCHI SYSTEM: ANALYSIS OF RISK VARIABLES

The Mahalanobis Taguchi System (MTS) is a binary classification system that incorporates multi-dimensional statistics with industrial engineering practices to determine key variables. The Taguchi aspect of MTS allows us to simulate many different scenarios, maximizing the variety of variable combinations while minimizing computation time. MTS is particularly useful when there are a large number of variables, e.g. medical applications. Many diseases that have the same genetic mutations can result in widely different diagnostic outcomes. The same mutation can result in a different expression of the gene and thus different progression of the disease. Environmental and lifestyle factors are thought to contribute to the differences and are currently of great interest to researchers. Cystic Fibrosis is a prime candidate for analysis by MTS. A long term part of our project is to apply MTS to Cystic Fibrosis patient data, which has the potential to correlate different lifestyle factors with the severity of this disease and to improve patient treatment.

Using the 'medical' model, MTS can be applied to analyze multiparameter problems that arise in urban environments. MTS will be applied to NYC Open Data with the aim of exploiting the ability of MTS to tackle data sets with a large number of variables. Experiments will be run to identify non-obvious 'risk' factors involved in creating 'healthy' vs 'unhealthy' urban situations. An automated program has been created to streamline the data analysis process. This will enable us to run more experimental scenarios in a shorter period of time.



The Mahalanobis Taguchi System (MTS) provides a powerful process for recognizing patterns and forecasting results. Taking cues from statistics and industrial engineering, it supports simulations of problems with a large number of variables. NYU-Poly student researchers are exploring its applications in areas such as genetic mutations in disease, as well as complex urban environmental issues.



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AN INVESTIGATION INTO THE MECHANICAL PROPERTIES OF CEMENT/GLASS MICROBALLOON SYNTACTIC FOAMS

The use of cement is widespread, and techniques on improving its load bearing ability and weight are being sought after. There have been a lot of techniques tried to develop lightweight cement based material. Lightweight cement based materials are designed to have a higher damage tolerance, significant compressive strength and be more thermal insulating. This research focuses on designing lightweight cement composites with both significant compressive strength and thermal insulating properties using carefully engineered glass microballoons that provide the required cenospheres in the cement matrix. Compressive properties of hollow particle-reinforced cement composites are studied using quasi-static and high speed compression testing. Glass hollow particles of three different wall thicknesses have been implemented (that have respective densities of 220, 320 and 460kg/m^3). The Modulus of elasticity was determined in each case and then correlated to both the volume fraction and density values of each sample. Within each density-specific test, different percentages of glass microballoons were incorporated (in our case 30%, 40% and 50%) along with a control group that contained only cement.

The results as expected, showed a linear relationship in significant reduction of the density of the cement composites as more glass microballoons were incorporated in the cement matrix. The modulus of elasticity of the composites also varied in a linear relationship depending on the volume fraction and the density of the glass microballoons used in the cement composites. The results can therefore be used to determine the kind mix design is ideal for a specific kind of job depending the percentage of weight reduction required and the desired compressive strength.



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DEVELOPMENT OF LIGHTWEIGHT POLYMER COMPOSITES

The demand for increasing fuel economy, payload capability and safety is constantly increasing in the automotive, aerospace and military fields. To satisfy this demand, weight saving porous structural composite materials can be used. Although porous materials help in weight saving, their drawbacks include lower mechanical properties and dimensional stability at high temperatures. Selectively reinforcing the pores can limit these disadvantages. An innovative method of reinforcing the pores is to use thin walled stiff hollow particles to embed porosity in the composite. The composites formed by dispersing hollow particles in a matrix medium are called syntactic foams. They are closed cell foam composites which can be tailored by selecting appropriate material combinations and proportions of the filler and matrix materials. The two parameters identified to tailor these composites are the volume fraction of the hollow particles used (Φ) and the wall thickness of the particles.

In the current study, silicon carbide (SiC) hollow particles are embedded in a vinyl ester matrix resin. Quasi-static compression and thermal expansion behaviors of the syntactic foams are characterized. Two different SiC particles of densities (440 and 790 kg/m^3) in 0.6 volume fraction are utilized in the present study. Theoretical models accounting for the Φ and wall thickness of the hollow filler are utilized to make theoretical estimates for the composites and are compared with the experimental results. The ability to tailor the properties of the material is an important asset for engineering structures because it can be used for weight reduction and improvement in safety.



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CARBON NANOFIBER REINFORCED LIGHTWEIGHT COMPOSITES FOR MARINE AND AEROSPACE STRUCTURES

This research aims to develop lightweight materials for use in marine and aerospace applications. These applications demand a material which can withstand extended exposure to water at temperature extremes, while under varying load. Boats and submarines require a buoyant material that can withstand long term exposure to water and high pressures. Exposure to water can lead to moisture penetration within the composite and degrade the material, causing it to lose strength and stiffness. When a material better retains its original properties after moisture exposure, it allows for a longer service life and more predictable behavior during service use.

This project examines the effects of moisture absorption on carbon-nanofiber (CNFs) reinforced epoxy composites. Glass hollow particles are used in conjunction with CNFs to develop naturally buoyant lightweight composites, called syntactic foams. CNF volume fraction, and hollow particle density and volume fraction are the study variable. Flexural testing was performed on these specimens before and after two weeks of immersion in high temperature water. By bridging cracks, the carbon nanofibers help retain some of the strength and material longevity lost due to degradation of the epoxy and glass microballoons, without greatly increasing the density of the material. The goal of this research is to make an optimal material for use in aerospace and marine vessels which will retain its strength even after long-term exposure to wet environments. The lightweight nature of these materials makes them attractive in applications where fuel economy, payload, or performance are important.



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ADVANCED COMPOSITE MATERIALS WITH LOW THERMAL EXPANSION FOR ELECTRONIC PACKAGING APPLICATIONS

As the digital world grows and expands, more and more high-performance computers and other electronics are being used by consumers everywhere. However, a problem that occurs quite frequently with these devices is overheating. Within the structure of the electronic packaging of any device, there are often connections between materials with varying coefficients of thermal expansion. If the differences between the coefficients are too high, it can be a cause for failure to occur over time. Thus, it would be ideal to minimize the thermal expansion that occurs, or reduce the difference in thermal expansion between the two adjacent components. In addition to having a low coefficient of thermal expansion, it is necessary for the material to be thermally conductive in order to dissipate heat properly and combat overheating.

In this study, thermo-mechanical analysis of aluminum alloy infused with silicon carbide hollow spheres is performed. Because the spheres are hollow, it also reduces the weight of the material. The samples for this research study are supplied by a manufacturer. Each sample is placed inside a furnace chamber with a probe that measures its length. Then, the temperature inside the chamber is increased, and the size of the sample is recorded to see how much it expands. The coefficients of thermal expansion are then calculated. Upon analysis of the different coefficients, it is discovered that the past a certain temperature, the aluminum alloy will expand further than the silicon carbide balloons. The ability to control the thermal expansion and weight of any material is vital to manufacturing and producing electronic products.

▼ Sandy Shen and Professor Nikhil Gupta





JOSEPH QUACINELLA

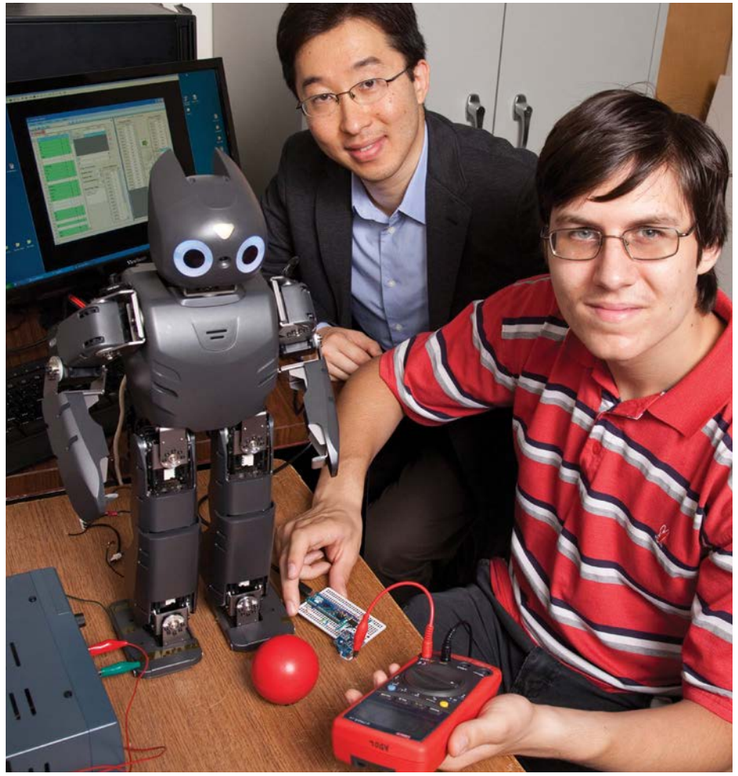
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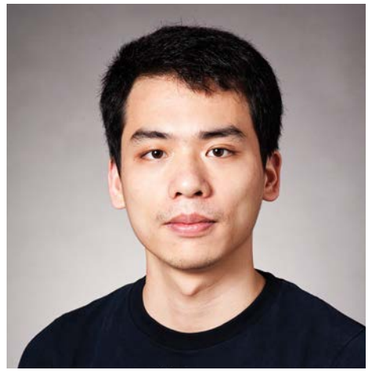
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DEVELOPING ALGORITHMS TO IMPLEMENT ENERGY EFFICIENT WALKING IN HUMANOID ROBOTS

The objective of this project is to monitor the energy consumption of robotic gait, and to modify the gait to consume less energy. The DARwIn-OP (an open hardware humanoid robot) uses a lithium polymer battery, which is only able to provide power for 30 minutes. Most other humanoid robots are also unable to operate for long periods of time. This is because walking consumes a lot of energy. Humans effectively fall and catch themselves with each step they take. This is an unstable but yet energy efficient gait. Developing unstable gaits for humanoid robots still remains a challenge.

In order to monitor the energy consumption, one must first determine the current and the voltage used in each of the robot's actuators. Monitoring the voltage is done simply by exporting the value from the internal sensor. Monitoring the current involves measuring the voltage drop across a current sensing resistor, and recording the value onto the Arduino board.

In order to edit the robotic gait, one could use RoboPlus Motion, a program developed to create custom movements for the DARwIn-OP. After specifying the angles for all the actuators at each specified instance in time, the robot would precisely act out the movements. The angles used for the robot are obtained from human subjects. By attaching sensors to the joints of humans, the angles could be recorded onto a computer and read into the program.

Although this research is primarily for humanoid robots, the energy consumption data could help to better understand the energy consumption of human gait.

ANALYSIS OF CARBON-BASED POWER PLANT OPERATIONS

The United States has one of the largest recoverable coal reserves in the world and has been dependent on coal-fired power plants for nearly half of the country's power needs. Simulating the processes and operations within a coal-fired power plant sheds light on its efficiency and performance. The startup processes of coal-fired power plants are very complicated tasks that require certain parameters to be met to fulfill the balance of plant systems. Startup is categorized as cold, warm, or hot cases, depending on the number of hours-after-system-shutdown. Each case of startup shall meet the predetermined ratings starting from boiler on to 100% steam turbine load. The minimization of startup time required to reach the turbine nominal continuous rating (TNCR) load proved to be critical in the reduction of wasteful fossil fuel consumption and the maximization of the plant's efficiency.

In this research activity, the overall performance of a sub-critical pulverized coal (PC) power plant designed to net a power output of 560 MW was modeled in MATLAB in order to simulate and analyze the efficiencies of the power plant's thermodynamic and systematic processes. The sub-critical PC power plant performs a net maximum efficiency of 36%-40% when steam turbine load reaches and maintains its TNCR value, where the turbine speed is 3000 RPM with a gross power output of 620 MW.

A generalized Simulink block diagram model of a coal-fired power plant was created to characterize major system parameters such as main steam pressure and temperature, reheat steam pressure and temperature, steam turbine speed, steam turbine load, high pressure steam bypass valves, auxiliary power consumption, and the flow rates of main steam with respect to the fuels supplied such as coal and heavy fuel oil into the sub-critical PC steam generator (the "boiler," in this case). Custom MATLAB S-Function blocks as well as MATLAB GUI toolbox are exploited to provide various visual outcomes such as auxiliary power consumption vs. fuel consumption, heavy oil flow, coal flow, and steam flow vs. time.



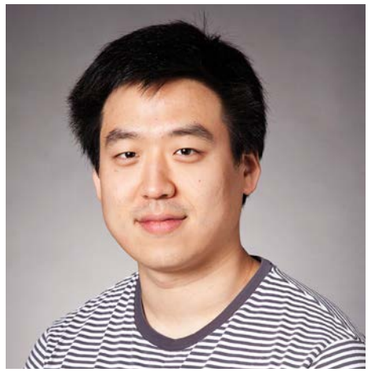
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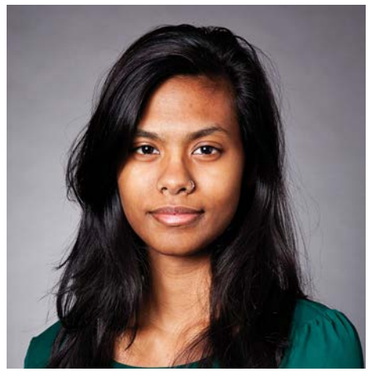
DEVELOPMENT OF AN UNMANNED QUADRICOPTER FOR ENVIRONMENTAL FLOW OBSERVATIONS

Today's experimental methods of monitoring surface water flows rely on the use of sensing devices and probes which tend to provide local rather than distributed information on the flow physics. For instance, Large-Scale Particle Image Velocimetry (LSPIV) is based on the use of remote cameras which capture images of tracers or objects floating on river surfaces. Images are then geo-referenced and analyzed to reconstruct flow velocity maps at specific river cross-sections. To alleviate LSPIV's spatial limitations and inaccuracies due to image calibration, this project entails the design, development, and testing of an aerial vehicle for nonintrusive and distributed surface water monitoring. Specifically, a quadricopter that integrates a digital camera and onboard lasers for image orthorectification is designed to monitor large areas.

The quadricopter is engineered to be lightweight, low cost as compared to those currently on the market, and highly stable to guarantee minimal vibrations and, therefore, accurate flow measurements. This is achieved by selecting a large arm span with a high-wing configuration and a custom-built camera gimbal to maintain the orthogonality of the lens with respect to the water surface. The vehicle is controlled via the Ardupilot, an open-source platform, and is used to develop flow velocity maps in the Gowanus Canal, Brooklyn.

▼ Professor Maurizio Porfiri and students working on the quadricopter





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PREFERENCE TEST ON ZEBRAFISH RESPONSE FOR FISH REPLICA SIZE

The integration of robots into animal behavior studies has several advantages including generating high-throughput data, controllable stimulus presentation, and repeatable responses. The developing field of Ethorobotics covers such aspects as using animals in studies of their behavior. Robot design itself, however, is constrained by the size of onboard electronics and servo motors. Therefore this project studies how the size of a bio-inspired robot modulates fish behavior.

Live zebrafish are tested in a dichotomous choice test to study the variations in different behaviors with respect to robotic replicas of different sizes. External servomotors are programmed and attached to the robotic replicas to mimic motions of live fish such as undulating, and covering the available tank region. Individual fish are tracked throughout the trial to extract position and velocity data and quantify spatial preference and behavior. Four experimental conditions that vary the size of the replica (2, 3, 4, and 6cm) are compared with two control conditions: a live fish and no fish presented as choices. The results from this study will help us in designing future robotic fish to maximize modulating live fish behavior.



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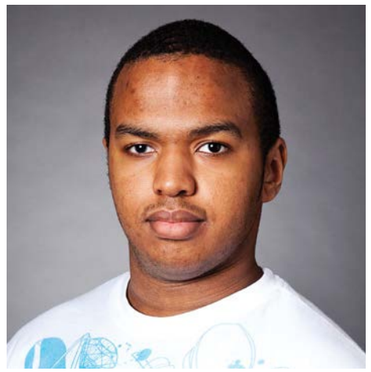
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EXPERIMENT FOR ENERGY HARVESTING FROM BIOMIMETIC FISH TAIL HOSTING PIEZOELECTRIC

This project focuses on energy harvesting through piezoelectric beam undergoing the oscillatory motion of a flapping biomimetic shark tail in an aquatic environment. A micro-fiber-composite (MFC) is selected as the base material for the piezoelectric beam. An MFC is a novel type of piezoelectric material invented at NASA that produces electricity via an electromechanical response. The results of this project may aid in determining the feasibility of harnessing energy generated from the motion of fish to power embedded communication and tracking devices placed on them. This may increase the lifetime of such devices as their batteries will not have to be replaced.

The experimental setup, which includes a biomimetic fish tail, is focused on testing the various base excitation amplitudes and frequencies to study the hydrodynamic effects on the tail and piezoelectric beam. The motion of the tail is controlled via a servo motor programmed using an Arduino microcontroller. This is used in conjunction with an external gear train to allow for precise adjustments in the base excitation amplitude. The mount for the apparatus is fabricated via a 3D printer.

The voltage signal produced by the piezoelectric material during the beating of the biomimetic fish tail is measured. From these results, the resonant frequency of the tail is determined and a power analysis by load resistance is conducted. Finally, the ability to self-power a wireless communication is tested by implementing a rectifying circuit module and RF communication module.



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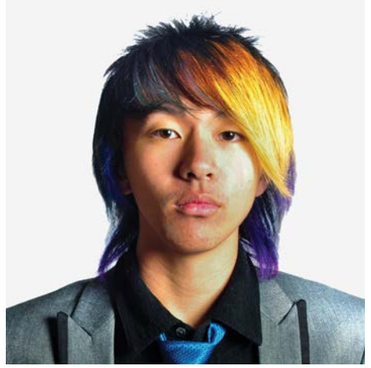
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DESIGN AND DEVELOPMENT OF A PORTABLE RAINFALL SIMULATOR FOR RAIN FORMATION AND PATTERN ANALYSIS

Rainfall measurements, such as rain drop size distribution and velocity, are typically performed by using optical disdrometers. These devices use a laser beam coupled with sensors that measure voltage loss in the beam due to drop extinction (a combination of light absorption in the drop volume and scattering from its surface). Even though capable of collecting large amounts of rainfall data for extensive period of times, disdrometers can be affected by a number of drawbacks such as extensive calibration and inaccuracies in inferring drop size and intensity from voltage reduction. Taking inspiration from optical flow visualization methodologies, this project assesses the feasibility of directly measuring rainfall through the image analysis of simulated precipitation captured with high-speed cameras

Specifically, a rainfall simulator and an optical acquisition setup are designed to simulate and study different kinds of rainfall by varying drop velocity, size, and intensity. Solid soda-lime glass particles are used as raindrop substitutes to reduce complexities in image tracking due to hydrometeor deformations while keeping optical properties (index of refraction) comparable to water. The versatility of the simulator allows for experimenting with a single to multiple beads falling from adjustable heights. Simple particle tracking software platforms are used to detect the particles, trace their motion, and estimate their velocity. Comparisons of experimental results to theoretical computations provide sets of values for camera settings, bead diameters, and drop velocities that guarantee the efficiency of the methodology.



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TECHNOLOGY MANAGEMENT AND INNOVATION

BROOKLYN ATLANTIS: EXPERIMENTS IN HUMAN-COMPUTER INTERACTION

Brooklyn Atlantis is a unique, multi-faceted project that solicits genuine collaborations from programmers, mechanical engineers, artists, and the environmentally-minded community. Originally created to gather environmental data from the Gowanus Canal, one of the most polluted bodies of water in the United States, Brooklyn Atlantis quickly developed into a full-blown ‘citizen science’ project that taps into the social phenomena known as ‘crowdsourcing,’ where the bulk of the research can be conducted by non-professional individuals from the local and online communities. With the online aspect of Brooklyn Atlantis, private individuals are able to create accounts on the Atlantis website and tag photos taken at the Canal, whilst learning more about its polluted waters.

At the front-end of Brooklyn Atlantis are a collection of amphibious vehicles and retrofitted boats, each equipped with underwater sensors that gather important pieces of environmental information such as water quality, water temperature, and dissolved oxygen levels, amongst other data types. These aquatic constructs are further equipped with cameras and GPS devices that allow us to display sensor data visualizations based against both time and location in the Canal. By integrating data visualizations with online community-based tagging, Brooklyn Atlantis hopes not only to study the Gowanus, but to understand how data visualizations, user-interface designs, and technical capabilities on the website can influence human interactions and involvement in this project, and in all projects as a whole.



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CREATING A WEBSITE FROM PIECES OF THE INTERNET

With the rapid evolution of and contribution to the internet, creating an app or a website from scratch has become a vain task. Programmers everywhere have already constructed environments and libraries intended to allow application designers to feel less back-end driven. In light of these libraries, designers need worry less about how to implement their work and can instead use what is readily available to express their creative genius. Open source tools are perhaps one of the greatest contributions to the cultivation of the world wide web.

In any website, the foremost component is the HyperText Transfer Protocol (HTTP), and this is the core comunication between the user client and the server. Of course, the HTTP is assisted by several other languages such as CSS (web styling) and Javascript (web control). Beyond these, necessary for any professional website is a database management system such as MySQL/PHP. A database contributes by storing and saving user data, as well as fetching any large amounts of information. Websites commonly use databases in areas such as user encrypted passwords as well as survey data.

That said, PHP is only one of the several languages used to manage the database end of a website. What is currently used to create this summer research's website is Ruby, with the assistance of Rails. In many cases, Ruby on Rails is preferred over PHP because of its organization by use of programming conventions. Ruby on Rails is the preferred language for this summer's project as it assists the fluency of the photo-sharing site.



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EXPERIMENTS IN HUMAN COMPUTER INTERACTION

As the pace of technology accelerates the capability to experiment and test hypotheses becomes more accessible: modern researchers can easily utilize what were once prohibitively expensive and complicated means to achieve their goals. However, for many tasks, researchers find themselves requiring the use of human hands, eyes, and minds to accomplish often mundane feats that nonetheless would challenge the capabilities of the average computer. Citizen science, a method wherein enthusiast volunteers are asked to contribute some effort to further scientific research, is an effective means of sifting through staggering numbers of samples or simply creatively contributing in ways that technology could not hope to accomplish. However, many such projects are plagued by a lack of volunteers: the average person will not take to time out of their day to contribute in even trivial ways.

This project was aimed at reducing such apathy by studying how users respond to different options and settings available within digital user interfaces. The main focus, Brooklyn Atlantis, is a multidisciplinary project where an aquatic robot is sent to explore, photograph, and take measurements of water quality from the ecologically damaged Gowanus Canal. The photos are then made publicly viewable on the Brooklyn Atlantis website, where users are asked to participate by tagging the photos to help identify significantly polluted or otherwise interesting locations in the canal. The website has different options available for different users and logs the time users spend on the website and how actively they tag photos and participate in the community, which will be used to determine which factors most encourage volunteer participation in the project.

Another, newer project involves a mobile application that is being designed for use by the elderly. This project will explore how participation can be fostered in that particular demographic, stereotypically assumed to find technology (such as the interfaces involved in citizen science) difficult to use.



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TECHNOLOGY, CULTURE AND SOCIETY

PROMOTE PHYSICAL ACTIVITY IN DEVELOPING COUNTRY

Nowadays, various developing countries are in the rapidly process of urbanization. Growing cities in those countries face rising rates of overweight, obesity, and physical inactivity among its citizens. In developed countries, research related active design has begun, which tied to obesity epidemic. Research has grown in developing countries to find more effective strategies to solve the issues. Also, recent research indicates their unique characteristics and challenges. For research already conducted about China, it shows the highest risk in China's rapidly growing cities and urban populations. And current urban development practices and policies in China heighten this risk. These include policies that support decentralization in land use planning; practices of neighborhood gating; and policies and practices tied to motor vehicle travel, transit planning, and bicycle and pedestrian infrastructure.

This summer research, for further study, would focus on literature review about articles related to developing countries. By reviewing and measuring classified articles, finding the relationship between the built environment and the situation of physical activities to identify planning and design strategies that support different kinds of physical activities in various high-density cities. From the cities' unique characteristics and researches conducted in developed countries, we identify those successful strategies to increase physical activity in another growing. Also, we focus on some key issues facing specific countries or groups of countries in order to find more effective and practical strategies to increase physical activities in cities, and to help urban design in the future.



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INTERNATIONAL HISTORY OF THE INTERNET

Although the internet has become an integral part of our day-to-day life, the truth about its origins is still mostly ambiguous and disputed. Most accounts claim that the internet was born in the United States under a large political scheme which did not have global communication in mind. However, given the nature of the internet, it is hard to believe that the it would develop without global collaboration. For that reason, this research focuses on the introduction and development of the internet in the Middle East, Jordan to be specific. Depending mainly on primary resources, this research shares the accounts of the experts who were responsible for introducing the internet to Jordan in an attempt to uncover any underlying international collaboration that might prove the hypothesis that the internet in not necessarily an exclusive ingenuity.



COLLIN GRUBBS

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DIGITAL HUMANITIES: STEINFINDER

SteinFinder is an explorative, location-based application built with the Layar framework in which sets of data points about Gertrude Stein are plotted and sorted in a variety of useful ways. Mobile users have the ability to submit new points, discuss and analyze existing information and view her work as a whole within a meaningful context. Publications, biographical information, archival resources, and user submissions are all part of a web of content designed to grow and mature over time. SteinFinder creates a platform for interaction and discovery within the humanities for the average person and allows connections to be made with this material from anywhere by anyone, while maintaining the potential to be a launchpad for more scholarly contribution and discussion simultaneously.

Some of the key aspects of creating an application like SteinFinder that can be successful are the design and implementation of a simple graphical user interface and making features as intuitive and interactive as possible. Interfaces that are overwhelming or confusing result in a disconnect with the user, and discourage them from further or in-depth activity with the program. Here the project has been considered from a visual analytics approach as an attempt to make the digital humanities more appealing and to provide a proof of concept for a meaningful use of the tools available in a digital format beyond storage and display. This project can lead to new conclusions about humanities topics by facilitating further analysis.

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INGENUITY IN ISOLATION: POLAND IN THE INTERNATIONAL HISTORY OF THE INTERNET

The Internet is often simply considered an invention of the United States. However, this disregards both the global nature of the internet and the infrastructural developments that were necessary on national levels in order for the internet to be implemented. Although networking technology was first implemented by the Advanced Project Research Agency, many of the core concepts behind the Internet, such as packet switching, have international roots. What is more, the Internet is about connection and so it requires the independently developed foreign networks of the international community for its function.

The goal of this project is to analyze early network development in Poland. Poland was chosen because it presents an interesting case study of network development concurrent to the development of the Internet but separated technologically through the CoCom trade embargoes on high technology and telecommunications technology to members of the Warsaw Pact. To analyze the technical developments of early network development in Poland and the cultural influence on the network's uses, documents pertaining to the topic have been found, compiled, translated, and analyzed.

After combing through numerous information technology periodicals, FidoNet newsletters, and other assorted sources, a number of developments, potentially unique to Poland, have been identified. Among them, a radio modem, which was developed to deal with the unreliable telecommunications infrastructure in Poland, and the use of computer networks to protest communist propaganda. Further work will need to go into examining possibly broader implications of these developments.

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