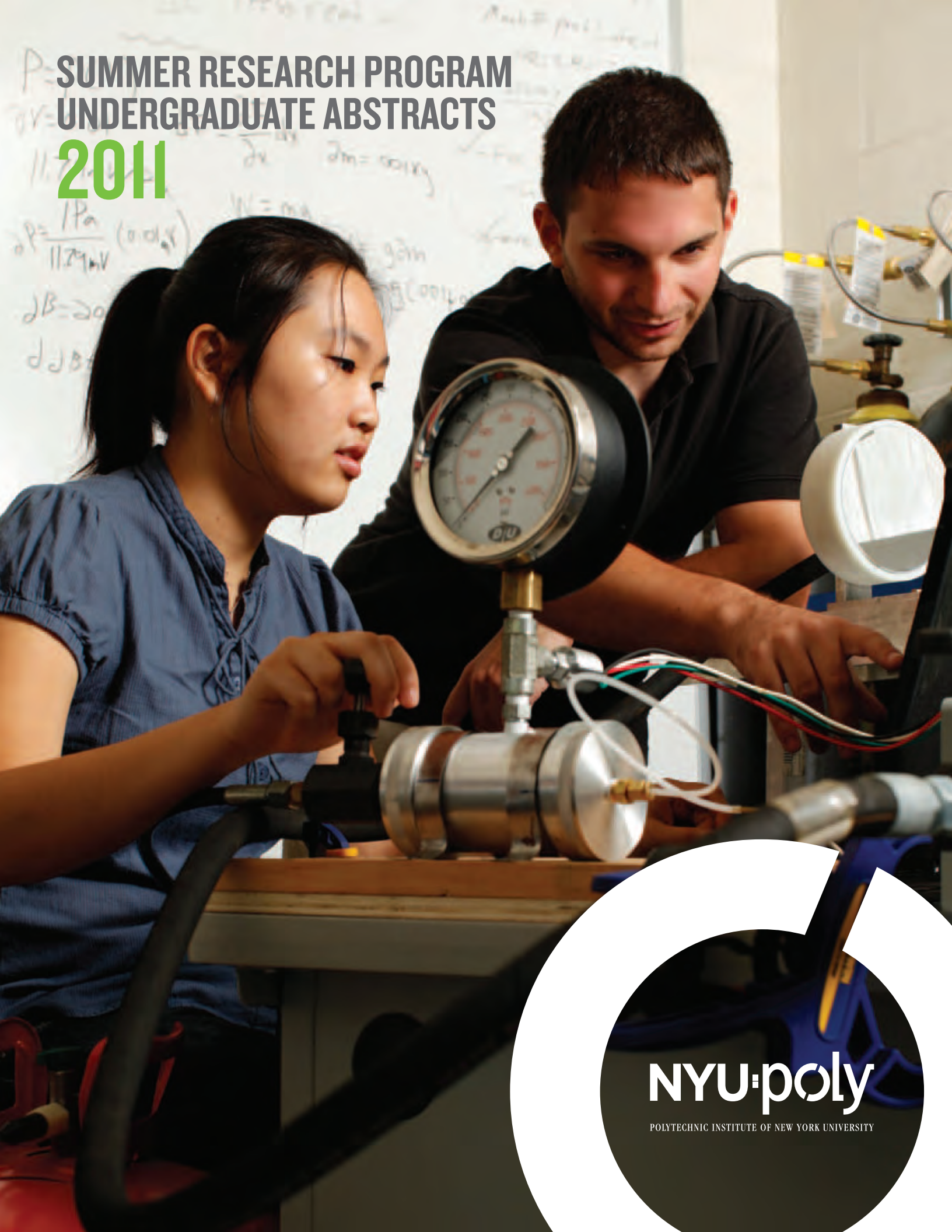
SUMMER RESEARCH PROGRAM UNDERGRADUATE ABSTRACTS

2011



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POLYTECHNIC INSTITUTE OF NEW YORK UNIVERSITY



SUMMER RESEARCH PROGRAM UNDERGRADUATE ABSTRACTS

FIFTH ANNUAL NYU-POLY 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, for the first time this year, NYU Abu Dhabi students to get involved in research during the summer. This program offers students far more than the traditional classroom experience by allowing them to work alongside faculty mentors on cutting-edge research projects. Close interaction with faculty and research staff provides students with an education experience that promotes 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 students' knowledge bases by applying classroom learning to solve practical and contemporary problems and to better prepare them for lifelong learning.

Summer 2011 was the fifth year of the Undergraduate Summer Research Program. Since its inception, 164 students and 102 faculty have participated in the program. In addition to their work in the labs, students attended seminars in which faculty members and guest speakers discussed their own research and areas of expertise. Additionally, the students presented their works-in-progress to the other members of the research cohort at a special lunch dedicated to practicing presentation skills and fostering inter-group collaboration on current and future projects.

The program was an initiative of Institute Professor Erich Kunhardt and Associate Provost Kurt Becker, who have played a vital role in making the program possible since its inception. NYU-Poly's faculty participation in this program was essential, as was the financial support from many faculty mentors and the Polytechnic Institute of NYU's Board of Trustees. The generosity of several alumni donors has also propelled the program's success. I'd like to thank Joseph G. Lombardino '58Chem, James J. Oussani '77ME and Harry C. Wechsler '48CM for their generous support of this year's program.

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 Convocation on August 29, 2011.

I congratulate all of the student researchers who participated in the 2011 Undergraduate Summer 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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CHEMICAL AND BIOLOGICAL ENGINEERING

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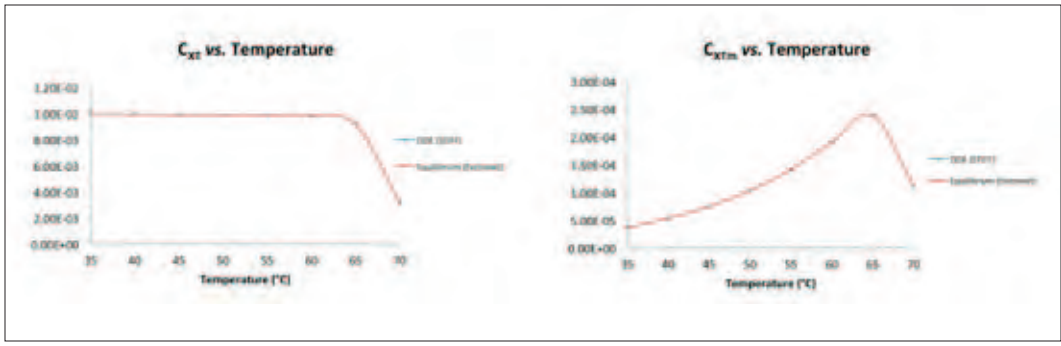
NYU-Poly

MODELING COMPETITIVE SURFACE HYBRIDIZATION OF DNA 20-MERS

An important area of DNA research is related to the medical field. There have been many links made between gene sequences and a person's genetic susceptibility to specific diseases and response to treatments. This is a great discovery to further human health, but to implement these advancements technologies must be created which accurately and efficiently identify gene sequences.

One current method for identifying gene sequences uses a technique known as surface hybridization. It consists of surface-immobilized DNA probe molecules that bind to other DNA molecules that are present in solution. It then uses fluorescent readouts to chart the degree to which hybridization took place. This process can prove to be time-consuming and inefficient. This is because of the possibility that the probe DNA molecule does not bind to the most complementary target DNA in solution, but rather binds to a somewhat mismatched sequence. These "mismatched" surface sites must then be allowed time to break apart and the probe DNA given a chance to bind to the correct, "matched" sequence. This significantly lengthens the procedure time and lowers the accuracy of the results.

This study attempts to devise a mathematical model for competitive surface hybridization of DNA using a perfectly matched (PM) 20-mer duplex and a single mismatch (MM) 20-mer duplex. Polymath v5.1 was used to model the hybridization kinetics at different temperatures using thermodynamic data obtained using the Nearest Neighbor Model on the UNAFOLD server. The hybridization kinetics is defined by two ordinary differential equations with respect to time and is solved using the STIFF approximation until time approaches infinity. Results show that the hybridization of a perfectly matched duplex is more favorable than a duplex with a single mismatch at all temperatures. To verify these results, the hybridization kinetics was also solved using an equilibrium model using two nonlinear equations. The next step for this research group is to perform dimensionless analysis to identify significant parameters that affect the equilibration time. This research could lay the foundation to developing a mechanism that would achieve faster hybridization of PM duplexes.



Diagrams by Matthew Arroz and Melissa Pona for Modeling Competitive Surface Hybridization of DNA 20-mers



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Chemistry/2014

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THE PRODUCTION OF AN OLEIC DIACID-DERIVED BIOLUBRICANT AND THE EFFECT OF VARIOUS ALCOHOL LENGTHS AND DEGREES OF BRANCHING ON LUBRICANT PROPERTIES

Petroleum-based chemicals are used for lubrication because of their favorable viscosity, pour point, flash point and oxidative stability. However, with growing concerns about the sustainability of fossil fuel-based products and their environmental hazards, the search for a greener alternative has intensified. Lubricants synthesized from vegetable oils offer a promising option, but because of their poor thermo-oxidative stability and poor cold flow behavior, they have had limited success.

This research's novelty lies in addressing these two problems by starting with oleic *di*acid and in recording the effect of alcohols with varying chain lengths and branching on the lubricant properties. The oleic acid is first converted to a diacid by fermentation with *Candida Tropicalis* in a Bioflo 110 7.5 L fermentor. The diacid is then purified by centrifuge separation and recrystallization. The production of the novel biolubricants then begins by refluxing the pure oleic diacid with different alcohols. The resulting products of the sulphuric acid catalyzed diesterfication are purified with column chromatography and their identity is confirmed with NMR. The properties of the diesters will be analyzed to see if the expectation of improved pour point, viscosity and cold flow properties corresponds to increased chain length and branching of the added alcohols.



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INTER-DOMAIN DISTANCE AND ITS EFFECTS ON CHIMERA FUNCTIONALITY AND STABILITY

Engineered proteins that survive longer and at higher temperatures are a great feat in the advancement of protein technology. These proteins are used in various fields, including the pharmaceutical and food industries. This research involves developing a new simplified method that enhances protein stability without compromising activity. The method entails fusion by direct insertion of a model target protein, TEM1 beta-lactamase (BLA), to a stable host protein, *Pyrococcus furiosus* maltodextrin binding protein (PfMBP) known for its ability to resist unfolding up to 105°C. Previous research has shown that two factors influencing the successful outcome of a more stable, yet catalytically equivalent fusion protein are (i) host protein and (ii) point where target protein is inserted into the host.

The purpose of the current research is to explore the effects of domain distance between host and target protein. As domains near each other, their opportunity to interact increases, allowing a plethora of events and features such as amino acid side group interactions and steric effects to influence the way in which they communicate. To study the effects of domain distance between target and host proteins on the target protein's stability and activity, we varied their inter-domain distance by inserting amino acid linkers (DKS) n at the 177th amino acid residue previously determined to be a suitable site. The DKS peptide linkers were used to vary distance while allowing flexibility between the fused domains. Circular dichroism and colorimetric enzymatic assays were used to study the effects of DKS variation.

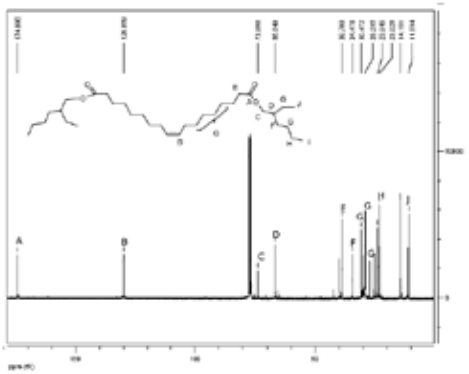
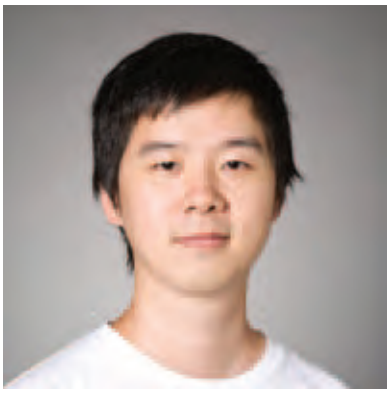


Diagram by Michael Hagan for The Production of an Oleic Diacid-derived Biolubricant and the Effect of Various Alcohol Lengths and Degrees of Branching on Lubricant Properties



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DETECTION OF AMYLOID OLIGOMERS BY PEPTIDE PROBES

Alpha Synuclein (αS) is a 140 amino acid brain protein whose aggregation is believed to be a cause factor for Parkinson's disease (PD). αS aggregation produces oligomeric and fibrillar aggregates. αS is also able to interact with other amyloidogenic proteins, such as beta amyloid (Aβ) implicated in Alzheimer's disease. Recently, this lab has developed an engineered Aβ variant as a probe for detection of Aβ oligomers. The goal of this project is to examine whether this probe can also be used for detection of αS oligomers.

To this end, αS was produced using recombinant DNA techniques and then incubated for aggregation. The high concentration of αS oligomers was obtained and their oligomeric nature was confirmed by various biochemical/biophysical techniques such as fast protein liquid chromatography (FPLC), western dot blot, sodium dodecyl sulfate polyacrylamide gel electrophoresis (SDS page), Native polyacrylamide gel electrophoresis (Native Page). The peptide probes were then tested for detection of αS oligomers by FLASH using PTI Fluorescence Spectrofluorometers.

CHEMICAL AND BIOLOGICAL SCIENCES



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PROTEASE-CATALYZED SYNTHESIS OF CATIONIC OLIGOPEPTIDES

Methods for synthesizing peptides with a precise amino acid sequence have been established. These methods, such as solid phase peptide synthesis (SPPS) and solution phase synthesis (SPS), are not environmentally friendly and are very expensive. When a certain amino acid sequence is not required, there is the chance to introduce new protease-catalyzed oligopeptide material synthesis that would be cost effective and environmentally friendly. Amphiphilic oligopeptides, such as lysine-co-leucine and arginine-co-tryptophan, may be good anti-microbial agents. Our monomers, arginine and tryptophan, were originally fixed at a concentration of 2.5 mmol in 2.5 mL of 0.9 M phosphate buffer (pH=10). A pH-stat device was used for pre-titration to the desired pH, and then a predetermined amount of protease, such as papain, bromelain, trypsin and chymotrypsin, was added. Reaction solutions were incubated for two hours at 40°C. The precipitated products were washed with 3 mL of pH 12 diluted NaOH and lyophilized for one day. Analysis was conducted by proton NMR and MALDI-TOF to determine chain length distributions. Several control factors were altered to see which favored the different specific chain lengths. These factors included reaction solvent (buffer vs. water), pH, incubation time, enzyme concentration and ratio of arginine-tryptophan. After protease screening, papain was selected based on monomer conversion to oligopeptide by contour mapping of MALDI-TOF data. Water-soluble fraction of peptide mixture by papain shows substantial anti-microbial activity against different pathogens.



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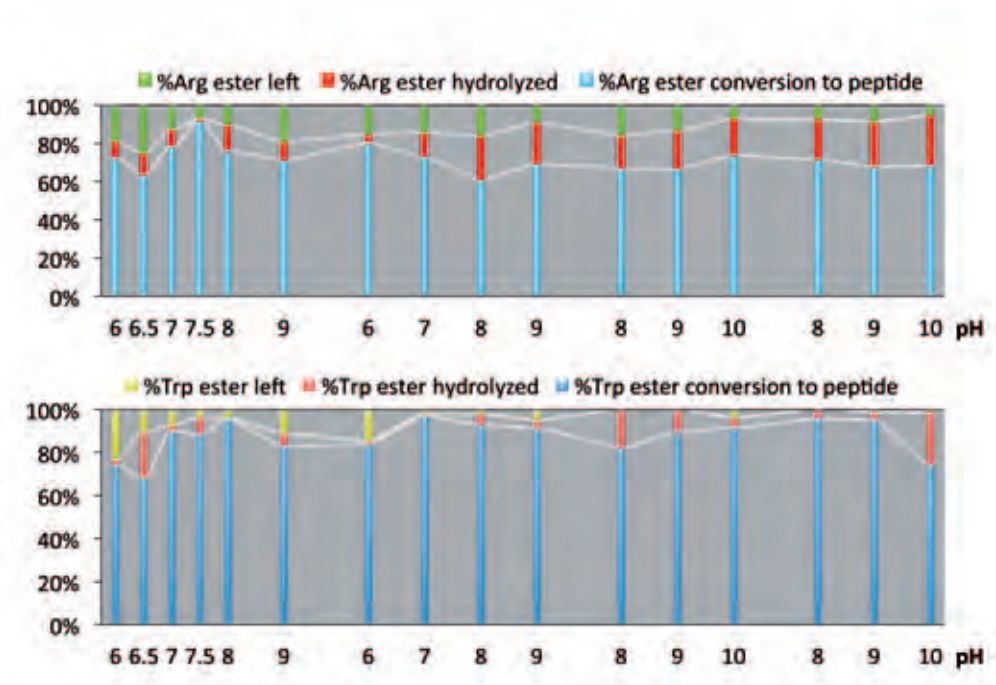
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NON-PHOTOCHEMICAL LASER-INDUCED NUCLEATION OF SUPER-COOLED WATER

In 1996, Garetz *et al.* discovered that upon treatment with a high-power infrared laser, supersaturated solutions of glycine and urea would nucleate; nucleation is the very first step of crystallization/freezing. This was named *non-photochemical* laser-induced nucleation (NPLIN), as the process did not involve absorption of the laser light. Since then, multiple studies of the effect of NPLIN on super-saturated solutions have been performed.

Testing the effect of the high-power laser on super-cooled liquids is the next step to understand the mechanism of NPLIN. Water, being an extremely important and heavily researched liquid, was chosen for this experiment. First, a novel apparatus, designed for the maintenance of 1 mL water samples at temperatures well below zero degrees Celsius during laser treatment, was built. Parameter testing was then performed, including testing of the effect of cooling rate and the dependence of water nucleation rate on temperature. Finally, initial laser experiments at below -10°C were performed, using green light. Initial results suggest that laser treatment can induce nucleation in super-cooled water, as well as produce different crystal morphology from spontaneous nucleation. Further research includes the continued testing of the effect of laser treatment on the nucleation rate of water.



Diagrams by Mohamed Abo Ali for Protease-catalyzed Synthesis of Cationic Oligopeptides

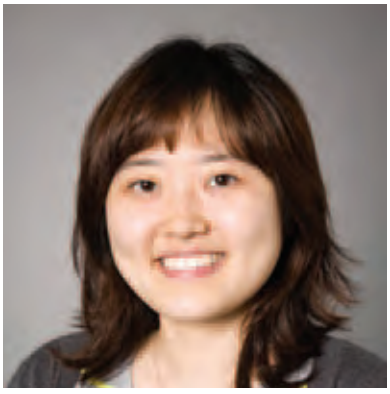


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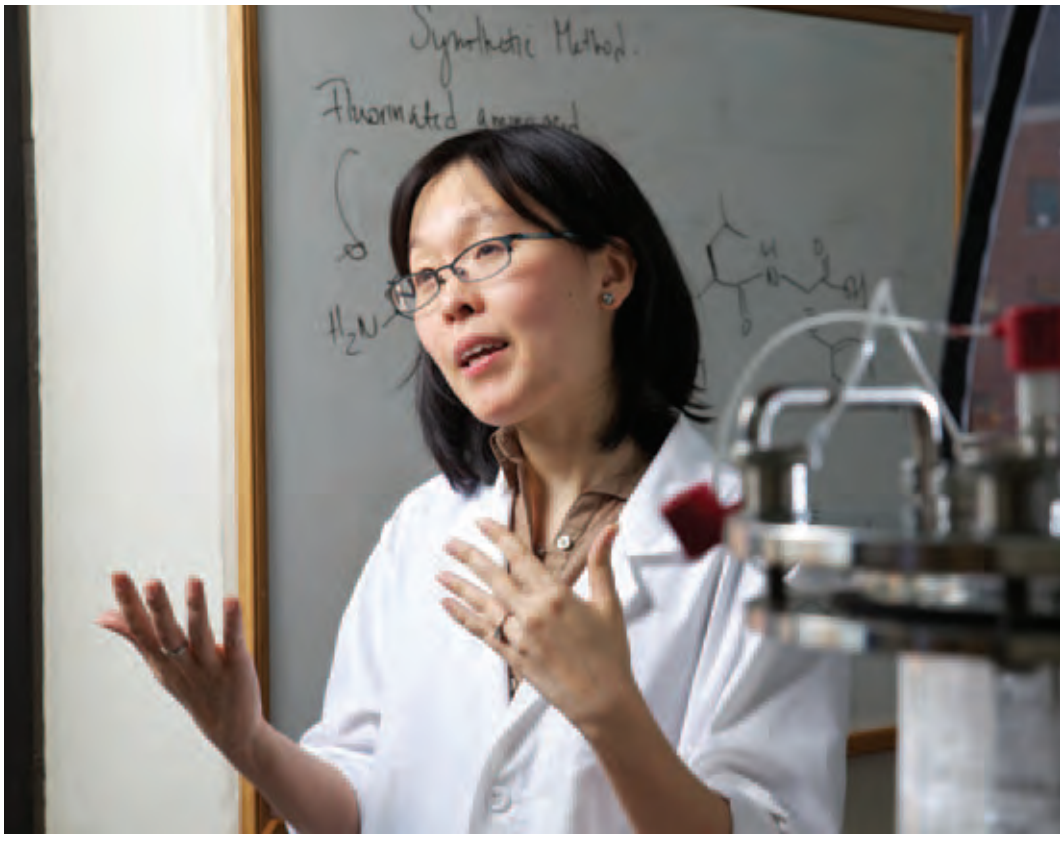
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STRATEGIES TO INCREASE THE CHAIN LENGTH OF PROTEASE-CATALYZED OLIGOGLUTAMATES

Proteases are enzymes that carry out the hydrolysis of peptide bonds; they have become useful in protease-mediated oligopeptide synthesis. Peptides play important roles in both industrial and pharmaceutical applications. Previous work by Geng Li *et al.* successfully synthesized oligoglutamate via protease catalysis with an average degree of polymerization (DPAvg) of 8. This research has reproduced their experiments in order to attain a higher DP of oligoglutamate. The goal of this work is to explore ways to increase the chain length of protease-catalyzed oligoglu via monomer modifications, which increase their water solubility. The following modifications have been explored: (1) the synthesis of α-ethyl-L-glutamate via lipase-initiated gamma regioselective hydrolysis of L-glutamic acid diethyl ester and (2) the synthesis of ethylene glycol diester-L-glutamic acid. By increasing oligomer chain lengths new possibilities arise for expanding the structure and function of oligopeptide custom-engineered features.

In order to synthesize oligoglutamate with higher DP, the diethyl L-glutamate hydrochloride monomer must be modified to increase its solubility in solution. The aim is to use lipase-catalyzed regioselective de-esterification of glutamic acid diesters to obtain a more water-soluble asymmetric derivative. A library of lipases was screened in order to identify an enzyme which would regioselectively de-esterify the monomer at the gamma position. The most effective lipase identified thus far is *Candida Antarctica* Lipase B (CALB). Additionally, monomer modifications of diethyl L-glutamate were also accomplished by the chemical synthesis of ethylene glycol diester-L-glutamic acid. The methods described in Li, G. *et al.*, *Macromolecules*, 2006, 39, 7915–7921 are being used to synthesize papain-catalyzed oligomers of these modified glutamic acid monomers. The final products are analyzed by matrix-assisted laser desorption/ionization time of flight (MALDI-TOF) and nuclear magnetic resonance (NMR) spectroscopy.





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KINETIC STUDIES ON THE REVERSIBLE INHIBITION OF CANDIDA ANTARCTICA LIPASE B

There have been many studies on the inhibition of pancreatic lipases because of the potential for anti-obesity medication. However, not much has been published on the inhibition of other types of lipases. *Candida Antarctica* Lipase B (CaLB) has been embedded in poly(caprolactone) (PCL) and effectively shown to degrade PCL by a novel method of degradation. One of the problems with embedded enzymes is the phenomenon of burst release, wherein the majority of enzyme gets released into the system and thereby effectively degrades bio-material in a relatively short amount of time. The reversible inhibition of CaLB was studied in order to avoid the ubiquitous problem of burst release and henceforth achieve a rather controlled degradation profile.

In this research, the reversible inhibition of CaLB was studied to avoid the most common and ubiquitous problem of burst release. Four inhibitors (Pristimerin, Tetrahydrolipstatin, Lauric Acid and Capric Acid) were chosen for study because they have been proven to reversibly inhibit pancreatic lipases. Reversible inhibitors were chosen for study because they do not covalently bond to the enzyme and incapacitate it. The CaLB catalyzed conversion of para-nitrophenyl palmitate (PNPP) into para-nitrophenyl (PNP) and an alcohol was studied in both aqueous and organic media. Assays were carried out with varying inhibitor concentrations in order to determine the concentration at which activity was halved (the IC50 concentration). The data were further studied by using the Michaelis-Menten equation for enzyme activity and by creating a Lineweaver-Burk plot.



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ENGINEERING THERAPEUTIC PROTEINS FOR CANCER TREATMENT

The histone code refers to patterns of post-translational modifications of histones, which play a critical role in gene regulation. Histone acetyl transferases (HATs) catalyze the acetylation of histones on specific lysine residues. P300/CBP associated factor (PCAF) is a HAT that acetylates the histone substrate H3 as well as the tumor suppressor p53. Recently, this lab has found the incorporation of *para*-fluorophenylalanine (pFF) in PCAF leads to enhanced activity of PCAF with p53, indicating the effectiveness of fluorinated residues in modulating substrate specificity of HATs for therapeutic applications. The goal of this project is to combine mutagenesis with unnatural amino acid (UAA) incorporation to synthesize a mutant of HAT that is ideal for therapeutic application through acetylation and activation of the tumor suppressor p53.

Through homology alignment and biochemical data, residues are identified for site directed mutagenesis (SDM) and four mutants of PCAF are created: V572A, C574L, E611N and Y612F. The effects of residue-specific incorporation of pFF on the substrate specificity of the four mutants are assessed, with wild-type PCAF being utilized as a control group throughout the experiments. The activity of the variants with H3 and p53 is determined through an assay that detects the production of coenzyme A by utilizing a sulfhydryl sensitive fluorophore, 7-diethylamino-3-(4'-maleimidylphenyl)-4-methylcoumarin (CPM). Circular dichroism (CD) studies are performed to determine the impact of the mutations and incorporation of pFF on the structure and thermodynamic stability of PCAF. Ultimately, upon completion of the project, valuable insight on the effectiveness of mutations and incorporation of fluorinated residues in engineering protein specificity will be determined.

Dr. Jin Kim Montclare advising students in her Chemical and Biological Sciences lab



NAVJOT SINGH
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ENGINEERING SMART PROTEINS FOR DRUG DELIVERY

Naturally existing proteins can be modified or mimicked in order to produce "smart proteins" that exhibit chemical and physical properties desirable for applications in medicine. Elastin-like polypeptides (E) and the coiled coil domain of Cartilage Oligomeric Matrix Protein (C) are two promising proteins useful for drug delivery because of their properties. E exhibits stimuli-responsive aggregation upon change in surrounding conditions such as change in pH, ion concentration or temperature. C, on the other hand, assembles into pentamers, bearing a pore that can bind to numerous molecules such as curcumin, all-trans retinol, vitamin D and other hydrophobic compounds.

Recently, this lab demonstrated that the fusion of E and C domain into a single polymer chain—EC and CE—assembles into particles capable not only of binding small therapeutic chemical compounds, but also of aggregating upon elevated temperatures. Also discovered was that the orientation of the fusion impacts the binding of a chemical as well as the thermo-responsive aggregation. To expand the temperature sensitivity for applications in hyperthermia-triggered aggregation, libraries of EnC and CEn in which the E domain was systematically shortened were generated. This project describes the biosynthesis and physicochemical characterization of these "smart proteins" for potential use in targeted drug delivery.



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SYNTHESIS OF PROTEIN SCAFFOLDS FOR CARTILAGE TISSUE ENGINEERING

Cartilage tissue regeneration requires scaffolds that can specifically bind to and interact with the extracellular matrix (ECM) proteins on the surface of chondrocytes. The goal of this research is to generate scaffolds and to incorporate cell-binding motifs, argine-glycine-aspartic acid (RGD) repeats, for cell adhesion. The scaffolds will be designed by using di- and tri-block co-polymers, COMPcc-ZR and COMPcc-ZE-COMPcc. COMPcc is the self-assembling coiled-coil domain of cartilage oligomeric matrix protein, while ZR and ZE is a leucine zipper pair that aids in the formation of heterodimers. Upon mixing, the block co-polymers highly cross-linked scaffolds may be generated by self-assembly. RGD motifs in the block co-polymers have been successfully incorporated, expressed in *E. coli* bacteria, purified the proteins and performed secondary structure and stability analysis using circular dichroism (CD). Future work will determine the secondary structure and stability using CD in the presence of small molecules such as vitamin D, all-trans retinol and curcumin. Once these proteins are successfully synthesized and characterized, they will be subjected to template chondrocyte cell growth and tissue regeneration.



CIVIL ENGINEERING



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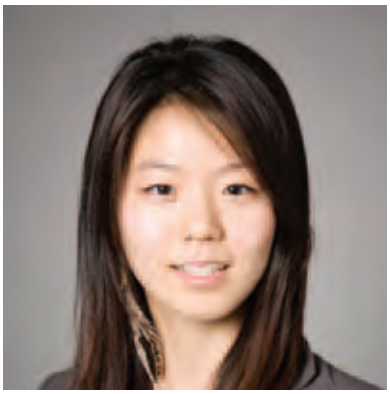
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CARBON-CAPTURING RECYCLED CONCRETE

The disastrous and costly effects of greenhouse gases and global warming can be mitigated through the design and production of "green" building materials—such as a cement mix made of recycled industry waste. The specific types of industry waste used in this project were fly ash (from coal combustion) and slag (from ore smelting). Typically discarded in landfills, these by-products were instead used to synthesize a cement paste without carbon dioxide (CO_2) emission.

Compared to the conventional manufacture of cement, in which oxides undergo calcination at 1500°C and therefore produce tons of contaminated CO_2, this recycling process is much more energy efficient due to the fact that it takes place entirely at room temperature. The introduction of bacterial catalysts accelerates the cement synthesis, thereby eliminating the need for thermal decomposition, eliminating the drastic rise in temperature and, ultimately, eliminating the production of CO_2. In addition, this project involved the pumping of CO_2 directly into the slurry in order for it to set and harden—the natural process of carbonation curing is accelerated, allowing the cement to sequester large amounts of CO_2 and chemically convert them into calcium carbonate ($CaCO_3$). Fundamentally, the resultant concrete is unique in the sense that its production, both the preparation stage and the curing stage, absorbs CO_2 instead of emitting it, and that it is recycled from discarded calcium-rich by-products of industrial work. Because concrete production is a major source of human-introduced CO_2, it is in our best interest to minimize its excess.



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pH MEASUREMENT OF ALKALI-SILICA REACTIVITY

The purpose of this project is to develop a new method to measure alkali-silica reactivity (ASR). The ASR occurs over time in concrete between the highly alkaline cement paste and reactive non-crystalline (amorphous) silica, which is found in many common aggregates (e.g., quartzite, opal, strained quartz crystals). In short, ASR is a reaction between reactive silica aggregates and alkaline cement in sufficient moisture.

The alkali-silica reactions develop in three stages: swelling and/or dissolution of soluble silica and formation of alkali silicate gels by their reactions with calcium ions supplied by cement hydration reactions. Concrete stays in shape for around 5 to 10 years. Then, the reacted alkali-silica changes into expanded gels. The expansion ultimately results in cracks and damages on infrastructures.

Alkali-silica reactivity of concrete is one of the principal causes of cracks and deformation of reinforced concrete structures. When alkali-silica reactivity occurs, the pH of concrete decreases from a value of 12.6 or higher to a value 9 or less; therefore, a measure of the pH is an indicator of the degree of ASR. This project introduces a new technique to further research alkali-silica reactivity by measuring pH in concrete with optic fiber sensors coated with sol gel polymers. This specific research is vital because it will contribute to reduce mass replacement and reconstruction of concrete infrastructures. The new method will strengthen the existing techniques to measure ASR, accomplish direct health diagnostics of concrete, lengthen the lifetime of concrete infrastructures and increase the safety and reliability of concrete as a building material.

Lan Duong and Sorock Kim working with recycled concrete under Alexey Sidelev in the Civil Engineering Lab



MICHELLE TSE
Civil Engineering/2013

New York, NY
Brooklyn Technical High School

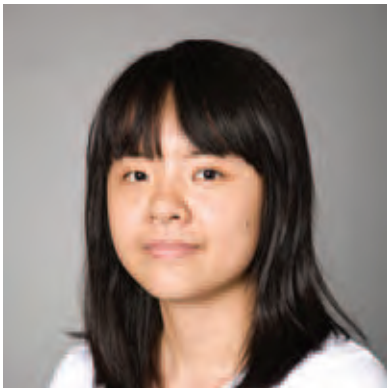
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DO SENSOR FOR IN-SITU BIOREMEDIATION

Environmental remediation provides a chemical treatment for reducing toxins in contaminated soil and groundwater. By reducing these toxins to an acceptable level, it prevents serious ecological and human health risks from occurring. One commonly used method of environmental remediation is in-situ bioremediation. This method of cleanup treats contaminated soils and groundwater supplies by using naturally occurring microorganisms present in these environments. However, because these aerobic microorganisms require oxygen to metabolize contaminants, oxygenating compounds must be introduced into these polluted zones in order to maintain an adequate oxygen supply for these microbes to consume these pollutants.

In order to determine the effectiveness of in-situ bioremediation, the amount of oxygen for the aerobic microorganisms to consume can be correlated to the decomposition rate of the contaminants in soil and groundwater. In the past, environmental engineers had relied upon membrane-based electrochemical sensors to intermittently monitor the aerobic activity of the microorganisms on a site. However, the required use of frequent maintenance and calibration of these crude sensors limited the use and effectiveness of this technique in the field. As an alternative, this research worked to developed a dissolved oxygen (DO) sensor to measure the amount of dissolved oxygen in subsurface soil environments. By using a fluorescent-based optical DO probe comprised of a fluorescence lifetime-based controller unit and a fiber optic cable which is coated in a sol-gel containing an oxygen sensitive dye, this DO sensor is capable of performing long-term in-situ monitoring similar to the former electrochemical sensors without the need for constant corrections.



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CEMENT CURING MONITORING USING FIBER OPTIC SENSORS

People have been using cement for thousands of years. However, the study of cement hydration has been an area of particular interest during the last century. Cement hydration is a complex combination of all chemical and physical processes taking place when cement comes into contact with water. Moisture and temperature are two important parameters in studying hydration because they can affect concrete enormously. For example, moisture is necessary in cement hydration, but too much moisture content may reduce the strength and durability of concrete. Also, hydration reaction is exothermic. Heat can accelerate chemical reactions and also permit cement to hydrate even in low temperature. However, too much heat can also cause cracking of concrete.

Traditional methods have some disadvantages since most of them need additional chemicals during testing of hydration process, which may involve additional variables to the researched parameter. Thus, this research seeks to develop new methods to monitor moisture and temperature during the curing process of cement using fiber optic sensors (FOS). FOS are relatively inexpensive and have many advantages, as they do not interfere with the concrete curing process or the chemical activities of cement particles. They allow not only non-destructive and in-situ monitoring, but also automated signal processing.

The aim of this research is to compare different designs of sensors to identify the best possible sensor. The preparation of sensors includes fiber polishing and sensing compound application. After being calibrated, the sensors were tested for their capability in sensing temperature and moisture in curing cement paste. Tests of different durable times as well as different cement paste receipts were conducted.



KOWSAR AHMED
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COMPUTER SCIENCE AND ENGINEERING

MULTI-TOUCH GESTURE-BASED AUTHENTICATION

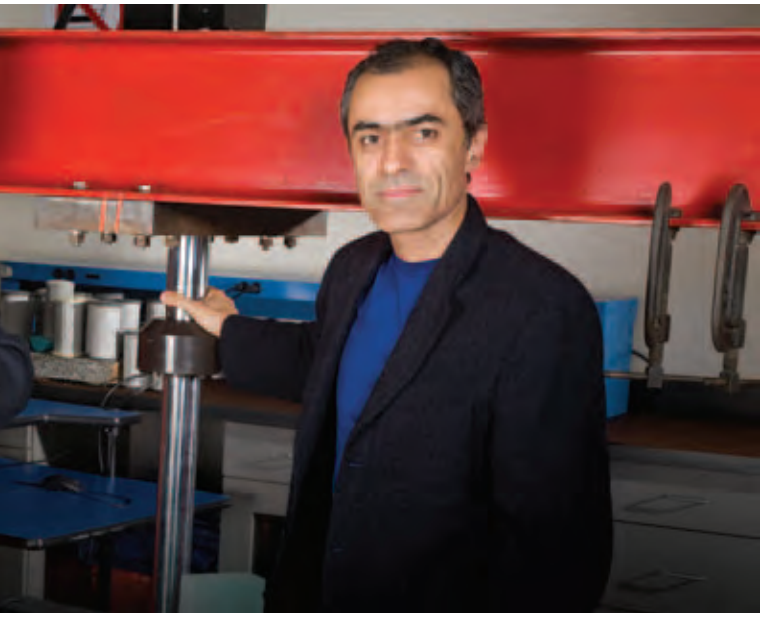
The project explores the biometric data obtained from multi-touch hand gestures in order to design a security scheme for authentication for multi-touch devices such as iPad.

The biometric information utilized for authentication is based on hand geometry and hand movements. Hand geometry is a type of characteristic biometric, whereas hand movements are behavioral biometric. Hand geometry includes information such as the size, shape and orientation of the hand (whether a user is left-handed or right-handed). Hand movements give information about how fast or slow a user performs a gesture and how flexible the hand is to perform certain types of gestures.

An iPad application was made to collect data of hand gestures from different users. A set of 22 different gestures was selected so that a broad range of biometric information could be gathered from the users. To maximize the biometric information obtained from each hand gesture, the users were required to perform the gestures with all fingertips. Each user who participated in the data collection process was asked to perform each gesture 10 times and the data obtained from each trial were saved as a text document in the iPad. After performing each gesture the user was also asked some survey questions related to the usability of the gesture.

After data were collected from more than 30 users, the raw data were extracted from the iPad. The raw data recorded X and Y coordinates of the fingertips on the iPad screen as a time series as the user performed a gesture. MATLAB was used to analyze and rearrange the raw data, so that each finger could be identified properly. Dynamic Time Warping (DTW) algorithm was used to find the distance between two gestures (DTW is the algorithm to find the distance between two time-series signals). If the computed distance between two gestures was within certain threshold value, then the gestures could be classified as from the same user.

Dr. Masoud Ghandehari in the Civil Engineering Lab



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photo not available

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Mahopac High School

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JAMES KLOPCHIC
photo not available

Computer Science/2014

Southlake, TX
Carroll Senior High School

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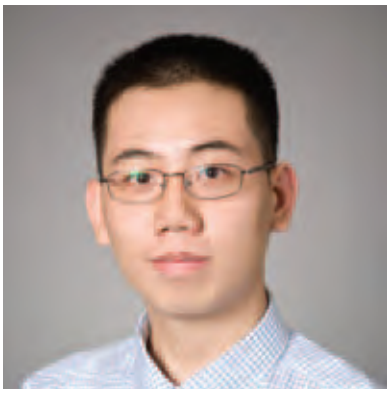
GESTURE-BASED BIOMETRIC AUTHENTICATION ON MULTI-TOUCH DEVICES

With the increase in cybersecurity threats as society embraces technology more and more, users are in need of better security. Biometric security revolves around the concept that a user's password is the user itself. There is a multitude of different ways to store this information, ranging from facial recognition to fingerprint analysis. With the growth of touch input devices such as the iPad, a new type of biometric authentication has formed—hand gesture authentication. By using a touch input device, the biometric signature of a user is stored through the touch points made during his or her input. By storing a set of template signatures for a user, the device will have a range of understanding of what the owner of the device's hand geometry and muscle memory tend to make him or her input.

Note Locker is an iPad application being developed to test this type of authentication on the general public. Note Locker provides the user with a virtual locker for storing private notes on the user's iPad. The application will allow a user with access to the device the option to write a note while locking the editing and viewing options only to the device's owner. This is done through using gesture authentication. By utilizing the familiarity of a well-known security device, a combination lock, the application is easy to understand. The users should be comfortable with performing the unlock gesture. In this system, the biometric data derived from the user's gesture during a five-time enrollment process will be used to make a decision at the verification step. By including a data retrieval system in the application, users will be able to submit their results and issues. With this information, the development of a user-friendly and secure application on multi-touch-based device, like iPad, is expected.

Nasir Memon working in the Information Systems and Internet Security (ISIS) Lab





MICHAEL HUYNH
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Manhattan Village Academy

Faculty
Haldun Hadimioglu

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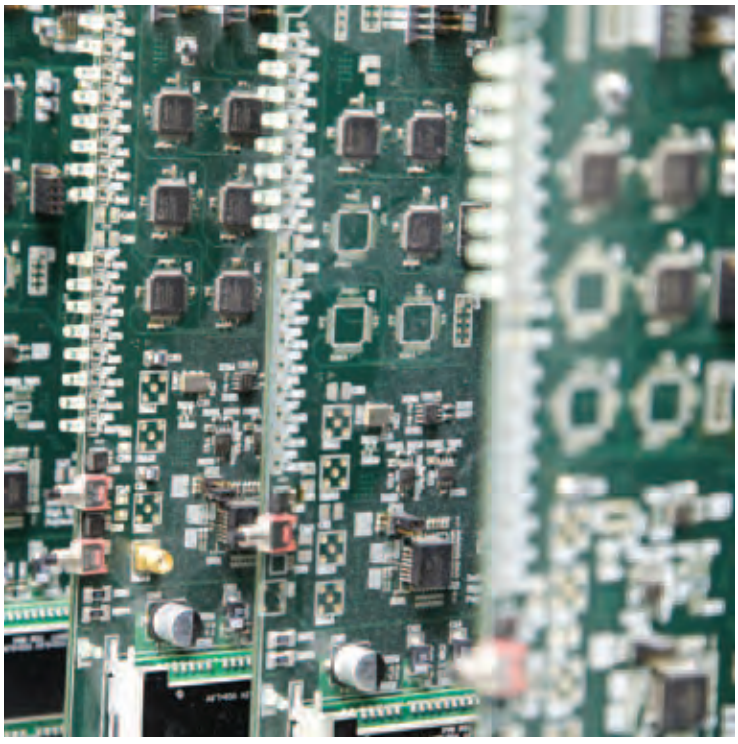
AN FPGA-BASED RECONFIGURABLE APPLICATION ACCELERATOR

The computer has become a ubiquitous part of daily life. While today's computers are designed to be general purpose, they perform poorly in cases where the computer is not suited well to the application. This is because the instruction set and the computer hardware do not match the application. This research explores matching them to the application. A field programmable gate array (FPGA) chip is a type of reconfigurable hardware that allows us to match the instruction set and hardware to the application. An FPGA board attached to a PC runs the application after the FPGA chip is programmed.

A Digilent Nexys-2 FPGA board with a Xilinx Spartan-3E FPGA chip, along with the Xilinx ISE CAD tool, is used to schematically design the computing platform. The FPGA chip emulates a microprocessor, a memory and an interface between the board and the PC. The microprocessor emulated is MIPS, which is commonly taught at universities. The interface between the board and PC, a circuit on the FPGA chip and a C++ program on the PC, are modified versions of those available from Digilent. Applications on the FPGA board, including summing elements of a vector, adding a constant to the elements of a vector and the bubble sort, are run.

An MIPS microprocessor and its memory were developed as the first step of a larger application accelerator project. This current platform does not emulate different instruction sets for different applications, but shows that it is possible even if the limiting style of schematic design is used. Future work includes streamlining the reconfiguration of the FPGA platform to applications. In addition, this work can be used as a teaching tool by a number of computer hardware courses at NYU-Poly and other universities.

Close-up of High Speed Networking Lab boards





ARA MANGOYAN
Computer Science and Mathematics/2013

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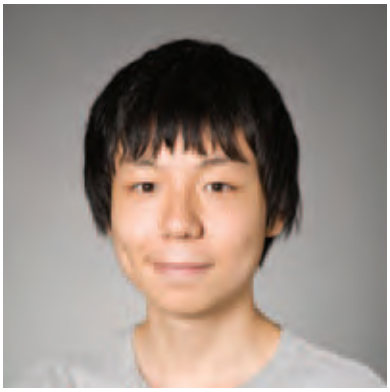
Faculty
Nasir Memon

NYU-Poly

IMAGE AUTHENTICATION BASED ON HEADER INFORMATION

Images are captured and created every second. The authentication of these images is necessary because image modification is so easy using widely available tools. Each image contains what is known as a header, which is a collection of information that uniquely identifies camera models. This header information changes when the image is modified even minutely. Initially, this project aimed to collect every possible image header. In order to complete this, millions of images were downloaded from publicly available databases, such as Flickr, and the header data were added to a database that will be used for authentication purposes.

An important task was observing the change in the header after an image was modified. This modified header information was also added to our database in order to detect when an image was modified by that particular modification tool. Currently, the goal of this research is to be able to authenticate any image based on the header through a web interface. To authenticate an image, the header information is extracted and compared with all entries in the database, and if the information is matched to a camera model, then it is authenticated. However, if it matches the signature of a modification tool or does not match any entries in the database, the image is without a doubt modified. This technique is significantly faster than other authentication techniques that look at the image at a pixel level. This method is also more reliable since slight modifications could go undetected by other techniques.



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Suzhou No. 10 High School

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Nasir Memon

NYU-Poly

EFFICIENT CAMERA MODEL DETECTION

Every camera has its unique fingerprint that differs from other cameras; this fingerprint is based on the Photo Response Non-Uniformity (PRNU) noise of the CMOS/CCD sensor inside the camera. It can be estimated by a wavelet-based de-noising procedure from an image, and the camera fingerprint can be obtained by averaging multiple noise estimates from the same camera. To verify whether a picture is taken by one specific camera device, the fingerprint of the image is estimated using the same de-noising procedure, and this fingerprint is compared to the device fingerprint. The comparison can be done by peak to correlation energy (PCE) measures. Camera model detection is useful in many areas, such as criminal justice.

In the case where comparing one camera fingerprint with a huge image fingerprint database in order to find the fingerprints closest to the query pattern, simply applying correlation to all the noises one by one is very inefficient. To speed up the search process, a method called Locality-sensitive Hashing (LSH) is used. In LSH, all the data are hashed in a way that data with a similar pattern will be hashed into the same bucket in the hash table with a relative high probability. In searching time, the hashing is also applied on the query data to decide the bucket index. Having this index, all the data in the same bucket with the query data are retrieved. Correlation is used on this smaller data set. This research shows that a variation of LSH, which is named e2LSH, can greatly reduce the size of the data set. As a result, by using LSH, camera model detection with a large database becomes much more efficient.



GRISWALD W. BROOKS
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Faculty
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ELECTRICAL AND COMPUTER ENGINEERING

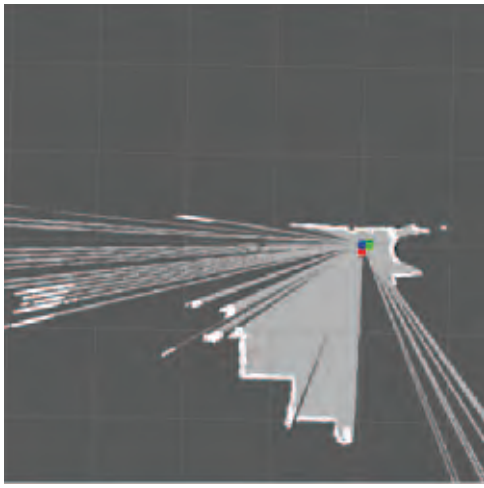
IMPLEMENTING A LOW-COST LASER RANGEFINDER FOR AN AUTONOMOUS MOBILE ROBOT

The objective of this project is the development of sensor processing and fusion algorithms for simultaneous localization and mapping (SLAM) of an autonomous mobile robotic platform. SLAM addresses the problem of generating a map of the environment while also maintaining an estimate of the vehicle's location. The principal sensors on board the platform will be an inertial measurement unit, wheel encoders, cameras and laser rangefinders. This sensor suite will feed the SLAM algorithm, enabling the platform to safely navigate though the environment. Although our main application is unmanned ground vehicles in this project, the same techniques may be applied to other unmanned platforms (e.g., unmanned aerial vehicles and unmanned sea surface vehicles).

In particular, the utilization of the Piccolo Laser Distance Sensor (PLDS) is considered due to its low-cost, compact footprint and low power consumption. As this is an embedded sensor on a commercial product, little information was available about sensor operation and interfacing. This necessitated custom software development to interpret the PLDS protocol, making the range information available for use. Robot Operating System (ROS) was used as the development environment due to the rich feature set and open-source nature resulting in shortened development time. Extensive data were taken to establish range, resolution, repeatability and accuracy of the PLDS. This information will establish the applications where the PLDS is best suited.

Griswald W. Brooks' maps for Implementing a Low-cost Laser Rangefinder for an Autonomous Mobile Robot





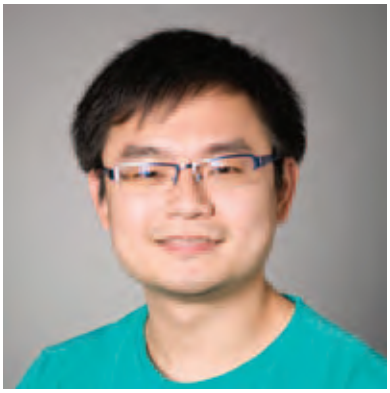


JULIAN PYMENTO
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Staten Island, NY
Staten Island Technical High School

Faculty
Francisco De Leon

NYU-Poly



KUANG ZHANG
Electrical Engineering/2013

China
Dongguan Middle School

Faculty
Francisco De Leon

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MODELING, COMPUTATION AND MEASUREMENT OF TRANSFORMER INRUSH CURRENTS

The transformer inrush current is a phenomenon that occurs in transformers due to heavy saturation of the core during energization. This phenomenon is magnified by the magnetic field that remains in the transformer after being turned off. When a transformer is switched online, the initial current drawn for a few cycles is far greater than the transformer's rated current. This abnormally large current is known as the inrush current, which, in practice, is very undesirable since the unusually high current may trip a circuit breaker. The magnitude of the inrush current is dependent on the point on the AC voltage wave at which the transformer is switched on. If the AC wave starts at its zero crossing point, the maximum inrush current is drawn.

The given task was to design a transistor switch with a control circuit capable of directing the switch to act as either a zero crossing detector or as a phase hop mechanism. The zero crossing detector finds the point at which the AC voltage wave transitions from its negative to positive cycle and turns the switch on at this point. This device allows measurement of the maximum inrush current after a prolonged period of being switched off. The phase hop mechanism uses the zero crossing detector initially, but then switches off at the next negative half cycle, and then functions as a zero crossing detector again at the next zero crossing. This enables a measurement of the maximum inrush current after the transformer has been off for a brief time.

The significance of this research is that it will be easier to measure accurate values for maximum transformer inrush currents. Therefore, before transformers are placed on power lines, better predictions can be made as to whether the circuit breaker will trip or the fuse blow due to very large inrush currents.

Chi Zhang working in the server room on Research in Hardware Root of Trust





YIXUAN SHI
Electrical Engineering/2012

China
Shenzhen Senior High School

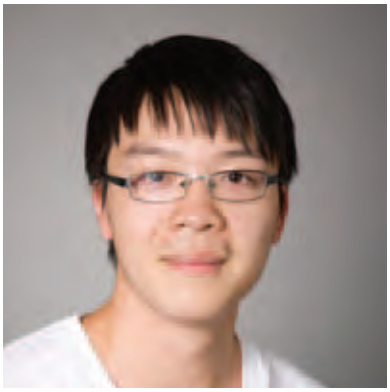
Faculty
Elza Erkip

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WARPLAB FRAMEWORK FOR SUCCESSIVE INTERFERENCE CANCELLATION

Most current wireless communications systems have to cope with a large degree of multiple access interference. In the uplink side of a cellular system, a base station simultaneously receives multiple interference signals from different users. Interference cancellation demodulates and/or decodes desired information, and then uses this information along with channel estimates to cancel received interference from the received signal. There are two methods to approach interference cancellation: one is parallel interference cancellation (PIC) and the other is successive interference cancellation (SIC).

The objective of this project is to look into a simple SIC scheme applied in WARPLab. At the receiver side, the SIC detects just one user per stage. The strongest received signal is detected first, then the next strongest and so on. This approach significantly improves the accuracy of signal detection, because the signal of a high-received power, which is the least affected, is detected first. This signal is removed by the time the second largest signal is detected. WARPLab is a framework that brings together WARP and MATLAB. WARP board is based on a Field-Programmable Gate Array (FPGA) integrated circuit. A MATLAB code is created to control the WARP board and analyze the bit error rate (BER). Two signals are generated by a PC with the same frequency, which is sent to two WARP boards as transmitters (users) by Ethernet wire. Another WARP board, serving as a base station, receives the interference signal. By applying SIC scheme and gold code, BER is analyzed in MATLAB.



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Ramesh Karri

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RESEARCH IN HARDWARE ROOT OF TRUST

The global expansion of the semiconductor industry leads to worldwide risk to hardware security. Intellectual property (IP) of integrated circuit (IC) design may be infringed through many different illegal methods, such as IC reverse engineering and hardware Trojan insertion. It is estimated that about US$100 billion of global information technology (IT) industry revenue is lost to counterfeiters annually. Approaches that protect the IC design flow are necessary.

Logic encryption is a technique to prevent most of the hardware-level attacks against ICs. A specific key input is generated by inserting additional gates into a design. Only if the key is input correctly can the IC work correctly. Otherwise, the outputs are useless. The previous logic encryption method enciphers a design by inserting XOR/XNOR gates randomly to affect its functionality. However, as the gates are inserted randomly, this technique does not guarantee that wrong outputs can be produced for every wrong key (the faults produced by the inserted gates may not propagate to the outputs); neither is the number of incorrect bits among outputs guaranteed.

Therefore, a better logic encryption is needed and should satisfy the following two criteria: (1) the inserted gates should affect 50% of outputs (if it affects all of the outputs, the wrong outputs become the same as the complement of the good outputs), and (2) it should work for most input patterns. Toward that effort, an algorithm has been developed to determine the locations to insert the additional gates. This research focuses on logic encryption for sequential circuits. C language, Perl language and a simulation tool implement the algorithm. The ISCAS-89 sequential benchmarks are used for testing.

ELECTRICAL ENGINEERING, PHYSICS AND CHEMISTRY

NICOLE RIVILIS
photo not available

Electrical Engineering/2014

West Hartford, CT
William H. Hall High School

Faculty
Stephen Arnold

NYU-Poly

THE QUEST FOR LABEL-FREE PROTEIN DETECTION "ONE AT A TIME"

When a virus infects a person, the immune system responds by developing antibodies against the infection at a much higher concentration than the virus particles. By taking advantage of this biological amplification and ultrasensitive detection of antibodies, one can catch a viral infection at its inception. No one has been able to do label-free, single antibody (protein) sensing, although they have crossed the threshold of a virus, a much larger structure. Researchers at the MicroParticle PhotoPhysics Lab (MP3L-NYU-Poly) succeeded in label-free virus detection in 2008, but there is still no proven method for protein detection. Since virus particles are about a hundred times the volume of antibodies, and signals are proportional to the analyte's volume, detection of antibodies seemed to be illusive. The goal of this project is to accomplish the necessary sensitivity enhancement by bringing together two existing methods of detection: Whispering Gallery Mode Resonators and Surface Plasmon Resonators. It has been demonstrated that frequency shifts are enhanced when plasmonic nanoparticles are added to a whispering gallery mode silica micro-cavity at the equator. In the same article, the MP3L-NYU-Poly authors projected the possibility of single-protein detection. A plasmonic gold particle is a resonator on its own. With the micro-cavity, it creates a resonator that excites another resonator to drastically increase sensitivity. This research seeks to fabricate such a hybrid sensor.

Dr. Stephen Arnold working in the Microparticle Photophysics Laboratory for BioPhotonics



MATHEMATICS



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San Mateo High School

Faculty
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Rachel Jacobovits

NYU-Poly

APPLICATION OF THE MAHALANOBIS TAGUCHI STRATEGY TO A RECOMMENDATION ENGINE

The growing prevalence of online commerce and services has led to an increased demand for effective recommendations made to Internet customers. Systems that accurately predict a user's preferences are becoming more widespread in the e-commerce industry. The Mahalanobis Taguchi Strategy, a multivariate pattern recognition technique, is being applied to this problem to provide a mechanism for detecting the most relevant variables based on their signal to noise ratio and making reliable suggestions while reducing the number of sources to be searched. For this project, the Netflix Prize data set is used to test the method's effectiveness for providing movie recommendations based on ratings given by other users. The Mahalanobis Taguchi Strategy is typically used to find variables that produce the greatest effect in separating distinct groups. However, this particular application provides certain challenges due to its divergence from a more traditional use of the strategy. While MTS is more commonly applied to static systems, its use in a dynamic setting with a changing set of reference data introduces questions that have not yet been addressed by previous applications of this approach.

The primary goal of this project is to assess the efficacy of the Mahalanobis Taguchi Strategy in recognizing and providing good recommendations as well as to determine the frequency with which the system should be recalculated in order to remain sufficiently dynamic to reflect a user's changing interests. This project focuses on movie recommendations and the Netflix Prize, but if effective, the strategy can be applied to many other computer-based recommendation systems.



QIANLI LIAO
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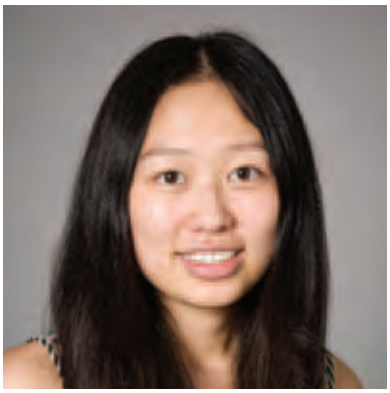
NYU-Poly

FACIAL RECOGNITION SYSTEM USING MTS (MAHALANOBIS-TAGUCHI SYSTEM)

Over the last decade, facial recognition has become a very popular area of computer vision. It is widely used in the security, entertainment and camera industries. However, most of the facial recognition algorithms can only serve a particular purpose: e.g., the algorithm that can recognize a particular person cannot distinguish between child and adult (or male and female), and vice versa, since they are task-oriented and designed for a single purpose. To solve this problem, this research proposes a general method for a large number of facial recognition tasks and implements it with a combination of several pattern recognition algorithms and techniques in which MTS plays an important role.

Taking the child and adult discrimination task for example, the procedure consists of three steps. First, the facial features are extracted from the target face. Facial features include, but are not limited to, eyes, nose, mouth and contour based on the actual task. Second, for each facial feature, algorithms such as PCA and artificial neural networks are run on the face and obtain the similarity to adults. Third, MTS is applied to such data and the final conclusion is made. Some of the facial features might be noisy data that interfere with the outcome, so the Taguchi Method and Signal to Noise Ratio are used to eliminate the noisy variables. After that, the Mahalanobis Distance is calculated and a conclusion is drawn.

An important advantage of this strategy is that, theoretically, it can be applied to a large number of other facial classification tasks such as gender classification, expression detecting, etc., so this system is very versatile.



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NYU-Poly

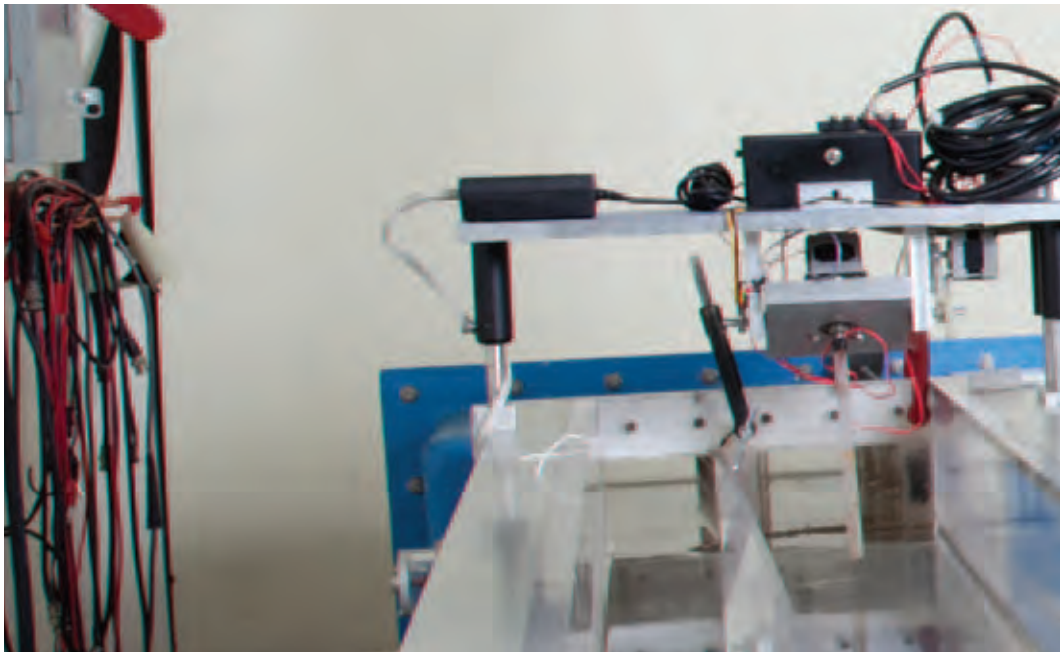
EFFECTIVE AND EFFICIENT TRADING INDICATOR SYSTEM BASED ON MTS

As there are a growing number of investors participating in stock trading, finding the right indicators among all kinds of indicators available in the market becomes the key to making money. The Mahalanobis-Taguchi System (MTS) is a pattern recognition method that uses multivariate data and separates the data into two distinct groups, the abnormal group and the normal group, based upon the Mahalanobis Distance. The number of variables necessary to perform this task is reduced via orthogonal arrays and signal-to-noise ratios.

In this project, MTS is used to find patterns in stock indicators. It predicts when the stock will increase its price by more than a certain percentage, for a particular time interval. The method was applied to Google's stock. The "abnormal" group consists of 40 days over the past 5 years when the stock price increased by more than 3%, also called the "lucky days;" the "normal" group consists of 60 days randomly selected from the past excluding the lucky days. The rest of the lucky days are used to test the results.

The most widely used technical indicators nowadays include simple moving average (SMA), exponential moving average (EMA), relative strength index (RSI), rate of change (ROC), volume, oscillators, etc. Each of the indicators provides a unique perspective in analyzing the price change. For example, by applying different simple moving averages to the stock prices, the historical price curves are smoothed according to different levels of needs. The ultimate purpose of this project is to eliminate all the less important indicators, and find the most effective and efficient technical indicator system for the stock market using MTS.

Dr. Maurizio Porfiri working in the Dynamical Systems Laboratory



MECHANICAL AND AEROSPACE ENGINEERING



BRIAN CAIRL
Mechanical Engineering and Electrical Engineering/2014

Huntington Station, NY
Walt Whitman High School

Faculty
Maurizio Porfiri

NYU-Poly

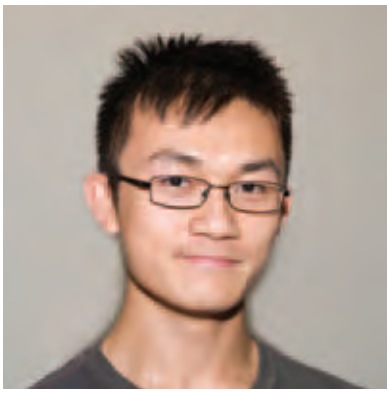
ENERGY HARVESTING FROM SUB-CARANGIFORM FISHTAIL LOCOMOTION

Current battery technology limits the longevity of modern day, mobile electronic systems. Such systems range from handheld devices and wireless sensor assemblies to larger, more energy-demanding systems, such as electric cars. Energy-harvesting devices, such as those comprising piezoelectric materials and ionic polymer-metal composites, may provide respite for onboard energy stores by tapping into inherent sources of energy loss. By-products, such as heat, light and vibration, are perfect candidates for conversion and energy supplementation.

The described project involves a feasibility study of harvesting energy from sub-carangiform fishtail motion. The aforementioned energy harvesting components would provide for the extended operation of fish tags already utilized in environmental monitoring and aquatic migration tracking applications. The robotic apparatus implemented in this study is intended to model, specifically, the physical and kinematic characteristics of a thresher shark tail and includes an endoskeletal structure surrounded by a polymer composite that are intended to mimic bone, cartilage and flesh, respectively.

This study further applies the experimental setup described, in concert with vision acquisition techniques, in determining the energy output capacity of the tail when energy-harvesting devices are applied at mechanically advantageous locations. Doing so allows for a detailed study of how the tail's motion and deformation correlate to energy output, and further, the optimal placement of said energy-harvesting devices. In this study, a range of experiments is conducted given varying input parameters of amplitude and frequency for a series of robotic tails, each varying in their endoskeletal width and rigidity.



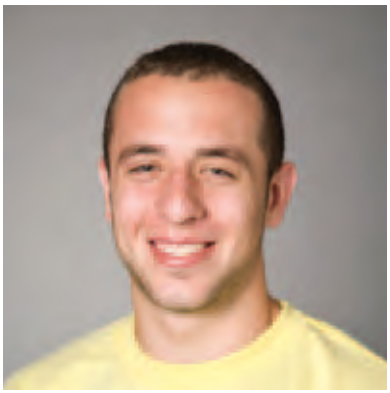


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Bronx High School of Science

Faculty
Nikhil Gupta

NYU-Poly



PETROS SKALIARINIS
Physics and Mechanical Engineering/2015

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Nikhil Gupta

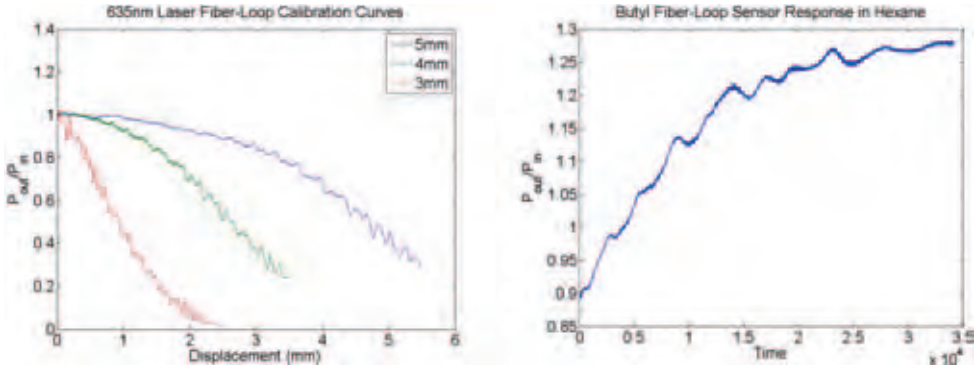
NYU / NYU-Poly

DETECTION OF HYDROCARBONS USING SINGLE-MODE, FIBER-OPTIC LOOP SENSORS

Oil spills are very harmful to the economy as well as the environment. Currently, electronic sensors are being used to monitor oil pipelines, which pose an extreme safety concern, namely unwanted explosions due to sparks. Such sensors also have the handicap of electromagnetic interference from outside sources. Fiber-optic sensors are a viable alternative because optics eliminates these disadvantages.

In this study, an innovative fiber-loop sensor was used to detect the presence of hydrocarbons, the primary components of crude oil. A 635nm laser was used to power a fiber-loop embedded in butyl rubber cylinders, which were placed in hexane and kerosene. In addition, a coat of polysiloxane was applied to the fiber in order to amplify the detection of the hydrocarbons. The attenuation of the laser intensity was in the range of 5% for a volumetric increase of 54% of the butyl (hexane), which paralleled force-displacement calibration tests that were performed.

Results demonstrated that the fiber-loop sensor is extremely sensitive in the presence of small concentrations of hydrocarbons. Combined with the safer implementation of the electronic source away from the oil, the sensor's high resolution makes it a possible candidate for future monitoring and prevention of oil spills.



Diagrams by Kevin Chen and Petros Skaliarinis for Detection of Hydrocarbons Using Single-mode, Fiber-optic Loop Sensors



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ROBOTS AND ANIMALS: WHEN ENGINEERING AND BIOLOGY INTERACT

Nature has recently become a great source of inspiration amongst engineers. One example of nature's influence on the engineering world is the development of robotic devices that are meant to mimic living things, particularly animals. The Dynamical Systems Laboratory is working on the development of a biomimetic robotic fish that will be able to steer schools of fish away from dangers such as oil spills and toxic waste. Even though many bio-mimetic robots have been created, rarely have their interactions with the animals whom they mimic been tested. Understanding this interaction is an important factor in the success of integrating robots into the wild. Animals are unique complex systems themselves and exhibit wide ranges of behavior, even within large groups. Fish, for example, demonstrate different individual behaviors even though they seem to move as one in a school.

The objective of this research is to investigate the interaction between the robotic fish and live fish to determine whether this interaction is dependent upon the individual differences in fish behavior. The experiment consists of two phases, determining the specific behavior of individual fish and the observation of the interaction between the robotic fish and the live fish. In the first phase, the level of boldness or shyness for each individual was determined. The second phase will shed light on the effects of individual differences in fish behavior on the interactions with the robotic fish.



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DEVELOPMENT, TESTING AND CHARACTERIZATION OF THE SECOND GENERATION OF SERVOFISH

The design of man-made machines has always taken some inspiration from nature. Recently, the development of robotic systems has adhered to the use of such inspirations and robots designed to mimic live animals has become a hot research topic. The interactions of such biomimetic robots with their live counterparts have many useful applications, including preference studies, monitoring of endangered species and their environment and prevention of destruction of ecosystems. A first-generation servomotor-propelled robotic fish was built in the Dynamical Systems Laboratory in 2010 to study such interactions. This robot participated in several ethorobotics research studies and has been the center of K-12 education activities at the New York Aquarium aimed at igniting student interest in science, technology, engineering and mathematics (STEM).

This project includes the design and development of a second-generation robot offering improvements and upgrades to its predecessor's design. Such upgrades include an improved assembly mechanism, more hydrodynamic design, standardized weights for altering buoyancy and the implementation of cheaper and more readily available parts for cost reduction. These improvements provide better robotic performance and larger accessibility to the robot for educational purposes due to the improved cost. Design of the robot is achieved with the aid of the commercially available computer-aided design software SolidWorks and fabrication is executed via an in-house rapid prototyping machine. The robot is characterized through free-swimming experiments for a set of input tail beating frequency and amplitude parameters, where its motion is recorded and examined using image analysis techniques. The robot's performance and maneuverability is evaluated and important hydrodynamic properties are extracted.

KEVIN HISCHIER
photo not available

Mechanical Engineering/2013

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MODEL-BASED DIAGNOSTICS IN AUTOMOTIVE SYSTEMS

The past several decades have witnessed an exponential increase in the number and complexity of electronic systems and subsystems in vehicles. As a consequence, the number of electronic controls and software has increased dramatically. Today, the number of electronic control units (ECUs) in high-end automobiles is over 70 from one or two per vehicle in the 1970s [1]. Given the distributed nature of a vehicle electrical system, it is often very difficult to identify the location and size of faults, especially if they are intermittent faults. This creates the need for powerful diagnostics and controls that detect, isolate and compensate for faults automatically.

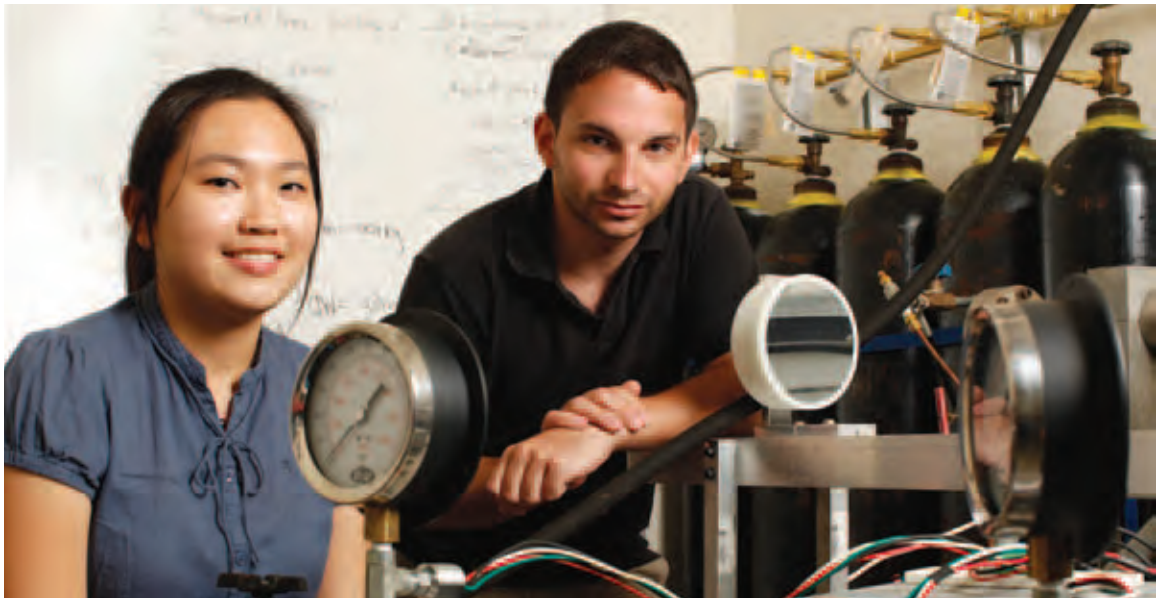
An example of the negative effects of the complexity of the modern automotive systems can be found in the Toyota Unintended Acceleration (TUA) case, where several vehicles have had an increase in unexplained acceleration. A recent study [2] of the National Aeronautics and Space Administration (NASA) shows an analysis of possible causes of this phenomenon. In this research, a failure mode analysis to evaluate the effects of propagation of the unintended accelerations to the overall vehicle is presented.

Mathematical models of the power-train dynamics, including the electronic throttle system, engine dynamics and vehicle dynamics, are derived from the physics of the processes involved. These models have been implemented in a MATLAB/Simulink environment and validated with experimental data extracted from relevant literature. The failure mode analysis focuses on the propagation of specific faults related to failure in the communication between the ECU and the throttle body system. These faults are modeled as stuck fully open, stuck fully closed and erratically moving between open and closed positions of the throttle valve. Further investigations of this research will address the design of fault-tolerant control strategy of active safety systems to mitigate the effects of the propagation of unintended acceleration in the vehicle.

References:

[1] B. H. Gharavi, K. V. Prasad, P. Ioannou. Scanning Advanced Automobile Technology. Proceedings of the IEEE, special issue on Advanced Automobile Technologies, vol.95, no. 2, pp. 328-333, February 2007.

[2] NASA. National Highway Traffic Safety Administration Toyota Unintended Acceleration Investigation, NASA Engineering and Safety Center, January 18, 2011.





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Strathmore High School

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NYU / NYU-Poly

THE IPHONE: CELL PHONE, MUSIC PLAYER, ROBOTIC FISH CONTROLLER

With over 108 million units sold, the iPhone, manufactured by Apple, is easily one of the most popular cell phones in the world and for good reason. Because of its 600 MHZ CPU, 256 MB RAM and vast networking capabilities, the iPhone can be used for virtually anything, including fostering informal science and engineering education in a broad community.

This project aims at developing an application for controlling a biomimetic robotic fish developed in the Dynamical Systems Laboratory for research and educational purposes. This application seeks to enable user-friendly control of the robotic fish through various networking protocols as well as allowing the user to receive vital operational data from the robot.

The application also includes a tutorial on the robot's control inputs of frequency, amplitude and offset of caudal fin beating. Additionally, the application remedies user-induced lag by modifying data-sending algorithms. The application is currently being adapted to incorporate a video feed of the swimming robot to allow users to control the robot using feedback. The results of this work will potentially impact the community at large by enabling any iPhone, iPad or iPod Touch user to control the robotic fish themselves at robotic fish installations planned throughout Brooklyn, such as the New York Aquarium.



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REDUCTION OF SUPERSONIC JET NOISE VIA FLUIDIC INJECTION

The intense noise generated by commercial and military supersonic aircraft poses a great threat to airport communities, especially during the takeoff and landing phases of flight. Because of this, such aircraft encounter several restrictions in terms of their traveling velocities, routes and take-off and landing intervals. The engines of such aircraft operate with supersonic exhaust flows, resulting in the formation of a series of quasi-stationary shock cells consisting of shock and expansion waves in their exhaust stream. There are three phenomena which contribute to the noise of supersonic jet engines—turbulent mixing noise, which results from the velocity gradient between the exhaust stream and stagnant ambient air; screech tones, which results from the vortical feedback of turbulent eddies near the nozzle lip; and broadband shock associated noise, which results from presence of shock waves further downstream of the nozzle exit.

The proposed method in this study was to enhance turbulence mixing by modifying the shear layer and to alter the internal shock cell structure of an under-expanded Mach 1.6 axisymmetric jet using a fluidic injection scheme. This was done by inserting a brass metal tube along the center line of the nozzle and forcing air through exhaust ports located at the extreme end of the tube at a rate of 20% of the mass flow rate of the primary flow. In order to measure the spatial directivity of the far-field sound spectra, sound measurements were taken from 30° to 90° (with respect to the downstream center-line axis) in 12° steps using a microphone that was placed 40 diameters away from the nozzle. The power spectral densities and overall sound pressure levels of the jet were then used to compute the noise reduction achieved in the proposed scheme.

Supatra Lee working in the Aerospace Engineering Lab



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UNDERWATER LARGE-AMPLITUDE TORSIONAL VIBRATIONS IN FLEXIBLE STRUCTURES

This project entails the experimental characterization of flexible beams undergoing forced torsional vibrations in quiescent underwater environments. The effect of excitation amplitude and frequency on the beam mechanical response is studied to identify relevant fluid-structure interaction effects, including added mass and hydrodynamic damping. Findings from this study will aid in the design of slender structures for marine applications, such as smart material-based energy harvesters.

A torsional exciter, capable of delivering excitation with adjustable amplitude and frequency to the submerged beam, has been designed and realized. Excitation is provided through a cylindrical shaft held in place by bearings mounted on a platform. The reciprocating rotational motion of the shaft is generated by converting the translational motion from a shaker or a motor-driven cam through an ad-hoc designed crankshaft system.

The system mechanical response is experimentally analyzed via image tracking and particle image velocimetry (PIV). The former method involves acquisition of image sequences of the beam motion using high-speed cameras. Points marked on the beam are tracked through the images and the twisting motion of the structure is determined by comparing the relative rotation of the two ends of the beam. Flow field features in close proximity of the vibrating beam are investigated through PIV techniques. Microparticles are seeded into the water and a laser plane perpendicular to a beam cross section is created. Images capturing the motion of the microparticles in the plane are acquired and analyzed using dedicated software, thus recovering relevant fluid-structure interaction characteristics.

FLUORESCENT PARTICLES FOR OVERLAND FLOW VISUALIZATION

The suitability of fluorescent particles as tracers for investigating hill-slope hydrologic processes is tested. This work is expected to help in determining overland flow paths and forecasting flash floods. This project encompasses the experimental testing of the visibility of inexpensive fluorescent particles in turbid flows and the development of self-manufactured particle tracers. Inexpensive fluorescent particles are tested in a custom-built reclinable water tunnel by using image-based analysis tools. The particles are tested in aqueous clay-water suspensions to simulate the natural environment conditions. Further, the fluorescence is tested by deploying the particle in shallow water flows over a grassy area.

The fluorescence decay rate of the particles under different light conditions is also studied by periodically measuring the emissions through a fluorometer. The particles are exposed to darkness, sunlight, UV light and ambient light conditions.Two methods of particle fabrication are investigated: coating 0.4g/cc particles with a fluorescent dye and grinding a block of resin, mixed with the dye, into a fine powder. In both instances the fluorescent dye, Rhodamine WT, is used. Rhodamine is normally used in the environment due to its low toxicity and high intensity emissions. Moreover, Rhodamine's enhanced visibility allows for efficiently tracking the particles by using image-based methodologies. Once synthesized, the particles are deployed in the reclinable water tunnel and tested for different combinations of water depths and velocities.

ROBOTIC HAND FOR SENSING: DESIGN, FABRICATION AND CONTROL

During space exploration missions, it is crucial to make the best use of time, energy and available resources. Since space suits are pressurized to resist the vacuum of space, they cause restricted, sometimes exhausting, motion. This is particularly problematic in the astronaut's glove, which behaves much like a balloon when pressurized and limits movement away from its inflated position.

Different glove designs have been proposed to best aid hand movements, but there is no consistent method of evaluating the stiffness of these gloves. This research team has developed an adaptable robotic hand that can fit inside various glove designs and consistently measure the actuator torque necessary to accurately move each finger inside the glove.

When the glove is pressurized, it can fit a human hand, but it cannot easily fit all of the necessary components of a robotic hand while maintaining an airtight assembly. This physical challenge was resolved through iterations of 3D solid modeling, 3D prints and fitting measurements. The second challenge was to design a prototype that would produce accurate and reproducible measurements. It was decided that each finger would be actuated by an individual servomotor arm to allow separate finger-torque testing. The present design uses Ohm's law to infer the current drawn by each servomotor, from which the torque applied at the base of the index, middle, ring and pinky fingers can be estimated. Future designs will incorporate higher degrees of freedom in the fingers as well as thumb movement.

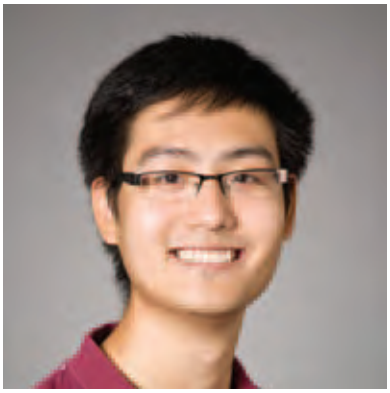


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Faculty
Joo H. Kim

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JACK POON
Mechanical Engineering/2012

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Brooklyn Technical High School

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Daniella Patrick working with Dr. Joo H. Kim in the Mechanical Engineering Lab



AADHAR ROHILA
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EXPERT DRIVERS'-BASED VEHICLE-ACTIVE SAFETY SYSTEMS

Vehicle-active safety systems, also known as electronic stability control (ESC), electronically enhance driving dynamics to avoid or mitigate accident severity. A recent study of the National Highway Traffic Safety Administration (NHTSA) [1] shows that the introduction of the ESC since the mid 1970s has had a significant impact on passenger vehicle safety by reducing single-vehicle crashes by 35% in passenger cars and by 67% in sport utility vehicles. The World Health Organization (WHO) [2], however, reveals that 1.2 million people annually worldwide are killed in road crashes and as many as 50 million are injured. These statistics are expected to increase by 65% in 2020 if appropriate actions are not taken.

To reverse these previsions, auto manufacturers and government agencies are focused on producing accident-free vehicles. While the current ESC aims at restricting the operation of the vehicle within the linear region of the tires, the next generation of active safety systems should get the vehicle to the maximum limit of handling conditions with tires operating in their nonlinear region. In fact, by fully utilizing the vehicle's handling capability, similar to what an expert driver would do, one should be able to stop the vehicle faster or to move the vehicle away from a hazard. Incorporating expert driving skills on active safety functions is an important step forward in the technology of accident-avoidance systems.

This work presents an expert drivers'-inspired active control that stabilizes the vehicle at the limits of its handling capabilities, allowing autonomous drifting. Drifting is a high-side slip maneuver, with the steering angle and the vehicle rotation in opposite directions, used by rally drivers during high-speed turns. Using a phase-portrait analysis, unstable *drift equilibria* can be individuated in a simple bicycle model with nonlinear tires. A local controller is then designed to stabilize the vehicle to drift equilibrium using steering and throttle. The efficiency of the proposed strategy is evaluated through high-fidelity simulations.

References:

[1] J. Dang. Preliminary results analyzing the effectiveness of electronic stability control (ESC) systems, U.S. Department of Transportation, September 2004.

[2] World Health Organization and World Bank. World report on traffic injury prevention: Summary, Geneva, 2004.



Aadhar Rohila working with faculty advisor Annalisa Scacchioli



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PREDICTION OF HUMAN DYNAMIC PARAMETERS USING OPENSIM INTERFACE

A new method to predict the dynamic and kinematic parameters of each segment of a human subject is proposed in this project. These parameters include mass, location of center of mass, moments of inertia and products of inertia for each segment. The existing methods of system identification in dynamics and control involve linearization of the system equation of motion. In this project, the proposal to use optimization to estimate system parameters is presented.

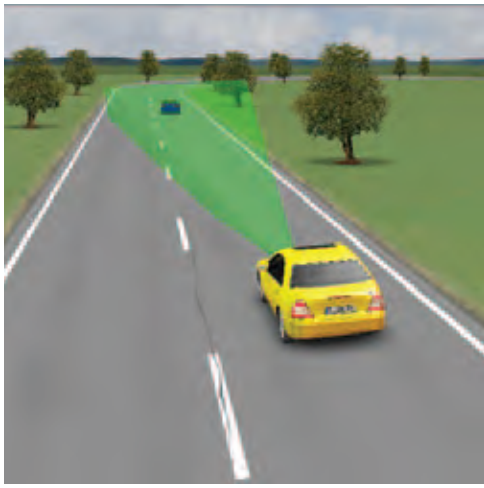
System identification is executed based on experimental data obtained from a Vicon motion capture system as well as a Bertec force plate. The six-camera motion capture system will be used to measure joint angles with respect to time, by means of several passive retro-reflective markers on each segment of the human test subject. The force plate will be used to measure ground reaction forces with respect to time. These experimental data will then be imported into OpenSim, an open-source software for modeling, simulating, controlling and analyzing the musculoskeletal system.

OpenSim allows the user to import motion analysis data, scale a computer model of the musculoskeletal system, perform inverse dynamics and kinematics analyses, generate and analyze dynamic simulations of movement and plot results. In the preliminary stages of this project, the applications of the OpenSim software to this new method of system identification are explored. The software is to be used to customize musculoskeletal models based on kinematic and kinetic data, analyze musculoskeletal geometry and joint kinematics and ultimately determine dynamic parameters from motion capture kinematics and ground reaction force data.

Aadhar Rohila's video/animation of project simulations for Expert Drivers'-based Vehicle-active Safety Systems









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Computer Science and Electrical Engineering/2013

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TECHNOLOGY, CULTURE AND SOCIETY

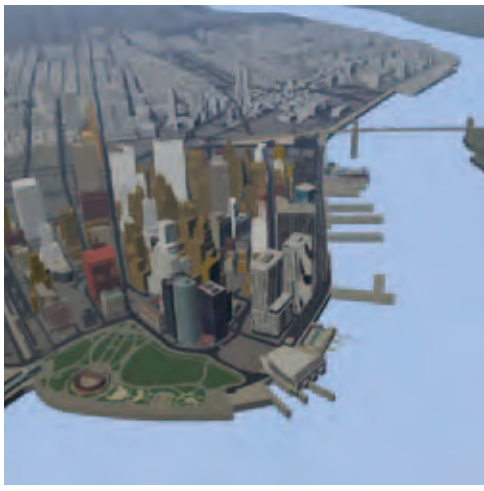
BETAVILLE: GRAPHICAL USER INTERFACE

Betaville is an open-source, multi-player environment built in Java in which real cities are modeled and altered in every way imaginable. Online users have the ability to construct, discuss and alter ideas for new works of public art, transportation, architecture and urban design within the environment. Betaville brings the real-life town hall meetings to the average person and allows creativity to grow and mature within the comfort of their home via the online environment.

One of the main design aspects of creating an interactive world-modeler like Betaville is the design and implementation of the Graphical User Interface (GUI). The GUI is the part of the program that users interact with on their computer screen such as the buttons and text fields. Having a well laid-out, aesthetically pleasing and easy-to-use interface can make or break the success of any computer software. Betaville re-sculpted its GUI by designing a tabbed-container hierarchy with a polished theme and creating a redux of the open-source FengGUI library. By creating a redux of FengGUI, Betaville was able to keep FengGUI's implementation of all the graphical components while custom-tailoring all of the components as they see fit for the Betaville project and fixing any unresolved bugs from the original FengGUI library. Upon the project's closing, those wishing to design and create within Betaville's online cities around the world will be able to so with ease using the new and improved GUI.



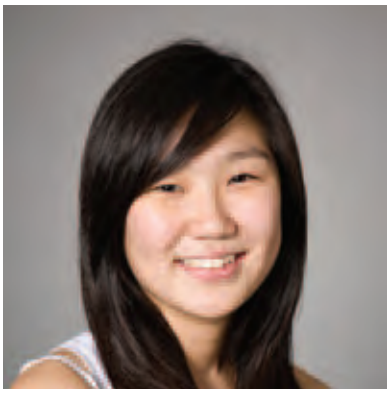












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BETAVILLE

As an innovative method for urban designing, Betaville enables not only professional modelers but also the general community to participate in the process of creating and modifying the city in which they live. Users, once in the world, can navigate around lower Manhattan browsing the buildings, as well as looking at the proposals, such as prototypes of buildings, created by other players. However, in order to create proposals, the user must go through the steps of building a model using a third-party 3D computer graphics software and importing the prototype into the world of Betaville.

Often, the knowledge of programs such as Google SketchUp and Autodesk Maya is necessary to create these 3D models. The goal of this research was to paraphrase this step by building an in-world modeler that will permit the players to create graphical urban structures in Betaville. Written in Java, MonkeyEngine was utilized for the needed graphics. The first step was to enable simple in-world modifications—translate, rotate and scale—of existing buildings. Figures such as arrows and boxes were used to make the modification process more explicit. At the same time, in order to provide accuracy, users are given an option to use text fields to edit coordinates, dimensions and rotations. Once complete, this in-world modeler will alleviate the need to rely on more difficult modeling programs and provide a comprehensible process of creating models by making the simulation more accessible to the general public, who may not be familiar with advanced modeling tools.



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RAINWATER MANAGEMENT IN URBAN CHINA

City infrastructure has been greatly stressed by growing population densities, especially in developing countries. The lack of foresight in developing water and sewer systems in China has resulted in a series of destructive urban floods in multiple major cities after frequent nationwide torrential rainstorms. The project examines the case of Changsha, a typical heavily populated, historical waterside Chinese city, where an acute question of how the existing drainage system could be better improved and maintained is raised. Multiple engineering methods are examined under the specific conditions of old Changsha city neighborhoods that were greatly influenced and damaged by urban floods. Orthodox engineering solutions to the problem were shown to be less effective in comparison with new approaches created in landscape architecture, storm water harvesting and household gray water system fields. The case solution goes beyond Changsha and may possibly be applied in many other cities that share the same characteristics.

Yet a new discussion concerning general urban infrastructure design rose behind the case, in which traditional factors of mere functional purpose in considering standard engineering solutions are no longer adequate enough for the rapid ongoing rate of urbanization and the increasing demand for enhancing quality of life. An additional triad of elements: ecological sustainability, aesthetic appeal and human happiness, is taken into account.

System of Systems Engineering, a methodology that aims to model and analyze complex meta-system problems of dynamic functionality and performance within constituent systems, is used in combination with Permaculture methodology, in which the design of urban settlements is modeled based on natural ecologies. A list of political, financial, legal, technical, social, operational and organizational factors will be considered in contributing to the complete solution.

Jarred Humphrey's graphical user interface for Betaville

2011 UNDERGRADUATE RESEARCH PROGRAM SEMINAR SERIES

As a part of the Summer Research Program, distinguished faculty and guests are invited to host a seminar on a topic of their expertise. This year, the program welcomed four such speakers.



JAMES KOWALICK
"THE MAHALANOBIS APPROACH AND TAGUCHI METHODS"

Speaker Bio: James Kowalick, PhD, is Kowalick Direct's founder and developer of the methodology for advertising optimization. Dr. Kowalick is widely recognized for his expertise in systems optimization, and is a four-time recipient of the coveted Taguchi Award. He designed more than 350 optimization experiments. Dr. Kowalick received his PhD in materials engineering from Drexel University. He also holds master's degrees in materials science and chemical engineering, and a bachelor's from Lehigh University's School of Engineering.



ERICH E. KUNHARDT
"TRIO; AND, ON THE AIMS OF EDUCATION"

Speaker Bio: Dr. Erich E. Kunhardt, former provost of NYU-Poly and an alumnus, is a professor of applied physics. Before joining NYU-Poly in 2006, Kunhardt served as the dean of the Arthur E. Imperatore School of Sciences and Arts and the George Meade Bond Professor of Physics at Stevens Institute of Technology. In 1984, Kunhardt had served on the NYU-Poly faculty of as a professor of electrophysics and physics and director of the Weber Research Institute (Microwave Research Institute), which at the time was engaged in research for President Ronald Reagan's Star Wars initiative. Throughout his career, Kunhardt has participated in numerous research and development projects relating to plasma physics and electrodynamics. While at Stevens, he introduced the original concept and term Technogenesis, whereby students and faculty create new technologies and take them from concept to marketplace realization. In 1999, Dr. Kunhardt helped create the PlasmaSol Corporation, based upon the Atmospheric Pressure Capillary Discharge Plasma technology he invented while at Stevens with Dr. Kurt Becker. He was named a finalist by Discover Magazine's Innovation Awards (2001) committee in the Environmental Category for the development of the technology used by PlasmaSol Corporation for environmental remediation.

Dr. Kunhardt holds a PhD in Electrophysics from Polytechnic Institute of NYU and bachelor's and master's degrees from New York University. In 1992, he was awarded an honorary doctorate from the Russian Academy of Sciences, Institute of Electrophysics. He is the recipient of numerous awards, including the Thomas A. Edison Patent Award and the Halliburton Foundation Excellence in Research Award. At Texas Tech, he received the Outstanding Faculty Teaching Award.



DANIEL STEIN
"LESSONS LEARNED* IN A CAREER IN PHYSICS *(USUALLY THE HARD WAY)"

Speaker Bio: Daniel Stein is dean for science and professor of physics and mathematics at NYU. He was also a Provost Faculty Fellow from 2005 to 2006.

With research interests that include theoretical condensed matter physics, statistical mechanics and mathematical physics, Dr. Stein's research primarily focuses on randomness and disorder in condensed matter systems with an emphasis on magnetic materials and on stochastic processes leading to rare nucleation events. He has also conducted research in a variety of areas, including protein biophysics, biological evolution, amorphous semiconductors, superconductors and superfluids, liquid crystals, neutron stars and the interface between particle physics and cosmology.

Dr. Stein earned his PhD in physics from Princeton University in 1979 and remained on the faculty there until 1987. From 1987 to 2005, he taught at the University of Arizona, serving as head of the Department of Physics from 1995 to 2005. He has been awarded numerous honors and awards, including the Alfred P. Sloan Fellowship, the University Of Arizona College Of Science Distinguished Teaching Award and the Commission on the Status of Women Vision 2000 Award. Dr. Stein was also elected a Fellow of the American Physical Society.



KURT BECKER
"RESEARCH AND PATENTS"

Speaker Bio: Kurt Becker, associate provost for research and technology initiatives at NYU-Poly, is an international expert in the areas of the experimental and theoretical study of electron-driven processes in plasmas. He was part of a group of pioneering scientists who determined the ionization cross sections for atoms and molecules, which are critical to understanding the charge carrier formation in plasmas.

He is also well-known for microplasmas or plasmas generated and sustained at atmospheric pressure. These plasmas are very unstable and prone to destructive arching. By confining these plasmas to less than 1mm, they become more stable. The plasmas provide a fertile environment for basic plasma physics and for developing new plasma technologies. Additional areas of interest include atomic, molecular and chemical physics, the development of new experimental techniques and processes, technology transfer and IP commercialization.

Dr. Becker joined the NYU-Poly faculty in his current capacity in 2007. Prior to joining NYU-Poly, he was associate director of the Center for Environmental Systems at Stevens Institute of Technology from 2003 to 2007 and department head from 2000 to 2007. He earned a Diplom in Physik (MS) and Dr. rer. Nat. Universitat des Saarlandes in 1978 and 1981, respectively.

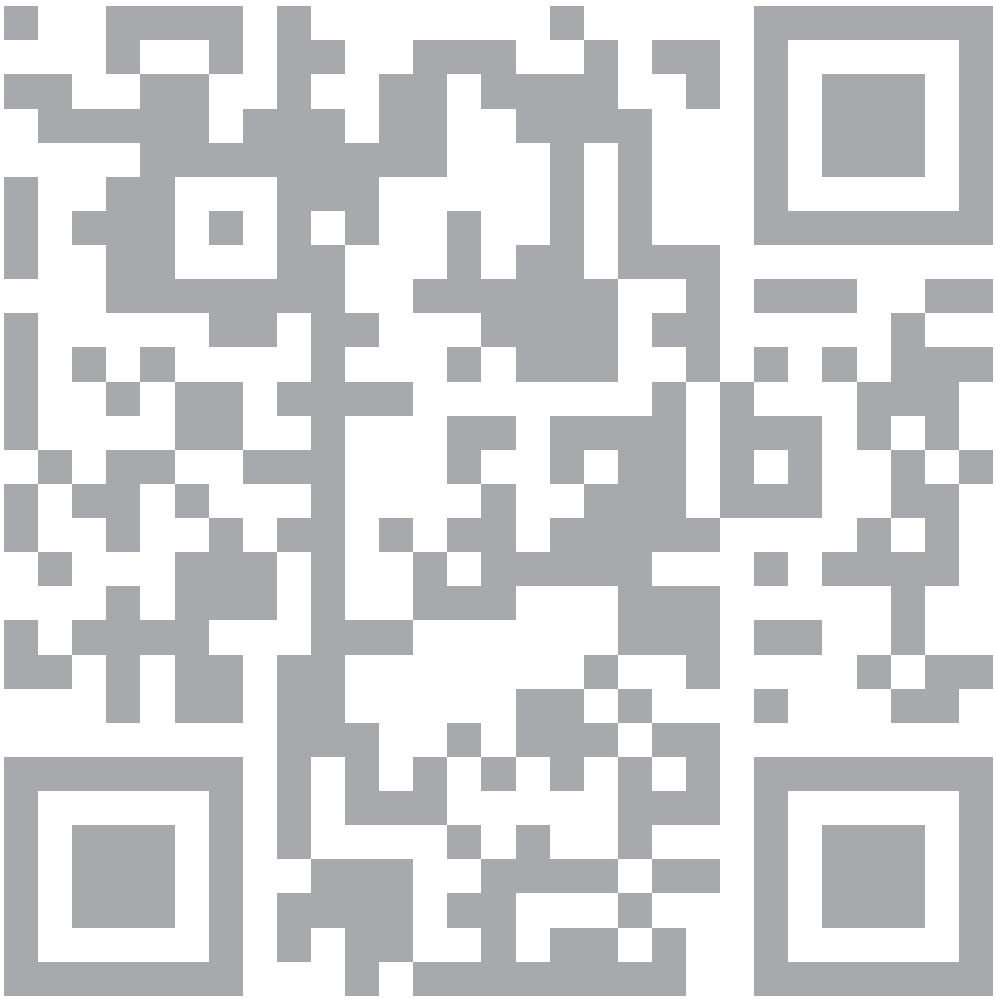
He is the recipient of the Dr. Eduard-Martin Prize for Excellence in Research, American Physical Society Fellow, Thomas Alva Edison Patent Award (with Erich Kunhardt), and an honorary professorship from the Leopold Franzens Universitat.

A prolific author, Dr. Becker has written over 200 articles in refereed journals and books, 375 conference presentations and abstracts and seven patents on the stabilization of atmospheric pressure plasmas and their applications. In addition, he has served on the editorial boards of numerous journals and was the invited presenter at national and international conferences.

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