NUNAN RESEARCH DAY
CYBER, WIRELESS, AND BIG DATA

MONDAY, APRIL 6, 2015
Sheraton Syracuse University Hotel & Conference Center

GRADUATE STUDENT POSTER SESSION

ABSTRACT BOOKLET

For details please visit lcs.syr.edu/nunan
NUNAN RESEARCH DAY
Syracuse University’s College of Engineering and Computer Science Graduate Student Poster Session
Sheraton Syracuse University Hotel & Conference Center

April 06, 2015

Schedule

• 9:30 am-11:30 am  Graduate Student Poster Session, Comstock, Harrison, and Adams rooms
  Come see our Ph.D. students present their research

• 11:30 am-1:00 pm  Lunch and Faculty Research Briefings
  Regency Ballroom
  Enjoy lunch while hearing the latest research breakthroughs featuring some of our newest faculty members in cyber, wireless, and big data

• 1:30-2:30 pm  Nunan Lecture Keynote Regency Ballroom
  H. Vincent Poor, Dean of the School of Engineering and Applied Science at Princeton University, presents “Fundamental Limits on Information Security and Privacy”

• 2:45-3:15 pm  Awards Ceremony
  Poster Competition winners announced and 8 prizes awarded
Dear Colleagues,

Today we are celebrating the excellent research performed in the College of Engineering and Computer Science and providing our Ph.D. students the opportunity to share their work with peers, alumni, and industry professionals.

Nunan Research Day was established in 2006 with a generous gift from the estate of Syracuse University alumnus James D. Nunan and his wife, Marge. James, an oarsman on SU’s sculling team, graduated from the College of Engineering & Computer Science in 1937. He was a chemical engineer at AMACO Oil and served as a military pilot in World War II.

The endowment allows for a major research lecture to be held in the spring of each year in conjunction with the poster session competition where we highlight our Ph.D. research from all 4 departments.

This year, the college is pleased that the Center for Advanced Technology in Computer Applications and Software Engineering (CASE), whose director is our own Distinguished Professor Pramod Varshney, will be jointly hosting the Nunan Research Day and Lecture with us. We are particularly excited to have H. Vincent Poor, the Dean of Engineering and Applied Science at Princeton University, deliver the Nunan Lecture entitled *Fundamental Limits on Information Security and Privacy*.

Please join us as we celebrate the incredible research and leading edge thought underway in the College of Engineering & Computer Science.

All the best,

Mark Glauser, Ph.D.
Professor, Department of Mechanical and Aerospace Engineering and Associate Dean for Research and Doctoral Programs
NUNAN POSTER COMPETITION
STUDENT ABSTRACTS ARRANGED BY DEPARTMENT

DEPARTMENT OF BIOMEDICAL AND CHEMICAL ENGINEERING 1-13

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING 13-25

DEPARTMENT OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCE 25-55

DEPARTMENT OF MECHANICAL AND AEROSPACE ENGINEERING 55-74
DEPARTMENT OF BIOMEDICAL AND CHEMICAL ENGINEERING

1. Recreating the Arterial Surface with Shape Memory Activated Polyelectrolyte Multi-layer Wrinkles

Ariel Ash-Shakoor, 3rd year Ph.D.
Eric B. Finkelstein, J. H. Henderson, P.T. Mather
Advisor: Patrick T. Mather

Cardiovascular disease is the leading cause of death in the world. Vascular grafts are implants that replace severely occluded, damaged arteries caused by cardiovascular disease. Small vascular grafts lack effective long term integration due to poor material interactions with endothelial cells, the cells that cover the luminal surface of all blood vessels. More specifically, cell-material interaction failures occur due to the lack of chemical cues to induce endothelial cell attachment following migration onto the graft material, and the absence of physical cues to induce natural endothelial cell alignment and morphology in vivo. Without the correct cell-material micro-environment, blood clots can form within the vascular graft thereby perpetuating the initial cardiovascular problem. This work seeks to address this problem with the use of a novel implant surface consisting of a layered composite polymer system of shape memory polymers (SMPs) and polyelectrolyte multi-layers (PEMs). Recently, SMPs have been used to induce cell alignment in vitro, while PEMs have been shown to improve endothelial cell attachment. The present work uniquely combines these approaches by using an SMP to compress PEM coatings to a useful wrinkled state through a buckling phenomenon. In particular, wrinkle patterns are formed by heat-induced shrinkage of SMPs that are first spin-coated with PEMs. By varying SMP strain and PEM processing variables, we have successfully created wrinkle patterns with similar features to arterial basement membrane proteins in vitro.

2. Alternatives to Antibiotics; Antimicrobial Peptides as Biocompatible Antimicrobial Agents to Target Bacterial Cell Membranes

Ali L Bahar, Ph.D.
Z. Liu, F. Totsingan, N. Kallenbach, D. Ren
Advisor: Dacheng Ren

The rapid increase in drug-resistant infections has presented a serious challenge to antimicrobial therapies. The failure of the most potent antibiotics to kill "superbugs" emphasizes the urgent need to develop other control agents. Membrane integrity is essential for the survival of bacteria irrespective of the metabolic stage of the cell and cell membrane is a major target of antimicrobial peptides (AMP). Cell membrane is ubiquitous in microorganisms and one third of the total proteins of a bacterial cell are associated with the membrane with many functions that are critical to cell physiology. Here we investigated the membrane potential of persister cells, a subpopulation of dormant phenotypic variants of bacterial cells that is highly tolerant to antibiotics. The flow cytometry results show that persister cells have lower membrane potential than normal cells. We also demonstrate that a synthetic AMP, 2D-24, is effective in killing the human pathogen Pseudomonas aeruginosa, which is a major causative agent of lung infection in cystic fibrosis patients. In addition, 2D-24 was found to be safe to the IB3-1 cell line originated from human lung epithelia and sheep erythrocytes at the concentrations that are effective against bacterial cells. Collectively, these results show that targeting cell membrane with AMPs is a promising approach to controlling persister cells.

3. Indoor Scene Understanding for Vision Based Smart Autonomous UAV’s

Anvith S Mahabalagiri, Ph.D.
Koray Ozcan
Advisor: Dr. Senem Velipasalar

Autonomous UAV’s are being used in a wide variety of indoor and outdoor applications. Our work focuses on exploring the use of vision based autonomous UAV’s as smart indoor assistive systems. One of the key challenges of such systems is the effective understanding of the indoor scene real-time decision making. We use computer vision techniques involving a combination of FAST features and Haar based object detection as a means of providing context to the scene in order to enable smooth navigation and decision making. We use Parot’s ARDrone2.0 to demonstrate a scenario of providing a context to the scene by identifying chairs and tables and identifying safe landing zones within the cluttered environment.
4. Computational Rheology of Surfactant Micelle and Micelle-Nanoparticle Solutions: A Molecular Dynamics Study

Abhinanden Sambasivam, Ph.D.
Dr. Subas Dhakal
Advisor: Dr. Radhakrishna Sureshkumar

Coarse grained molecular dynamics (MD) simulations [1-2] are used to study the equilibrium structure, shear-induced structure changes and rheology of cationic cylindrical micelle solutions. Systems that consist of up to a million coarse grained particles are simulated in the presence of explicit solvent and salt interactions. Addition of nanoparticles (NPs) to cationic wormlike micelles results in the formation of electrostatically stabilized micelle-NP junctions. The molecular mechanism and the kinetics of such junction formation will be elucidated. The effect of salt concentration and NP volume fraction on the structure and rheology of micelle-NP networks will be discussed. At sufficiently high salt concentrations, it is observed that branching in micelles results in a decrease in zero-shear viscosity of the solution. Non-equilibrium MD simulations are performed for micelle and micelle-NP solutions, showing shear thickening due to shear-induced structure (SIS) formation and shear thinning behavior depending on the salt and surfactant concentration. A shear-induced isotropic to nematic transition was observed for Weissenberg number $Wi \lesssim O(1)$, where $Wi$ is defined as the product of shear rate and the intrinsic structure relaxation time of the system. For $Wi > 1$, micelles align in the flow direction. Mean square displacement of NPs in such solutions suggests that particles could undergo transient trapping due to entanglement constraints arising from the micelle structure.


5. Effects of Plasmonic Thin Film Filters on Microalgal Growth and Biomass Composition

Bendy Estime, Ph.D.
Dacheng Ren
Advisor: Radhakrishna Sureshkumar

A plasmonics-based technology was developed to improve microalgal biomass production. Specifically, thin polymer films consisting of spherical silver nanoparticles were fabricated and used as plasmonic filters that selectively enhance blue-green light absorption in microalgal cultures. For the microalgal species *Chlamydomonas Reinhardtii*, the use of plasmonic filters led to an increase in the microalgal dry biomass by more than 25% and an increase in chlorophyll and carotenoid pigments by more than 35%, compared to the control cultures without using these films. Further, increased light stress by plasmon resonance did not affect lipid and
carbohydrate accumulation within individual algal cells. However, higher cell densities obtained with plasmonic filters resulted in enhanced overall carbohydrate and lipid production. This work certainly offers the potential to develop a scalable, durable and safe technology for improving algal bioreactor efficiency.

6. Material Stiffness Affects Bacterial Adhesion and the Physiology of Attached Cells

Fangchao Song, 5th year Ph.D.
Advisor: Dacheng Ren

Bacterial biofilm formation is a leading cause of chronic infections, which leads to nearly 100,000 deaths and 28-45 billion dollars of cost each year in the U.S. alone. Our recent study shows that substrate stiffness could influence both bacterial attachment and growth of attached bacterial cells. In addition, the cells attached on soft surfaces are longer and less tolerant to antibiotics than those on stiff surfaces. However, the mechanism of how bacteria sense surface stiffness and regulate their gene expression is still unknown. In this study, *Escherichia coli* RP437, *Pseudomonas aeruginosa* PAO1, and *Pseudomonas aeruginosa* PA14 were used as model strains to investigate how bacteria sense poly(dimethylsiloxane) (PDMS) surfaces with different stiffness (0.1 and 3 MPa), which were prepared by controlling the degree of crosslinking. By comparing the attachment of mutant strains on both stiff and soft surfaces, we found that flagella are involved in sensing the surface stiffness. In particular, the motB mutant of *Escherichia coli* RP437 exhibited defects in sensing the stiffness of PDMS. The results are helpful for understanding the mechanism of biofilm formation and designing new antifouling biomaterials.

7. Molecular Architecture of the Blood Brain Barrier

Flaviyan Irudayanathan, 2nd year Ph.D.
J P Trasatti, Pankaj Karande
Advisor: Shikha Nangia

The blood brain barrier (BBB) is a complex tissue interface found in capillary blood vessels of the brain. The BBB protects the brain from invading pathogens and harmful chemicals. On the flip-side the BBB prevents many crucial lifesaving drugs from entering into the brain, which presents an obstacle in treating brain related diseases such as Alzheimer’s. The BBB is formed by cell to cell adhesion of tight junction proteins. Claudin-5 is a membrane protein that aggregates and interfaces between two adjacent endothelial cells to form tight junctions. Claudin-5 is the key tight junction protein at the BBB controlling all molecular level traffic. Molecular understanding on how claudin-5 interacts to form the tight junction will be very crucial in exploring treatment options for brain associated diseases. Owing to difficulties involved in expression and isolations
molecular level understanding on these proteins are still vague. Here we present our novel collaborative research approach on claudin-5 interactions studied using in silico multi-scale molecular dynamics simulations and chemical cross linking experiments. Our results provide new insight into how claudin-5 proteins interact in a cell membrane to form the tight junctions, and subsequently the BBB.

8. Controlling Pseudomonas Aeruginosa Persister Cells by Human Granulocyte Macrophage-Colony Stimulating Factor

Geetika J Choudhary, Ph.D.
Xiangyu Yao, Rebecca A Bader, Dacheng Ren
Advisor: Dr. Dacheng Ren

Bacterial cultures harbor a small fraction of dormant phenotypic variants known as persister cells, which exhibit high-level drug tolerance and are associated with chronic infections. Granulocyte Macrophage-Colony Stimulating Factor (GM-CSF), a cytokine secreted by macrophages in response to microbial infections is known to be a major regulator governing the functions of immune cells. In this study, GM-CSF was selected to test its effects on the viability and persistence of the wild-type Pseudomonas aeruginosa PAO1, its mucoid mutant P. aeruginosa PDO300, and the non-pathogenic Escherichia coli K12. GM-CSF was found to sensitize P. aeruginosa PAO1 to multiple antibiotics including ciprofloxacin, tobramycin, tetracycline, and gentamicin. In comparison, no such effect was found against normal cells of P. aeruginosa PAO1 and PDO300, and the persister cells of non-pathogenic E. coli K12. Also, GM-CSF could sensitize the biofilm cells of P. aeruginosa PAO1 and PDO300 to tobramycin in the presence of biofilm matrix degrading enzymes DNase I and alginate lyase respectively. The DNA microarray and qPCR analyses indicate that treatment with GM-CSF induced the genes for flagellar motility and pyocin production in the persister cells of P. aeruginosa PAO1. Using co-immunoprecipitation (Co-IP) and western blotting, FliC was found to bind to GM-CSF. In addition, GM-CSF treated P. aeruginosa PAO1 persister cell suspension was found to lyse P. aeruginosa PAK, consistent with the induction of R2-pyocin genes by GM-CSF revealed by DNA microarray results.

9. Coarse Grained Parameterization the Gram-negative Bacterial Membrane

Huilin Ma, 2nd year Master’s
Flaviyan Jerome Irudayanathan, Wenjuan Jiang
Advisor: Dr. Shikha Nangia

Gram-negative bacteria are responsible for the alarming number of antibiotic resistant bacterial diseases worldwide. Despite a push for new antibiotic therapies, there has been a decline in the number of newly approved drugs due to limited understanding of how drugs interface with
the trilamellar bacterial cell envelope. It is apparent that molecular understanding of the bacterial membrane is essential in developing effective antibacterial strategies. Probing bacterial membranes experimentally or simulating them over relevant timescale remains a challenge due to the complexity of the bacterial cell wall.

To overcome this challenge, we have developed an affordable, highly benchmarked, coarse grained parameter set for the bacterial outer membrane that reproduces experimentally determined structural and dynamical properties. Modeling the membrane in a coarse grained resolution makes microsecond timescale simulations affordable compared to atomistic resolution simulations that are limited to a few hundred nanoseconds. In this work, more than 18 different systems were studied with a combined simulation time of over 100 microseconds. The model provides excellent starting point for molecular level investigations of antimicrobial action of short peptides and for deciphering the mechanistic aspects of antibiotic permeation into bacterial cells.


Huan Gu, Dacheng Ren
Advisor: Dacheng Ren

Bacterial adhesion to surfaces and subsequent formation of microcolonies are important to biofilm formation, which is a major cause of chronic infections and persistent biofouling. Despite the significance of bacterial biofilms, the mechanism of biofilm formation and associated drug tolerance are still not fully understood. A major challenge in biofilm research is the intrinsic heterogeneity in biofilm structure, which leads to temporal and spatial variation in cell density and gene expression. To understand and control such structural heterogeneity, we created surfaces with patterned functional alkanethiols to obtain E. coli cell clusters with systematically varied cluster size and distance between clusters. Previously, by using this well-defined surface system, we found that multicellular connections can be formed between cell clusters and genetic factors such as autoinducer-2 mediated quorum sensing are involved in the interaction among cell clusters. Inspired by these results, antibiotic susceptibility of E. coli biofilm cells was monitored to understand biofilm-associated antibiotic resistance. The results revealed that antibiotic susceptibility of biofilm cells increased first and then decreased to the level of overnight planktonic cultures. This finding suggests that the metabolic activity of biofilm cells changes over time. In addition, E. coli RP437 cells between square patterns were found more sensitive to ampicillin compared to the cells in the square patterns. This supports our previous finding that active interaction between all clusters is involved during biofilm formation. Collectively, these results provide missing information that links cell-to-cell signaling and interaction among cell clusters to the structural organization and physiology of bacterial biofilms.

Jiuxu Liu, 2nd year Ph.D.
Yue Nan, Yujie Shen, Lawrence L. Tavlarides
Advisor: Lawrence L. Tavlarides

Biodiesel synthesis under sub/supercritical methanol or ethanol conditions provides both energy and economic benefits over the conventional base catalyzed biodiesel production process. Comparing with methanol which is used to produce biodiesel in North America, ethanol is a more renewable alcohol, and fatty acid ethyl esters (FAEE) have lower cloud and pour point compared to fatty acid methyl esters (FAME). High cost of anhydrous ethanol is an important reason why the industry avoids using it. Sub/supercritical technology is able to use cheap non-anhydrous ethanol to produce biodiesel to make this technology more cost effective and competitive. However in order to reach a high reaction conversion without using any catalysts, one has to either apply a high temperature or a long residence time, this will thermally decompose the product, which further degrades fuel quality. In order to fully understand how to reach a high biodiesel yield with minimum thermal decomposition, it is important to study the mechanism of both transesterification reactions and thermal decomposition reactions. Our group has studied the kinetics and phase behavior of FAME synthesis under supercritical methanol conditions. Our next objectives of this research are to a) study the kinetics and optimize FAEE synthesis with and without homogeneous acid catalysts under sub and supercritical ethanol conditions, b) study the mechanism and kinetics of FAEE thermal decomposition and its effect on fuel viscosity and cold flow properties. Accordingly, experiments are designed for each objective respectively. Experimental results will be presented on the poster.

12. Exploiting Shape Memory to Study the Effect of Change in Fiber Alignment on Cancer Cell Motility

Jing M Wang, 6th year Ph.D.
Jay H Henderson
Advisor: Jay H Henderson

Extracellular matrix architecture can play a critical role in cell motility during disease pathogenesis, including that of cancer. Aligned collagen fibers have previously been used to study the effect of ECM architecture on cancer cell motility. Due in part to the stasis of such in vitro model systems, the relationship between changes in ECM architecture and cell motility remains poorly understood.

The goal of the present study was to establish a model system to study the effect of change in fiber alignment on cell motility. We present a model system that employs a programmable shape memory electrospun scaffold and show that changes in fiber alignment can direct cell motil-
ity. Such programmable shape memory electrospun scaffold can either change from temporarily highly aligned fiber architecture to permanent unaligned architecture, or change from temporarily unaligned architecture to permanent highly aligned architecture, upon triggering at body temperature 37 °C. Human fibrosarcoma cells were cultured on such programmed scaffolds. Cell migration time lapse videos were captured for 24 h and analyzed by automated cell tracking algorithm ACTIVE. The resultant cell track morphology, mean square displacement, and velocity show that on dynamic scaffolds, cells moved without preferential direction on temporarily unaligned scaffold prior to triggering of shape change, but changed to directional motility along the fiber alignment direction after scaffold recovery. In contrast, on dynamic temporarily aligned scaffolds, cells moved along the fiber alignment direction prior to triggering of shape change, but changed to non-directional motility after recovery.

13. Active Surface Wrinkling Influences Cell Migration Behavior and Control

Megan Brasch, 4th Year Ph.D.
N Deakin, ML Manning, CE Turner, JH Henderson
Advisor: James Henderson

Dynamic reorganization of a cell’s local microenvironment has been shown to critically alter migration, adhesion, and morphological behaviors in vivo during development, wound healing, and disease. While static microenvironments with patterned topographies, stiffness variations, or chemical gradients have been used to characterize cell responses in vitro, they are incapable of capturing the dynamic functionality of extracellular matrix naturally seen in the body. Here, we use a thermally responsive class of materials, shape memory polymers (SMPs), to dynamically manipulate the topographical environment cells experience. By providing physical manipulation of the microenvironment, we demonstrate the ability to control cell migratory behavior in response to a dynamic topographical change provided by SMPs.

14. White Light Self-writing of Microstructures in Polymer Materials

Saeid Biria, 1st year Ph.D.
Advisor: Ian D. Hosein

Light spontaneously divides into thousands of microscale “self-trapped” beams in a photopolymer. As a result, thousands of microscale cylindrical “channels” are permanently inscribed in the medium: each beam “self-writes” an individual channel. A wide-area light source is empowered by this process to create large-scale microstructures in photocurable materials, rapidly and cost-effectively. The channels have the potential to enhance both the optical transmission and electronic properties. This is urgently needed, as polymer microstructures become more
ubiquitous in technologies such as electronics, optics, microfluidics, and biomaterials. However, a major setback in this process is the limited range of polymers thus far in which self-writing has been demonstrated. In this work, we present our achievements in harnessing white light to self-write permanent microstructures in cross-linking acrylates and epoxies, which are two important materials systems for creating durable, transparent coatings for technologies such as solar cells, displays, and solid-state lighting. Our method is easily scalable, and amendable to conformal coating of surfaces, and the using of white light enables this process to be easily implemented and accessible to a wide range of industries.

15. Generating Complex Wrinkle Patterns for Active Cell Culture via Shape Memory Polymers

Shelby M Buffington, 2nd year Ph.D.
Derek Loh
Advisor: Dr. J Henderson and Dr. P Mather

Many tissues undergo continuous remodeling of the extracellular matrix (ECM) in response to environmental stimuli. However, in vitro biomaterial systems used to probe cell responses have traditionally been static and unable to replicate dynamic environmental changes. To address this gap, we and others have developed shape-memory polymers (SMPs) capable of changing topography during cell culture on either the micro or nano scale. To advance this work we replaced the SMP with a triple shape polymeric composite (TSPC) enabling the formation of nano-double wrinkled topographies. TSPCs were fabricated using previously reported methods. The resulting material can “learn” two temporary shapes and one permanent shape. Tensile strain was independently programmed into each material phase at different temperatures with varying strain ratios and angles of strain between the two phases. TSPCs where sputter coated with gold and recovered causing the gold coating to buckle and wrinkles to form. Patterns were assessed using atomic force microscopy and scanning electron microscopy. Wrinkle formation was affected by the total amount of strain in each phase, and the ratio of the strains and angle between the two programmed strains. We hypothesize the difference in pattern formation caused by the ratio of strains is due to the stiffening of the gold film in response to the first wrinkle transition. We postulate that cells will display unique responses to these dynamic ECM scale patterns and future experiments will focus on quantifying these effects.

Funding from NSF IGERT Program, DGE-1068780 and use of the Syracuse Biomaterial Institute Facilities is acknowledged.
16. Transport Across the Blood-brain Barrier: A Kinetic Monte Carlo approach

Wenjuan Jiang, 3rd year Ph.D.
Shikha Nangia
Advisor: Shikha Nangia

The blood-brain barrier serves the critical role of allowing only certain types of molecules to enter the brain from the blood stream. This important capability protects the brain from exposure to harmful chemicals, but as a side-effect it also prevents live-saving drugs from entering the brain essential for treatment of neurodegenerative diseases. The BBB is a consequence of highly specialized endothelial cells, lining the blood capillaries that form strands of cell-cell adhesion structures called tight junctions. These tight junctions act as molecular gate-keepers in controlling the diffusion of essential molecules through the paracellular pores. Due to the inherent complexity of the BBB such as the dynamic nature of the pores, micrometer dimensions of the tight junction strands, and timescale in hours or days, both molecular and mathematical modeling with simple analytical solutions are inadequate. We have therefore developed specialized stochastic simulation algorithm (SSA) to handle the complexity of the reaction-diffusion transport across the blood brain barrier. This algorithm is being developed as part of our group’s parallel SSA (pSSA) solver code. The program is being written in C++ programming language and is currently in development and testing phase. Once completed, transport kinetics of specific ions, water, and small drug molecules significant for brain related ailments will be computed. It is expected that the pSSA code will make testing of new drugs computationally tractable and aid in the process of finding non-surgical ways of treating the brain-related diseases.

17. Synergistic Computational and Experimental Approaches for Optimizing Anticancer Drug Delivery Nanocarriers

Xiaoyi Wang, 2nd year Master’s
Wenjuan Jiang, Juntao Luo, Shikha Nangia
Advisor: Shikha Nangia

Engineered nanocarriers are promising drug delivery vehicles in the field of nanomedicine due to their tunable physiochemical properties. However, designing nanocarriers is challenging due to stringent design requirements such as stability, drug-loading capacity, size distribution, target specificity, and most importantly the nature the encapsulated drug. In this work, we have developed a collaborative and experimental and multiscale computational modeling approach capable of evaluating macromolecular assemblies (micelles). Our drug delivery platform of choice is polyethylene glycol-b-dendritic oligomer copolymer (PEG-b-oligomer) called telodendrimer, which due to its modular structure allows easy
chemical modifications and has been shown to form optimal carriers for Food and Drug Administration (FDA) approved cancer drugs—Paclitaxel (PTX) and Doxorubicin (DOX). Our computational results indicate that the facially ampliphilic molecule cholic acid (CA) is a desirable telodendrimer building block for the stability of the PTX loaded micelle with an exterior shell of PEG chains corresponding to 5 kDa molecular weight (PEG5kCA8). For DOX, however, the CA groups are not optimal and need to be replaced with more hydrophilic building blocks that match the DOX molecule characteristics.

These results are in agreement with the experimental observations indicating the success of multiscale computational approaches in optimizing drug delivery nanocarriers based on the nature of the encapsulated drug. Furthermore, this work highlights the significant role multiscale computational approaches can play in designing optimal drug specific nanocarrier to complement experimental research and reduce both the time and the cost of the process.

18. The Effect of Simulated Inflammatory Conditions on the Corrosion and Fretting Corrosion of CoCrMo alloy

Yangping Liu, 5st year Ph.D.
Jeremy Gilbert
Advisor: Jeremy Gilbert

Cobalt-chromium-molybdenum (CoCrMo) alloy is widely used in orthopedic devices. Ions and particles released from CoCrMo have been recognized as a major concern. Recently, inflammatory cell induced corrosion of CoCrMo alloy has been documented in our laboratory. This mechanism of corrosion results from stimulated immune and inflammatory cells releasing reactive oxygen species such as hydrogen peroxide (H₂O₂), utilizing Fenton reactions, and acid to amplify corrosion processes. How simulated inflammatory based H₂O₂, Fenton reactions and acid affect CoCrMo corrosion is not fully understood. The goal of this study is to assess the effects of simulated inflammatory species on the corrosion and fretting corrosion behavior and surface oxide structure of CoCrMo alloy.

19. Adsorption of Iodine on Reduced Silver Mordenite

Yue Nan, 2nd year Ph.D.
Lawrence L. Tavlarides
Advisor: Lawrence L. Tavlarides

Having a very long half-life of 15.7×10⁶ years, iodine-129 is one of the major concerns in the spent nuclear fuel reprocessing off-gas treatment. The research in this field over the past four decades has found reduced silver exchanged mordenite (AgºZ) is the state-of-the-art of iodine removal due to its regenerability, high resistance to NOx, and moderate sorption capacity. However most of the studies focused on the macro-scale ad-
sorption (deep bed) and no kinetic and equilibrium models for elemental iodine adsorption on thin bed AgºZ were developed. Therefore, this work focuses on the single-layer (thin bed) sorption studies to construct detailed kinetic and equilibrium models of the iodine and water adsorption process with AgºZ. Single-layer sorbents experiments are in progress to obtain equilibrium and kinetic data at a wide range conditions which covers the conditions of importance for the iodine and water off-gas capture. These data and models to be developed will allow a better understanding of the adsorption/co-adsorption behavior on single pellets, and will be employed to analyze the deep bed adsorption in future work. This work is a part of our study on off-gas treatment modeling and verification to support DOE’s efforts to develop advanced adsorption unit operation models for off-gas treatment. Our collaborators at Georgia Institute of Technology, Prairie View A&M University, and Oak Ridge National Laboratory are working on the modeling tool development and verification, and capture of $^{14}$C (in the form of CO$_2$).

20. Structure and Rheology of Polymer Solutions from Coarse-grained Molecular Dynamics Simulations: Effects of Polymer Concentration, Solvent Quality and Geometric Confinement

Yutian Yang, 5th year Ph.D.
Advisor: Radhakrishna Sureshkumar

Structure, dynamics and rheology of solutions of flexible linear polymers are investigated using coarse-grained (CG) molecular models and molecular dynamics (MD) simulations in presence of explicit solvent mediated interactions. MARTINI force field is employed to describe the polymer, solvent and the underlying physico-chemical interactions. The CG models are validated against atomistic ones by comparing the predictions of certain structure parameters such as persistence length, radius of gyration and radial distribution functions of the monomeric units. First, we will present results for the dynamics of a single polymer chain in shear flow. The effects of chain length and shear rate on the configuration statistics, e.g. tumbling frequency and orientation distribution of the end-to-end vector, will be presented and compared to experimental observations and predictions of stochastic dynamics simulations. Further, the effects of solvent-polymer interactions under good, theta and poor solvent conditions as well as geometric confinement in presence of favorable, neutral and unfavorable polymer-wall interactions on the configuration dynamics of a single polymer chain will be also discussed. Specifically, the role of solvent quality will be shown to have a pronounced effect on coil-stretch transition in shear flow. CGMD predictions for the relationship between the zero-shear viscosity and polymer concentration in dilute and semi-dilute regimes will be presented and compared to experiment results. Shear thinning behavior is observed in both dilute and semi-dilute solutions in non-equilibrium molecular dynamics simulations. Possible approaches using MD simulation data to parameterize phenomenological constitutive
models such as the Carreau-Yasuda model will also be discussed. (Support from the National Science Foundation through grants CBET-1055219 and CDI 1049489 is gratefully acknowledged).

## DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

### 21. Impacts of Installing Green Infrastructure on Stormwater Quality

**Alexander Johnson,**
Advisor: Cliff I. Davidson

Cities across the U.S. have decided to invest in green infrastructure (GI) such as green roofs, bioretention systems, and porous pavement to reduce the volume of stormwater runoff. However, the effects of GI on water quality is unknown. The goal of this project is to assess the impact of installing GI in Syracuse, NY on the chemistry of stormwater runoff. Here, runoff chemistry from a 0.56 hectare green roof in downtown Syracuse is evaluated and compared to an adjacent gray roof. Precipitation chemistry is also determined. Pollutants currently studied are the anions $F^-$, $SO_{4}^{2-}$, $NO_{3}^{-}$, and $PO_{4}^{3-}$. Preliminary sampling for runoff and precipitation events from June-August 2014 show variable anion concentrations. Phosphate concentrations are not detectable in runoff from the gray roof but are measurable in that from the green roof, suggesting that fertilizer was added to the soil media. Future work will involve dry deposition sampling for dry periods between storms using aerodynamic surfaces. This will quantify the amount of each species added to the chemical load of the roof surface and will provide estimates of the contributions of dry deposition, wet deposition, and leaching from soil in the stormwater runoff sampled. These studies will also expand to trace metal analyses, specifically for Cu, Pb, and Zn, due to their toxicity and presence in the atmosphere from industrial activities.

### 22. Social and Physical Characterizations of Combined Sewer System Communities in the United States

**Carli Flynn, Ph.D.**
Yige Yang, Jiayi Tang, Diona Antoine, Jeff Minnich
Advisor: Cliff Davidson

Sewer management is a critical societal challenge across the US. Combined sewer systems (CSSs), which are largely located in older and heavily populated urban areas, are designed to collect stormwater runoff, domestic sewage, and industrial wastewater in a single centralized pipe network. In addition to aging and insufficient sewer systems, many CSS communities face multiple social challenges. Throughout the past century, combined sewer overflow mitigation efforts have been composed almost
Nunan poster competition 2015

student abstracts

14

exclusively of gray infrastructure technologies. Until recently, this paradigm has served society’s needs for public health protection, environmental quality, and flood prevention relatively well. However, the increasing fraction of land area covered by impervious surfaces has caused increasing stormwater runoff in urban areas. Furthermore, sociopolitical and environmental drivers related to social justice, sustainability, and climate resilience are becoming increasingly significant in municipal stormwater management decisions. The interests of stormwater planning authorities in developing more sustainable management practices, such as green infrastructure technologies, have evolved from supplemental projects of marginal value to a suite of innovative practices that can replace many traditional projects. This research explores the sociopolitical and environmental factors that characterize CSS communities, which in turn influence the decisions of municipal and regional planning authorities. A variety of social and physical factors are considered, including impervious surface developments, precipitation rate and frequency, population changes, regional social capital, political interests, and available resources. Results from this research will have practical implications for strategic planners, policy analysts and decision-makers who seek to transition urban water infrastructure systems toward more sustainable futures.

23. Investigation of Global and Local Strain Development in EPS Geofoam with Non-Contact Displacement Monitoring

Chen Liu, 2st year Master’s
Advisor: Dawit Negussey

Laboratory testing of EPS Geofoam or other solids often rely on physical contact and global deformation monitoring to characterize stress – strain behaviors. For local measurements, the number of discrete gage lengths are limited to one or two locations. Displacement monitoring in conditions involving submersion in water and confining pressure or tests in extreme temperature chambers are difficult to perform with contact detection. 2D observations are virtually impractical. To overcome these difficulties, a GeoJac automatic load testing system with conventional displacement transducer was used together with ARAMIS. ARAMIS is a 3D optical displacement tracking system for full field or localized non-contact continuous monitoring. The ARAMIS system consists of two CCD cameras mounted on a tripod and a track beam. The separation of the cameras and distance of the tripod can be adjusted to accommodate full field exposure of the test sample. Displacement and stress strain results derived from conventional global measurements are compared with data recorded by the ARAMIS system. The strain distribution across the EPS samples were different. The maximum strains were at the lower and upper rigid boundary contacts due to edge effect. Time laps images and video recordings show that the progressive strain development for the cellular structure of the EPS sample is in approximately horizontal layers rather than inclined shear bands as commonly occur in soils and
other rigid materials. The optical non-contact system can accommodate any sample size and full scale models to directly detect both static and dynamic response in 3D and high resolution.

24. Response of the Mercury Cycle in an Adirondack, USA Lake Watershed to Recovery From Decreasing Acid Deposition and Lime Application

Geoffrey E Millard, 2nd year Master’s
Charles Driscoll, Mario Montesdeoca
Advisor: Dr. Charles T. Driscoll

Following decreased acid deposition, some impacted lakes in Northern Europe and the Northeastern USA are beginning to recover. The resultant increased pH in these lakes has led to increased dissolved organic carbon (DOC), which is positively correlated with both total and methylmercury concentrations. Understanding how ecosystem mercury dynamics respond to recovery has important implications for fisheries and human health. Trophic transfer of mercury is of particular concern in Adirondack lakes containing heritage brook trout populations, genetically unique communities unaffected by stocking practices. Honnedaga Lake is one of seven lakes in the Adirondack Park of New York State with heritage brook trout. Though this ecosystem previously impacted by acid deposition is beginning to show signs of recovery, model projections indicate this process could take decades. A demonstration watershed liming is being conducted to investigate the changes in watershed mercury dynamics due to artificially accelerated recovery. Time-series analysis of mercury concentrations reveals a first flush effect of significantly elevated levels shortly after treatment (THg post-treatment peak=5.5ng/L, THg reference peak=2.15). Six months after treatment, there is no significant difference in methylmercury concentrations from reference values (p=0.524), while total mercury remains significantly higher (p=0.004). This pattern suggests that mercury is leaching from the treated watershed at elevated levels but is not readily methylated before exiting the tributary. Further study is required to determine the long-term impacts of an accelerated recovery on mercury transport and bioavailability.

25. Developing Critical Loads of Acidity for Streams in the Great Smoky Mountains National Park, USA

Habibollah Fakhraei, 5th year Ph.D.
C.T. Driscoll
Advisor: Dr Driscoll

Critical loads (CLs) for nitrogen and sulfur will be estimated for stream-watersheds in the Great Smoky Mountains National Park (GRSM). Among 30 stream-watersheds studied in this research, 13 sites are listed under Section 303(d) of the Clean Water Act as impaired due to elevated acidity. We investigate the potential recovery of these sites in response to
recent and future projected declines in atmospheric deposition. We use a dynamic biogeochemical model, PnET-BGC, to develop CLs to recover the acid neutralizing capacity of streams above three target values of 0, 20 and 50 µeq L⁻¹. As important inputs of the model, spatial and temporal patterns of atmospheric deposition and climatic drivers are estimated by developing empirical models of collected data from monitoring stations inside and near the GRSM. The PnET-BGC model parameters are calibrated based on long-term observed stream chemistry. The calibrated model is run for different reduction levels of atmospheric deposition to develop S and N load-response curves. Using these response curves, the CLs and exceedances of atmospheric S and N deposition are calculated and depicted through GIS maps. Sensitivity and uncertainty analyses are conducted on the most sensitive model parameters and inputs to determine 90% level of confidence for the future model projections.

26. The Complexity of Nutrient Limitation in Adirondack Lakes Recovering from Acidification

Jacqueline Gerson,
Karen Roy
Advisor: Charles Driscoll

With decreased acid deposition, nitrogen (N):phosphorus (P) ratios in lakes could be lowered, potentially decreasing P limitation of phytoplankton and altering food web dynamics. This effect could be particularly pronounced in the Adirondack Mountains of New York State, a historic hotspot for effects of acid deposition. We used Mann-Kendall Tao associations between total phosphorus (TP), chlorophyll a, dissolved organic carbon (DOC), acid neutralizing capacity (ANC), and nitrate concentrations in Adirondack lakes to determine if decreases in atmospheric deposition alter phosphorus dynamics in freshwater ecosystems impacted by acidification. We sought to assess whether the lakes show decreases in P limitation as N:P ratios change and whether these changes differ based upon lake-watershed characteristic (e.g., seepage, chain drainage, non-chain drainage, thin glacial till, medium glacial till). We found that associations were highly dependent upon lake class, with associations for variables for seepage lakes differing greatly from drainage lakes. Differentiations between non-chain drainage and chain drainage, as well as till depth, were also important factors in determining associations. Though associations could be found between variables using annual values, high seasonal dependence was also evident; for example, association was found between chlorophyll a and nitrate in the winter, while TP and chlorophyll were associated in the summer. Information on total phosphorus and chlorophyll a from the Adirondacks will inform how changes in atmospheric nitrogen deposition influence trophic status of lake systems throughout the region.
27. Hydrogeomorphic Classification of the Natural and Restored Wetlands in St. Lawrence Valley

Kyotaek Huu Hwang, 2nd year Ph.D.
Advisor: Dr. David G. Chandler

Evaluation of wetland restoration needs to be carefully conducted because the ecosystem components respond with different degree of sensitivity to its landform. Since landscape features, such as topography, land use and flow regime, promote ecosystem species, geomorphology needs to be considered as one of the main drivers for sustaining wetland ecology. In order to define wetland ecosystem functions and services, regional classification of a wetland should be accompanied. In this study, natural and restored wetlands in St. Lawrence Valley are classified by the hydrogeomorphic approach and their hydrologic characteristics over the classes are investigated. The wetland ecosystems distributed over large area are broadly classified in terms of geomorphic setting, water source, and hydrodynamics and then hierarchically specified into regional subclasses to determine unique features. Wetland hydrology for each subclass is also characterized for functional assessment using hydraulic gradient between surface water within the system and adjacent upland groundwater. The regional wetland classification and functional assessment will provide useful tools to make a proper restoration plan.

28. Investigation of EPS Geofoam Failure in a Lightweight Fill Application

Luke Andrews, 1st year Master’s
Advisor: Dawit Negussey

In 2006, a culvert and embankment on highway I-88 failed due to heavy flooding. The New York State Department of Transportation reconstructed the embankment using EPS geofoam as a lightweight fill because similar applications of EPS had been successful and it could expedite the construction process. Excessive settlements forced the removal of the EPS a year after completion. The DOT’s review concluded the performance of the foam was due to poor quality material supplied by the manufacturer. Large amounts of recycled content and low density blocks caused deformations in the embankment. Our investigation revealed additional factors that contribute to the degradation of EPS performance. The original manufacturer supplied virgin material for testing and we also collected disturbed and relatively undisturbed samples from the field. Strength and deformation properties of the materials were determined and compared. We also took into consideration the loading conditions that the EPS was subjected to during construction and long term, and the effect it may have had on the material’s performance. We found ground water conditions, block layout design, and construction methods that made this embankment unique from successful applica-
tions of EPS geofoam and contributed to its failure. Suggestions for the improvement of EPS geofoam applications are based on these findings.

29. Effective Retrofit of Moment Resisting Connections Using Perforated Beam Section (PBS)

Mohammadhossein Mamaghani, 1st year Ph.D.
Eric M. Lui, Hossein Ataei
Advisor: Eric M. Lui

Since the Northridge earthquake, researchers have proposed various methods to relocate critical beam sections away from column face in moment resistant frames to avoid brittle fracture at beam-to-column connections under intense ground motions. These methods include the use of reduced beam section (RBS) with various flange cutout geometries, corrugated web plates, beam link, reduced web depth, and heat-treated beam section. All these methods are aimed towards providing a fuse, i.e., a section of reduced plastic moment capacity, on the beam at a pre-determined offset from the column face where inelastic deformations will occur, thereby absorbing the earthquake energy through stable hysteresis. In the present research, reduction in plastic moment capacity at the desired location is achieved by the use of perforations made in the beam flanges or web. The proposed Perforated Beam Section (PBS) involves making holes in selected locations on the beam flanges or web. When compared with traditional RBS which requires radius cutting the flanges, corrugated web plates which require cutting out the beam web and replacing it with corrugated plates, beam link which requires replacing a portion of the beam with a beam section with a reduced plastic moment capacity, reduced web plate which requires fabricating a beam section with a reduced beam depth, and heat-treated beam section which requires special heat treatment procedure, the proposed PBS is less tedious and more economical to fabricate, and it does not require special considerations in its design. To demonstrate the viability and effectiveness of the proposed PBS, finite element analysis was performed on various perforated beam section geometries with perforations made in the upper and lower flanges or web of wide flange beams under a cyclic loading protocol. The analysis results show that the proposed PBS not only allow the expected shifting of the plastic hinge away from the beam-to-column joints, they show stable hysteresis and enhanced lateral torsional buckling when compared to traditional RBS. The use of PBS for new structures or as a retrofitting system for existing structures with pre-Northridge connections can be quite cost effective given its simplicity in design and ease of fabrication.
30. Sustainable and Innovative Design Methods for Geotextile Tube Dewatering

Mahmoud Khachan, Ph.D. Candidate
Dr. Shobha Bhatia and Zeru Kiffle
Advisor: Dr. Shobha Bhatia

Several industries have adopted geotextile tubes as a cost effective and successful dewatering technology over the past three decades. The dewatered materials include dredged sediments, industrial wastes, coal combustion products, and municipal wastes. In conjunction with the success and efficacy gained by using geotextile tubes, there were increased environmental concerns associated with the use of synthetic chemical flocculants to enhance the dewatering rate, in addition to concerns about the strength and stability of the dewatered materials. This research aims to address these concerns by introducing sustainable and practical alternatives to current dewatering practices. Ecofriendly flocculants (starch-based) that are made at Syracuse University Geotechnical Laboratory as an alternative to the widely used synthetic flocculants are introduced in this research. The effect of green flocculants on dewatering rate and on retained sediments properties was evaluated using pressure filtration and centrifuge tests. Tests results showed that green flocculants effects are very similar to those of synthetic flocculants. In some cases, where organic sediments were used, the green flocculants were more effective than the synthetics. Furthermore, two new methods for measuring the concentration of the residual flocculants in the effluent that seeps through geotextile tubes were introduced. The two methods are Streaming Current Method, and Kaolin Settling Rate Method. Additionally, a study about possible methods to improve the stability of the dewatered sediments was conducted. Randomly distributed discrete fibers were found to be effective in increasing the shear strength of the dewatered sediments by about 80%. Finally, two dimensional mathematical model that incorporates geotextile tube dewatering physical processes, such as sedimentation and filtration, is introduced in this research.

31. Quantification of the Thermal Properties of a Large Extensive Green Roof

Mallory Squier, Ph.D.
Zhi Cui
Advisor: Cliff Davidson

Green roofs alter the thermal properties of the building envelope, their impact influenced by building material properties and climatic factors. This study quantifies the thermal properties of a large (0.56 ha) extensive green roof located in Syracuse, NY. During construction, temperature sensor profiles were installed at 5 locations to measure the temperature gradient through the roof layers. Temperature data recorded from Fall 2013 to Fall 2014 are first filtered for ideal ambient conditions, dry weath-
er, and no snow cover, and are then modeled as sine functions. Lag times are determined as the phase shift of the sin function. The wide range of meteorological conditions experienced seasonally in Syracuse along with the controlled interior space underlying the green roof, result in changing heat flux conditions throughout the year. R-values collected from material manufacturers and the literature are used as inputs to model heat transfer through the roof layers. Insulation is found to be the rate-limiting step, though the insulating effects of the growth medium under dry conditions are also apparent. The insulating contribution of the growth medium varies with soil moisture and its impact with variation in climate.

32. Adsorption Mechanism of Heavy Metals by Soils and Cellulosic Waste Material During Geotextile Process, a Sustainable Approach

Prabesh Rupakheti, 2nd year Master’s
Advisor: Dr. Shobha K Bhatia

The aim of this study is to investigate the potential of different soil and cellulosic waste material, Kraft Pulp, to adsorb heavy metals (Pb, Cu, Cd, and Zn) from dredged sediment slurries in geotextile dewatering process. Leaching of heavy metals during many remediation projects and dewatering processes have been a serious issue around the globe. Also, knowledge of adsorption capacity of soils to heavy metals is critical to understand the bio-availability and speciation of these heavy metals in the natural environment. Batch adsorption tests were carried to quantify the maximum adsorption capacity and adsorption mechanism of Silty (Tully Fines), Sandy (Tully Coarse), pure kaolinite clay and Kraft pulp. The adsorption data fitted well with Langmuir and Freundlich isotherms. The Silty soil showed very high adsorption for lead metal with very high adsorption capacity as determined from Langmuir isotherm. Sandy soil also had high adsorption capacity to lead metal with maximum adsorption capacity of 14.513 mg Pb per gram of soil. The adsorption of Pb on Kaolinite clay was not as high as with other soils. The adsorption capacities of Tully soils to Cu was almost same with maximum adsorption capacity of 6.55 mg Cu per gram of soil. However, Kaolinite had maximum adsorption capacity of 1.995 mg Cu/gm soil. Zn and Cd were better adsorbed by Kaolinite than Tully soils.

33. Socio - Environmental Impacts of Pavement Maintenance, Repair and Rehabilitation Activities

Sudipta Ghorai, 4th year Ph.D.
Dr. Baris Salman
Advisor: Dr. Sam Salem

Preservation treatments help in extending the remaining service life of pavements, but at the same time, they may have considerable environ-
mental impacts due to the acquisition of raw materials, transportation of the processed materials from extraction to production site, manufacturing of the final product, and the use of various equipment during the treatment process. Traditional and accelerated maintenance, repair and rehabilitation (MRR) techniques were identified for both flexible and rigid pavements. Environmental and social impacts of the commonly used MRR strategies were calculated in amounts of greenhouse gases emitted, energy consumed, resources used and social cost of carbon. A life cycle assessment (LCA) approach was used, taking into account the life extension of the pavement for each type of strategy. LCA results showed that for flexible pavements, accelerated rehabilitation techniques like partial or full depth reclamation have less life cycle environmental impacts than traditional techniques like milling and overlay or total reconstruction. For rigid pavements, all the rehabilitation techniques are comparatively new. The socio-environmental impacts were found to be similar for both traditional techniques like concrete full depth repair and accelerated techniques like precast concrete pavement systems. Minor treatment processes for both flexible and rigid pavements like fog seal, crack seal, concrete seal joints, diamond grinding, and concrete partial depth repair have minimum impacts with maximum benefits when the corresponding life extensions are compared. Overall results showed that traditional asphalt pavement MRRs have considerably higher environmental impacts than rigid pavement MRRs. The results obtained can assist highway construction management professionals to select environmentally sustainable MRR solutions.

34. A Sustainable Asset Management Framework for Transportation System Management and Operation Systems

Song He,
Advisor: O.M. Salem

Due to aging transportation infrastructure, congestion has recently become a severe problem causing increased user costs and fuel consumption. With limited budget available, maintaining existing infrastructure facilities is a more preferable option to new construction. A transportation system management and operation (TSM&O) system can improve performance, security, and reliability of the overwhelmed transportation system. This study aims at establishing a sustainable asset management framework taking the triple bottom line of sustainability into consideration in order to fill the gap of traditional asset management practices which have focused primarily on infrastructure like pavements, bridges, pipelines and culverts. Similar to conventional asset management methodologies, the proposed sustainable asset management framework for TSM&O systems features inventory and condition database, performance modeling, risk analysis, life-cycle cost analysis and benefit/cost analysis; however, environmental and social impact will also be included in the analysis, and specific modeling techniques which are more applicable to the nature of TSM&O system components are developed and based on to determine
which TSM&O alternatives have the overall lease life-cycle cost including economic, social and environmental aspects and thusly support agencies’ decision making processes. Spatial analysis software like ArcGIS, traffic simulation tools like PARAMICS and VISSIM, and traffic emission modeling tools like MOVES are utilized to establish TSM&O system inventory, predict mobility impacts of TSM&O alternatives, and determine environmental impacts and benefits. The decision support system under the sustainable asset management framework will be validated by case studies.

35. Improving Sustainability of Work-Zones by Implementing Lean Construction and Total Quality Management Techniques

Sharareh Pirzadeh, 3rd year Ph.D.
Sudipta Ghorai
Advisor: Dr. Sam Salem

Pavement construction, maintenance and rehabilitation have considerable impacts on environment, society, and economy. These impacts can be minimized by implementing lean construction strategies that focus on reducing wastes and improving performance, as well as increasing the overall value of the facility to the end users. Work zone sustainability can also be improved to a great extent by applying total quality management (TQM) principles.

The objective of this study is to identify the adverse effects of work-zones activities for pavement projects, and demonstrate how lean construction techniques and TQM principles can provide sustainable solutions. For example, 5S’s can help reducing the waste which is a cause of environmental degradation. The last planner technique can be used to prevent schedule delays and to accelerate the construction process, and assist in reducing the excess emissions due to unstable traffic around the work-zones and from heavy equipment. It can also minimize vehicle operating costs due to congestion and improve the mobility of work-zone. Increased visualization approaches such as speed advisories, delay advisories; regulatory speed limit changes merge control and alternate route guidance, can further enhance safety and mobility. Other impacts such as noise pollution; and reduced accessibility to businesses and emergency facilities can be minimized using phased scheduling which allows the selection of construction time and duration suitable for the surrounding community.

TQM is an approach to long–term success through customer satisfaction. TQM helps an organization in improving processes, products, services, and the culture in which they work.
36. Effect of Corrosion on Strength of RC Bridge Columns Subjected to Lateral Loads

Sara Sotoud, 5th year Ph.D.
Advisor: Dr. Riyad S. Aboutaha

Recent strong earthquakes have shown that the primary cause of collapse in many existing older structures is column failure. Therefore, old existing reinforced concrete bridge columns that were designed before the development of new seismic codes are at risk of damage due to lateral loading. Generally, it is more economical to retrofit vulnerable structures than replacing them. In order to propose an effective rehabilitation method, good estimation of load carrying capacity of RC columns is very important.

Corrosion of reinforcing steel bars is the primary durability problem that causes degradation of reinforced concrete structures located in aggressive environments. Corrosion of steel bars reduces load-carrying capacity of reinforced concrete members due to area loss of reinforcing steel, bond deterioration, loss of concrete cover, and decrease in confinement by transverse reinforcement.

This study investigates response of corroded steel reinforced concrete columns subjected to lateral loading in addition to compressive axial load. A finite element model was developed using ANSYS and the lateral load-deflection curves of corroded RC columns were calibrated against existing experimental tests data, by others. Lateral capacity of RC columns are influenced by corroded longitudinal or transverse reinforcing bars. Effects of parameters such as steel bar area loss percentage, compressive strength of concrete, reinforcing ratio, and axial load ratio on lateral strength of columns are discussed. The results of this investigation suggest that corrosion of steel bars has significant impact on load carrying capacity of corroded concrete columns.

37. Optimizing Insulation Applications For Retrofitting Of Existing Buildings

Jeff Chen, 4th year Ph.D.
Advisor: Dr. Riyad S. Aboutaha

The number of housing units in New York State is more than 8 million, with a median construction year around 1958. The average expenditure level of a residential unit in New York State is approximately $2,500 and 56% of this expenditure corresponds to space heating. As such, given the high number of old buildings and increasing energy scarcity, application of insulation materials in an optimum manner has the potential to provide tremendous energy savings, economic benefits and reductions in environmental impacts. Furthermore, enhancement of the building envelope will result in improvements in the indoor thermal comfort levels, less reliance on the heating systems, and resiliency against climate change.
The research team is developing a decision support system (DSS), which will provide appropriate insulation options in consideration of: 1) Embodied energy associated with building insulation materials; 2) Building use phase energy savings that can be achieved by using different amounts and configurations of building insulation materials; and 3) Life Cycle Cost Analysis (LCCA), given the type and details of a building. The DSS will integrate the results from above three components and determine the optimum insulation application. Development of such DSS may lead to development of a stand-alone user-friendly decision support tool in the subsequent phases, which may be used by homeowners, contractors, designers, policy makers, regulatory agencies, and financial institutions. The research team members conducted a preliminary research with regards to embodied energy in building materials and use phase energy savings, and will leverage their experiences from previous projects.

38. Numerical and Finite Element Analyses of Geotextile Tubes in Dewatering Projects

Zeru Kiffle, 3rd year Ph.D.
S.K. Bhatia
Advisor: S.K. Bhatia

Geotextile tubes have been widely used in the last thirty years for containing and dewatering waste and contaminated sediments. Geotextile tube technology is used in various industries such as dredging and environmental remediation, agriculture, municipal waste water treatment, pulp and paper, mining and food processing.

In medium and large scale dewatering projects where geotextile tubes are used, they are stacked for the reason of space limitation and economic feasibility. In the aspect of stacking in multiple layers, stability is one important geotechnical design consideration. The stability issue may be due to self-weight of the stacked layers, weak foundation or overburden (applied load) on top of the stack. There are case histories which depicted failures of stacked geotextile tubes as described in literatures. Performing investigation of these scenarios, through numerical and finite element modelling will help in avoiding future failures by recommending the right design parameters.

In the study, existing mathematical calculation methods are programmed in Mathcad to analyze the geometry and stress on the geotextile tubes filled hydraulically with sediment slurry. Then the finite element model were developed to evaluate the level of deformation and stress on the geotube and contained solid during stacking. The finite element program used for these model was ABAQUS.

As a continuation of this investigation, numerical and finite element analysis will be made on slope stability of stacked geotextile tubes. In addition, large scale test will be performed to verify numerical calculation of geotextile tubes filled with sediment slurry.
DEPARTMENT OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCE

39. Wearable Camera based Accurate Step Counter

Abhishek Bhaskar, 1st year M.S.
Koray. O, Anvith.K.M
Advisor: Dr. Senem Velipasalar

Wearable sensors are becoming more and more popular in monitoring daily human activities. Physical activity monitoring such as tracking and counting of human footsteps can be a vital gait analysis tool in applications such as indoor navigation, monitoring physical health, etc. In this project, we present a new method for counting footsteps by using images captured from a mobile phone camera. We use an optical flow based approach technique where we use the apparent motion of the foot as a pattern to detect and count steps. Current implementations of pedometers in mobile phones mainly rely on step length and step frequency estimation from built-in accelerometers. However, depending on the attitude of the device or the smoothness of the movement sometimes steps during walking are not correctly counted. We come over this by using the camera of the mobile tilted down to see the movement of the feet. We employed optical flow based algorithm to count steps. We compare our work to the existing sensors and their methods and show that our implementation can be a robust step-counter.

40. Guided-Wave Nanophotonic Devices based on Networked Plasmonic Waveguides

Ashish S Chanana, 2nd year Master’s
Matthew Davis, Amit Agrawal, Jay Kyoon Lee
Advisor: Jay Kyoon Lee

The prospect of controlling the interaction of light with matter at nanoscale has been widely studied in recent years, and entails characterizing optical and optoelectronic devices at resolution higher than the diffraction limit. One technique that allows localization of light to subwavelength dimensions is through the use to surface-plasmon-polaritons (SPPs) wherein the interaction of light with free-electrons on a metal surface can lead to a bound surface electromagnetic-field that is confined to deep-subwavelength dimensions. Studies based on SPPs merged with the field of nanotechnology have resulted in novel imaging technologies, nonlinear and quantum-optic devices and the ability to design materials with unusual electromagnetic properties with potential applications ranging from enhancing the efficiency of photovoltaic devices to detection of bio-molecules at ultra-small concentrations. Here we report the design of nanophotonic devices based on SPP waveguide structures that would act as a true counterpart to today’s electronic devices.
devices, providing orders of increase in data-speeds while maintaining nanoscale dimensions. The devices are based on metal-dielectric-metal (MDM) waveguide structures composed of Ag/SiO$_2$/Ag heterostructure that utilizes interference effect within multiple intersecting plasmonic-waveguides. The specific devices we have been exploring include guided-wave devices such as L and T-bends, 4-way-splitters and 2x2-networked structures, wherein by altering the device geometry one can tune its operating frequency, and by changing the angle of incidence one can switch these devices between ON/OFF states. We plan to fabricate and experimentally characterize these devices for applications in color routing, as directional-filters and optical-switches. We will discuss preliminary design rules and constraints based on results obtained from the finite-difference-time-domain simulations.

41. The Smart Grid: Privacy Security and Economic Issues

Amav S Kavadia,
Sanjna Pawar
Advisor: Dr. Tomislav Bujanovic

A Smart Grid is a highly complex system comprising of advanced distributed power generation, advanced metering infrastructure (AMI), control centers and a backbone of communication networks. This inherently complicated system already has many technical obstacles and challenges in implementation. Most of these obstacles are slowly being overcome with advances in engineering and technology. Some of the often-overlooked challenges are which relate to the ‘non-engineering’ part of the smart grid and they are Privacy, Security and Economics. Issues pertaining to privacy, security and, to some extent economics did not plague the traditional electrical grid. These issues have cropped up as a result of the implementation of two-way communication systems in the smart grid that can result in very legitimate privacy and security issues. Also, the cost of implementing such a large-scale system has cropped up many economic issues in the implementation the smart grid. Our research aims to properly describe the issues being faced and to suggest certain solutions.

Source: Smart Power: Climate Change, the Smart Grid, and the Future of Electric Utilities, Peter Fox- Penner, Island Press, 2010

42. Insecurity through obscurity: Process-level runtime monitoring of native code on Android devices

Andrew Henderson, 4th year Ph.D.
Advisor: Heng Yin

Third-party Android applications (apps) provide a wide variety of functionality to end-users. While the majority of these apps are implemented in architecture-agnostic Dalvik bytecode, many apps require the use
of native code binary libraries for improved performance or low-level interfacing. Malicious functionality can reside within this native code and escape detection by Android malware detection systems designed to discover and/or monitor only the bytecode portions of an app. Even worse, malicious behavior at the bytecode-level can be obfuscated using native code. Dynamic analysis of native code behavior is typically too heavy-weight for runtime deployment on an actual Android device. The most powerful dynamic analyses use instruction-by-instruction emulation of the binary code under analysis, which incurs considerable performance overhead.

We propose a new Android-based process-level instrumentation technique that uses selective dynamic analysis of the Android Zygote process to monitor the execution of ARM-based native code within apps of interest. Heavy-weight analysis is only performed while executing instructions belonging to native code, minimizing the performance overhead of instrumented code. We are able to detect suspicious kernel system calls made from an app’s native code and monitor the invocation of Java method calls made from native code.

43. Reliable Inference from Unreliable Agents

Aditya Vempaty, 4th year Ph.D.
Lav R. Varshney
Advisor: Pramod K. Varshney

Obtaining reliable performance from unreliable systems has been a perennial problem of interest. Since Shannon discussed the problem in 1956, many researchers have addressed different aspects of this problem. Almost sixty years since Shannon, this problem is most relevant now. Systems with humans and machines solving inference problems are all around us. System/component malfunction, malicious sensors (Byzantines), or unskilled humans give rise to multiple sources of unreliable inputs in such systems. For example, crowdsourcing is an important application where this setup is applicable as anonymous human workers are often unreliable. Understanding the effect of unreliable agents in such systems and ensuring reliable inference is the goal of this work. Three basic ways of increasing reliability are explored: improving components, using error-correcting systems, and/or complete redesign of system. Besides design principles, some information theoretical results for understanding the asymptotic behavior of belief sharing among such unreliable people are also derived. Two seemingly different applications are considered: Internet of Things and Crowdsourcing. Some related work, where statistical models to understand human decision making are being developed in collaboration with cognitive psychologists, will also be discussed.
44. On Physical Layer Secrecy of Collaborative Compressive Detection

Bhavya M Kailkhura,
Advisor: Pramod Varshney

This work considers the problem of detecting a high dimensional signal (not necessarily sparse) based on compressed measurements with physical layer secrecy guarantees. First, we propose a collaborative compressive detection (CCD) framework to compensate for the performance loss due to compression with a single sensor. We characterize the trade-off between dimensionality reduction achieved by a universal compressive sensing (CS) based measurement scheme and the achievable performance of CCD analytically. Next, we consider a scenario where the network operates in the presence of an eavesdropper who wants to discover the state of the nature being monitored by the system. To keep the data secret from the eavesdropper, we propose to use cooperating trustworthy nodes that assist the fusion center (FC) by injecting artificial noise to deceive the eavesdropper. We seek the answers to the questions: Does CS help improve the security performance in such a framework? What are the optimal values of parameters which maximize the CS based collaborative detection performance at the FC while ensuring perfect secrecy at the eavesdropper?

45. Image and Video Transmission in Cognitive Radio Systems under Sensing Uncertainty

Chuang Ye, 3rd year Ph.D.
Gozde Ozcan
Advisor: M. Cenk Gursoy and Senem Velipasalar

This work studies the performance of hierarchical-modulation-based image and video transmission in cognitive radio systems with imperfect channel sensing results under constraints on both transmit and interference power. Data intended for transmission is first compressed via source coding techniques and then divided into two priority classes, namely high priority (HP) data and low priority (LP) data, by taking into consideration the unequal importance of bits in the output codestream. After dividing the compressed data into packets of equal size, turbo coding is applied. Finally, the resulting packets are modulated using hierarchical quadrature amplitude modulation (HQAM). In this setting, closed-form bit error probability expressions for HP data and LP data are derived over Nakagami-$m$ fading channels in the presence of sensing errors. Subsequently, the effects of probabilities of detection and false alarm on error rate performance of cognitive transmissions are evaluated. In addition, tradeoffs between the number of retransmissions and peak signal-to-noise ratio (PSNR) quality are analyzed numerically. Moreover, performance comparisons of multimedia transmission with conventional
QAM and hierarchical QAM are carried out in terms of the received data quality and number of retransmissions.

46. SEIntent Firewall: Android IPC security via intent access control

Carter Yagemann, 1st year Master’s
Advisor: Kevin Du

Android’s Intent framework encourages application developers to utilize IPC in their applications with a frequency unseen in traditional desktop environments. The increased frequency of IPC present in Android devices, coupled with Intent’s ability to implicitly find valid receivers for IPC, bring about new security challenges to the computing security landscape. SEIntent Firewall proposes an access control solution for Android IPC security. This solution replaces the already existing Android intent firewall with a security enhanced intent firewall which centralizes all the new and existing IPC access control mechanisms present in Android, allows for an expandable framework which can evolve as the security needs of Android changes, and which can be implemented and maintained with minimal revision to the already existing system components. SEIntent Firewall also builds on top of the existing request packet structure of Android, Intents, to include meta attributes which, when coupled with a new comprehensive rule set, allow for more intuitive and fine-grain access control.

47. Request Level Tracing in Distributed Systems

Tang Chunxu, 2nd year Master’s
Advisor: Dr. Yuzhe Tang

This is an era of Big Data. With the advent of Google’s three famous papers, which are about Google File System (GFS), Google Big Table and Google MapReduce, we arrive in an epoch when analysis of large amounts of data fills up our lives. In the tide of Big Data, we witness an explosion of distributed systems in the recent decade. Nowadays, large-scale systems are usually based on other services, and a trivial request may trigger executions of multiple systems, which renders the whole system even more complicated. A tool, which aids to understand inner behaviors of large-scale systems, is necessary.
Here, I introduce my design of a request level tracing system, composed of Apache HBase, HTrace and YCSB (Yahoo Cloud Serving Benchmark). Apache HBase is a column-oriented database, which is built on top of Apache Hadoop Distributed File System (HDFS), and is widely used to store key-value pair data. I first leverage HTrace to trace, visualize and analyze inner data flows of HBase by requests. And then, I deploy YCSB to stress test HBase’s performances of different kinds of operations, and finally create a linear regression model to predict system performances.
48. Bidirectional Charger Circuit and its Applications

Danush Ravishankar,
McCleve Paul-Gerald Joseph
Advisor: Dr Prasanta K. Ghosh

Conventional electrical power transmission and distribution system are operated for the simple one-way transportation from remote and large power plants to consumers, but the system is just about to change, to satisfy some emerging needs. Above all, availability of bidirectional transport is necessary in order to introduce distributed generations as well as to effectively use renewable energy sources such as solar and wind. Advances in storage technologies and the needs of the electric power grid enable energy storage to become a more substantial component of the electric power grid of the future. Electric Vehicle (EV) is seen as a suitable solution to most of the existing problems as it also presents a reduction of the amount of CO2 emission leading to a cleaner environment. One of the scenario is the EV’s battery can be charged when the demand is less and be used to help the grid during peak demand hours maintaining the stability of the system. In this way the rechargeable battery can be considered as a renewable energy source throughout its lifecycle and can be done through a bidirectional charger. We designed a smart grid compatible electric vehicle battery bidirectional charger. The control strategy of the charger fulfills the IEEE Standards, demanding or injecting a balanced and sinusoidal into the grid minimizing the losses in the power flow. Simulation and experimental results are showed and we aim to develop a detailed mechanism of control to enhance the efficiency and lifespan of a Wind farm.

49. PINPOINT: Efficient and Effective Resource Isolation for Mobile Security and Privacy

Paul Ratazzi,
Ashok Bommisetti, Nian Ji
Advisor: Prof. Kevin Du

Virtualization is frequently used to isolate untrusted processes and control their access to sensitive resources. However, isolation usually carries a price in terms of less resource sharing and reduced inter-process communication. In an open architecture such as Android, this price and its impact on performance, usability, and transparency must be carefully considered. Although previous efforts in developing general-purpose isolation solutions have shown that some of these negative side-effects can be mitigated, doing so involves overcoming significant design challenges by incorporating numerous additional platform complexities not directly related to improved security. Thus, the general purpose solutions become inefficient and burdensome if the end-user has only specific security goals.

In this presentation, we introduce PINPOINT, a resource isolation strategy that forgoes general-purpose solutions in favor of a “building block” approach that addresses specific end-user security goals. PINPOINT em-
bodies the concept of Linux Namespace lightweight isolation, but does so in the Android Framework by guiding the security designer towards isolation points that are contextually close to the resource(s) that need to be isolated. This strategy allows the rest of the Framework to function fully as intended, transparently. We demonstrate our strategy with a case study on Android System Services, and show four applications of PINPOINTed system services functioning with unmodified market apps. Our evaluation results show that practical security and privacy advantages can be gained using our approach, without inducing the problematic side-effects that other general-purpose designs must address.

50. Power Control for Cognitive Radio Systems with Unslotted Primary Users Under Sensing Uncertainty

Gozde Ozcan, 4th year Ph.D.
Mustafa Cenk Gursoy and Jian Tang
Advisor: Mustafa Cenk Gursoy

This paper studies the optimal power control policy and frame duration that maximize the throughput of secondary users operating under transmit power, interference power, and collision constraints in the presence of unslotted primary users. It is assumed that primary user activity follows an ON-OFF alternating renewal process. Secondary users first sense the channel albeit with errors in the form of miss detections and false alarms, and then start the data transmission only if no primary user activity is detected. Under these assumptions, we determine the optimal power control policy subject to peak transmit power and average interference power constraints and propose a low-complexity algorithm for the joint optimization of the power level and frame duration under collision constraints. We further analyze some important properties of the collision duration ratio, which is defined as the ratio of average collision duration to transmission duration, and investigate the impact of the probabilities of detection and false alarm on the throughput, optimal transmission power, and the collisions with primary user transmissions.

51. Social Media Data Assisted Inference with application to stock prediction

Hao W He, 5th year Ph.D.
Arun Subramanian, Sora Choi,
Advisor: Pramod K. Varshney

Access to the massive amount of social media data provides a unique opportunity to the signal processing community for extracting information that can be used to infer about unfolding events. It is desirable to investigate the convergence of sensor networks and social media in facilitating the data-to-decision making process and study how the two systems can complement each other for enhanced situational awareness. In this paper, we propose a copula-based joint characterization of heterogeneous time series, which not only exhibit temporal dependence but also inter-
modality dependence. This model is then applied to the Google Trend (GT) data and stock price data of Apple Inc., which serves as a substitute for the sensor data, for inference. Superior stock prediction performance of our proposed copula-based approach is shown, by taking the non-linear dependence among social media data and sensor data into consideration.

52. A Highly Efficient Memristor Crossbar Based Sparse Matrix Vector Multiplication Framework

**Jianwei Cui**, 2nd year Ph.D.
Advisor: Qinru Qiu

Sparse matrix vector (SpMV) multiplication is the cornerstone of many scientific and machine learning based computations, and making SpMV multiplication efficient is essential to these applications. Unlike conventional methods that utilize general-purpose processors as SpMV computing engine, in this work, we present a highly efficient SpMV multiplication framework featuring mixed signal memristor crossbar accelerator. We demonstrate a novel memristor crossbar architecture that supports high precision iterative memristance programming and solves the sneak path problem with marginal hardware overhead. We further propose a method called Adaptive Sparse Matrix Reordering (ASMR), which leverages linear transformation to partition rectangular matrices for minimum number of nonzero sub-blocks under the constraint of the given sub-block size. Running SpMV multiplication with ASMR optimization provides 47.5% (1.9X) improvements in computation time and 47.6% (1.9X) in energy consumption on the same memristor accelerator. This counts for 63.1% (2.7X) reduction in computation time and 98.6% (71.4X) reduction in energy consumption compared to running the same SpMV multiplication on an Intel i7 general-purpose processor.

53. A wideband Balun working from 1GHz to 3GHz

**Jinwen Liu**,
Advisor: Brandon Jun Choi

54. Adaptive Frequency Estimation in Smart Grid Application

**Jinnan Hussain**, 2nd year Master’s
Wolf Peter Jean Philippe
Advisor: Dr. Tomislav Bujanovic

For future smart grids, estimation of the system frequency in real time will become a required application utilized in order to have generation and loading be dynamically updated. Thus to further develop estimator techniques and provide new solutions towards adaptive frequency estimation and system fault identification, a more unified estimation framework is introduced. For a three phase system consisting of both balanced and unbalance conditions, the estimation of instantaneous frequency is explored.
because the strategy illustrates new advantages for both balanced and unbalanced conditions that include but are not limited to voltage sags, harmonics and supply and demand mismatch as well as all other obstacles encountered for accurate frequency estimation in a smart grid.

55. Negative Resistivity Coupled CRLH Leaky Wave Antenna

Kepei Sun, 3rd year Ph.D.
Jun H. Choi
Advisor: Jay K. Lee

This research work integrates negative resistance into the leaky wave antenna (LWA) to control the amplitude distribution of the radiating apertures. LWAs are frequency scanning antennas that steers the radiated beam as the frequency is varied. If the antenna is horizontally oriented, the excited wave travels along the LWA and leaks energy out maximally toward the direction determined by a zenith angle $\theta_0 = \sin^{-1}\left(\frac{k_0}{\beta}\right)$. Among various types of LWAs, we use composite right/left-handed (CRLH) structure that presents significant advantages over conventional structures, providing continuous frequency scanning from backfire to endfire, including broadside direction. The proposed LWA is realized by periodically loading the structure with negative resistance. Applications of negative resistance based on active components have been previously demonstrated in designing zero insertion-loss filters. The main principle was to couple negative resistivity into microstrip circuits to compensate the attenuation due to finite metal conductivity, dielectric losses and radiations. When adapted into LWAs, better control of current distribution along CRLH antenna may be achieved. In general, the propagating wave along a LWA has exponentially decaying amplitude distribution. Consequently the radiation pattern would be determined by the decreasing amplitude (or the current distribution induced). If the wave amplitude can be modified by negative resistance, the deliberately changed current distribution could lead to radiation pattern improvements, e.g., suppressed side lobe level, enhanced directivity and boosted gain. Although the proposed design may increase the overall power consumption, the added controllability of the radiated pattern is worthy of investigation.

56. High Performance Cognitive Architecture for Information Association

Khadeer N Ahmed, Ph.D.
Qinru Qiu
Advisor: Dr. Qinru Qiu

The advancement of High Performance Computing (HPC) technologies have enabled the realization of Neuromorphic architectures for comput-
Neuromorphic computing systems refer to computing architectures inspired by the working mechanism of human brains. These architectures are used for both computing and understanding brain processes. They perform large number of simple but highly parallel computations and decision making tasks. The rapidly reducing cost per FLOP of state-of-the-art computing hardware allows large-scale implementation of machine intelligence models with neuromorphic architectures and opens the opportunity for new applications. Achieving real time decision making and cognition are key challenges we are facing. We propose a neuromorphic architecture for Intelligent Text Recognition System (ITRS) and model it such that it can harness the massively parallel computing resources provided by today’s cutting edge technologies. To gain maximum throughput the system is designed so as to take advantage of heterogeneous computing resources. Naturally different optimization techniques are employed for each sublayer of the application based on the hardware platform it is running on. A novel scheduling scheme is proposed to take make the system efficient on hybrid platforms and at the same time being scalable at multi core level and at the cluster level. Both fine and coarse grained scheduling of workload is done for efficient load distribution.

57. Observing the Power Grid

Kangping N Li, 1st year Master’s
Advisor: Tomislav Bujanovic

Electricity has been the most essential fixture in contemporary society. Development of this industry has formed the most complicated system ever existed, the power grid. Since the storage capacity of the grid is very limited, the balance between consumption and generation of electricity becomes vital. How well the balance is maintained can be observed by analyzing signals that propagate across the power system. Traditional power grids has always been opaque from a user perspective, which means the data measured by sensors are available to utilities but restricted to users. This limitation has made researches into specific areas difficult and time consuming. However, increasing user visibility and participation, which is one of the main goals of smart grid, should be realized. Researchers will be able to observe the power grids in real-time from a large number of points. Advanced measurement technology, such as synchrophasor and frequency monitoring network (FNET) has made this assumption possible now. By real-time monitoring and observing data from wall outlets, we can realize automatic response to grid events. Widespread usage of this observation technique will result in a more resilient, secure, and efficient power grid around the world.
58. Wearable Camera and Accelerometer-based Fall Detection on Portable Android Devices

Koray N Ozcan, 4th year Ph.D.
Senem Velipasalar
Advisor: Dr. Senem Velipasalar

Robust and accurate detection of fall events is crucial especially for elderly activity monitoring systems. In this paper, we present a fall detection system using wearable devices, e.g. smart phones and tablets, equipped with cameras and accelerometers. Since the portable device is worn by the subject, monitoring is not limited to confined areas, and extends to wherever the subject may travel, as opposed to static sensors installed at certain rooms. Moreover, a camera provides abundance of information, and thus fusing camera- and accelerometer-based results provides lower false positive rates compared to only accelerometer-based systems.

Image feature descriptive components are widely used in areas such as scene understanding, object detection, face recognition and texture classification. We employ histograms of edge orientations (EO) together with the gradient local binary patterns (GLBP) for the camera-based part of fall detection. We have compared the performance of the proposed method with that of using original histograms of oriented gradients (HOG) as well as a modified version of HOG. Experimental results show that the proposed method outperforms using original HOG and modified HOG, and provides lower false positive rates for camera-based fall detection. In addition, we have developed an accelerometer-based fall detection method, and fused the results of the two sensors to have a robust fall detection system that has higher sensitivity, and is less prone to false positives during daily activities.

59. Bird Species Classification Utilizing Low Dimensional Representation and Deep Learning

Liwen Sun, 3rd year Ph.D.
Bhavya Kailkhura, Sora Choi;
Advisor: Pramod Varshney

Automatic classification of bird species based on audio records is of increasing importance in ecology, conservation monitoring and vocal communication studies. The goal of this work is to develop a classification method of bird species from huge amount of noisy data recorded at National Ecological Observatory Network (NEON) sites. Our approach consists of three steps. Firstly, for noise separation the spectrogram of signal is decomposed into two parts: low rank noise and sparse target signal using the Robust PCA (RPCA) algorithm. Then, a deep learning algorithm is employed to learn appropriate features from the target signal in an unsupervised manner. As the last step, we use the Random Forest algorithm for the classification. Promising performance results based on
the collected recordings will be presented.

60. Bidirectional Electric Vehicles Charger for Efficient Energy Management

Mc Cleve N Joseph, 2nd year Ph.D.
Dr Tomislav Bujanovic
Advisor: Dr. Prasanta Ghosh

Introduction of large number of electric vehicles (EV) in the global markets in near future implies that the engineering community must develop bidirectional charger system that would allow efficient charging/discharging in a safe manner. In an EV charger system, several on-board electronic control units must operate in a synchronized manner when connected to the power grid. In addition, functionality and the storage capacity of the EV battery in the vehicles creates a new kind of electric load for the electric power grid. The bidirectional EV charger should be able to satisfy some major grid constraints including power quality, harmonic rejection, active and reactive power flow control. EV battery can used as an energy source in an emergency situation throughout its lifecycle and should allow energy flow to the power grid. In this paper we present a design of a smart grid compatible electric vehicle battery charger. In this design for the grid-side converter, a voltage source control is employed for AC system bus voltage and the DC-link voltage. For the EV-side converters, constant-current and constant-voltage control mechanisms are used for charging and discharging control. The EV charger includes a high-efficiency bidirectional DC-DC converter with low circulating current and its Zero-Voltage Switching (ZVS) characteristic improves the overall charger operational behavior. We have simulated the bidirectional charger system under different conditions. Simulation results clearly show that bidirectional energy flow between the power grid and the EV can be achieved in a controlled fashion as needed.

61. Plane Detection with Depth Sensors using K-means

Maria Scalzo, Ph.D.
Advisor: Dr Senem Velipasalar

This effort develops an approach for detecting large planar regions in depth images. Our technique deals with noisy depth data by merging regions from different depth-bands. Each depth band is first divided into a set number of clusters through the use of k-means. The clusters from each band are then merged based upon their centers. Finally, the true planes, which represent the floor, ceiling, and walls will have a larger number of points that are merged into a single group. We propose this plane detection algorithm using depth images to narrow down the necessary search areas of an image for object detection. Without narrowing down on possible object locations, a typical object detector uses an
exhaustive sliding window technique. The potential benefits of such an approach include enabling mobile phone object detection. That is, by detecting planar regions we can focus in on the possible location of objects and expend computational resources only on those regions.

62. Electromagnetic Macro Model for Propagation in Cellular Networks

Mohammad Abdallah, 3rd year Ph.D.
Tapan K. Sarkar
Advisor: Tapan K. Sarkar

Understanding the physics behind the propagation in cellular networks is the key to improve the Quality Of Service (QOS). However, the physics of the propagation in cellular networks is not well understood because most of the available analysis is based on either statistical or empirical models. These models do not catch the basic physics of the propagation over imperfect ground. We present an attempt to emphasize on the physics of the propagation over imperfect ground, which is the case in cellular networks, rather than just use some available statistical or empirical models. We propose a macro model for the propagation in cellular networks which only considers the effect of the imperfect ground. We do not consider other obstacles like buildings, trees and so on in our macro model. Furthermore, we show that the frequency range over which cellular communications operate is chosen such that the reflection from buildings is negligible so signals can penetrate buildings and terrain and do not significantly bounce inside the rooms. Hence, the clutter effects generated by buildings or trees are considered to be second order effects, as the primary being the effect of the imperfectly conducting ground which is seldom accounted for in any propagation model. We also provide some results taken from AWAS (method of moments code which uses Green’s function based on Sommerfeld formulation) to compare with the measured data taken from Okumura’s experiment, we conclude that there is perfect match between the macro model results taken from AWAS with Okumura’s data.

63. Application of Electric Vehicles in an economical way to improve the power delivery system reliability

Mohammad Nikkhah Mojdehi, 4th year Ph.D.
Prasanata Ghosh
Advisor: Dr. Prasanta Ghosh

The power system dynamics can be better controlled by the smart usage of electric vehicles (EVs). EVs with their diverse capabilities can create opportunities for System Operator (SO) to improve the system efficiency, economics, and sustainability of power delivery system. For instance, demand response and reactive power support can be provided by EVs quickly, when needed by the system operator. These types of services are
becoming a necessity because of higher power demands and continuous change in supply-demand environment. On the other hand, since higher battery price discourages consumers to purchase EVs, creating ways to reduce the overall battery cost by generating revenue through participation in the power market, would be a win-win situation for both, EV owner and the SO. Revenue generation for EVs could be achieved by supplying active and/or reactive power to the grid. We present a model of EV operation as a load during charging activity, as a generator during discharging activity, and as a reactive power service provider under different conditions including the effect of battery degradation during the active power exchange between the battery and the grid. The developed model also includes charger technical constraints. Simulation results show optimal operating cost estimation, active and reactive power service by the EV under different scenarios. Results indicate significant change in active power charging and discharging patterns when the battery degradation cost is included. Revenue generation potential of EV opens up avenues for EV owner to recover part of the investment made in purchasing the electric vehicle.

64. Energy Efficiency in Multiple-Antenna Channels with Markov Arrivals and Queueing Constraints

Mustafa Ozmen,
M. Cenk Gursoy
Advisor: M. Cenk Gursoy

Energy efficiency in multiple-antenna fading channels is analyzed in the presence of Markov sources and queueing constraints, which are imposed as limitations on buffer overflow probabilities. Two random arrival models, namely discrete Markov and Markov fluid processes, are considered. Employing the notions effective capacity of time-varying channels and effective bandwidth of time-varying sources, maximum average arrival rates of these sources that can be supported by multiple-antenna wireless systems under statistical queueing constraints are determined and the throughput levels are identified. In the low signal-to-noise ratio (SNR) regime, minimum energy per bit and wideband slope expressions are obtained. Performance with both uniform power allocation and low-SNR optimal power allocation across transmit antennas is investigated. It is shown that the minimum energy per bit does not depend on the queueing constraints and source burstiness. On the other hand, wideband slope is shown to decrease as queueing constraints get stricter and/or sources become more bursty, thus resulting in degraded energy efficiency.
65. Fast Online Learning to Recommend a Diverse Set from Big Data

Mahmuda Rahman, 5th year Ph.D.
Advisor: Jae C. Oh

Building a recommendation system to withstand the rapid change in items’ relevance to users is a challenge requiring continual optimization. In a Big Data scenario, it becomes a harder problem, in which users get substantially diverse in their tastes. We propose an algorithm that is based on the UBC1 bandit algorithm to cover a large variety of users. To enhance UCB1, we designed a new rewarding scheme to encourage the bandits to choose items that satisfy a large number of users. Our approach takes account of the correlation among the items preferred by different types of users, in effect, increasing the coverage of the recommendation set efficiently. Our method performs better than existing techniques such as Ranked Bandits and Independent Bandits in terms of satisfying diverse types of users. In future, we want to extend our work to coordinate a number of recommendation systems with heterogeneous learning capabilities and item sets working together to build the recommended set.

66. A Filter Design Method for Construction of 3D Plasmonic Directional Light Sensor

Matthew Davis,
Henri Lezec, Jay K. Lee, Amit Agrawal
Advisor: Dr. Jay K. Lee

In this work we have developed an efficient analytical method for the design of plasmonic filters. We demonstrate the usefulness of this model by designing a plasmonic 3D directional light sensor based on the bullseye structure. Though largely described by classical electromagnetic theory, the field of plasmonics boasts a wide range of seemingly exotic technology with applications including sensing, imaging, and nonlinear optics. Fundamental to this field are surface plasmon polaritons (SPPs); which are charge oscillations existing between the interface a metal and a dielectric. Advances in theoretical understanding and the discovery of enhanced transmission has led to highly wavelength sensitive spectral responses, such as seen with periodic groove or hole arrays. This wavelength sensitive spectral response is useful for color filtering in sensing, display, and imaging devices. We have recently discovered that an aperiodic slit-grooved-array (SGA) can act as a wavelength-dependent plasmonic directional light filter (PDLF). A time consuming FDTD approach to SGA design is feasible for 1D devices, however extending this approach to 3D results in impractical computation times. We have constructed an analytical 1st-order model for SGA device that allows for a FDTD-free filter design process. Using this approach we have condensed days of simulation time to a few minutes. Another advantage to this model is its use in the construction of 3D filters. In this poster we show how the
plasmonic filter design model is constructed and emphasize the immense time saving factor this produces in the plasmonic filter design process.

**67. Automatic Generation of Security-Centric Descriptions for Android Apps**

**Mu Zhang, Yue Duan, Qian Feng, Heng Yin**
Advisor: Heng Yin

To improve the security awareness of end users, Android markets directly present two classes of literal app information: 1) permission requests and 2) textual descriptions. Unfortunately, neither can serve the needs. A permission list is not only hard to understand but also inadequate; textual descriptions provided by developers are not security-centric and are significantly deviated from the permissions. To fill in this gap, we propose a novel technique to automatically generate security-centric app descriptions, based on program analysis. We implement a prototype system, DescribeMe, and evaluate our system using both DroidBench and real-world Android apps. Experimental results demonstrate that DescribeMe is able to effectively bridge the gap between descriptions and permissions. A further user study shows that automatically produced descriptions are not only readable but also effectively help users avoid malware and privacy-breaching apps.

**68. Mechanism Design for Sensor Management in Wireless Sensor Networks**

**Nianxia Cao, 4th year Ph.D.**
Swastik Brahma, Pramod Varshney
Advisor: Pramod Varshney

In this poster, we introduce the general mechanism design problem in game theory. For typical Wireless Sensor Networks (WSNs) where the crowdsourced data is applied, the sensor management problems (such as sensor selection and bit allocation) can be formulated based on the mechanism design framework. Experiment results show that the mechanism design based sensor management approach balances the tradeoff between the estimation performance and the energy consumption of the WSN.

**69. Hidden Markov Model Learning and Likelihood Estimation using GPUs**

**Philip Pratt-Szeliga, 5th year Ph.D.**
Fatmagul Bahar and Terry Pierson
Advisor: Dr. James Fawcett

Graphics Processing Units or GPUs are co-processors that contain many ALUs and must execute computations in a SIMD/SPMD manner. Using
Parallel GPU algorithms and data structures, a developer can obtain 20x to 100x speedup using a single device. Four to sixteen devices can fit into a computing system giving a total maximum speedup of approximately 400x to 1600x. However, without using specialized parallel GPU algorithms and data structures the speedup on a single device ranges from -10x to 10x. Hidden Markov Model (HMM) learning and likelihood estimation are important tools for use in computational biology for clustering and can be used in many diverse fields to cluster time varying signals. We will show a parallel algorithm and data structure for accelerating likelihood estimation using GPUs and demonstrate that a 92x speedup can be achieved using a single Tesla C2050 GPU. Given a sixteen GPU system, this work can convert a 111 core-year computation into a 27-day computation.

70. Finding Rising Stars in a Social Network: A Multiobjective Approach

Pivithuru Wijegunawardana, 2nd year Ph.D.
Dr. Chilukuri Mohan
Advisor: Dr. Kishan Mehrotra

When networks change with time, it is important for decision-makers to identify nodes that are expected to become most influential in the future. An example problem for which data is available is the identification of rising stars among academic researchers. A common approach to find rising stars is to apply weighted PageRank algorithm on a network in which nodes represent authors, and edges represent co-authorship. PageRanks of authors are obtained for multiple consecutive years; individuals with ‘large’ PageRank gradients are identified as rising stars. These methods do not consider citation information in the evaluations. In the proposed method, we have simultaneously considered the co-author network, citation network and publication venues, and identify non-dominated rising stars. We use the h-index, the total number of papers, and the total number of citations (in a future year) to evaluate the performance of proposed algorithm. We use Arnetminer bibliography data for 1990-1995 to identify rising stars and evaluate their performance in 2006 and 2014. In 2006, the average values of h-index, number of papers and citations by our method were 14.56, 79.37 and 819. In comparison for the method proposed by Li et al.(2009), the averages are 8.18, 57.31 and 307.56. The averages rise up to 54.9, 229.63 and 20066.63 in 2014, indicating that the authors continue to rise. Lokman et al.(2006), state that an “outstanding scientist” will have an h-index of 40. By this metric, most of the rising stars identified by our approach (using 1995 data) had become outstanding researchers by 2014.
71. AnRAD: A Neuromorphic Anomaly Detection Framework for Massive Concurrent Data Streams

Qiuwen N Chen, Qinru Qiu
Advisor: Qinru Qiu

The evolution of high performance computing (HPC) technologies have enabled the large-scale implementation of neuromorphic models and pushed the research in computational intelligence into a new era. Among the machine learning applications, unsupervised detection of anomalous streams is especially challenging due to the requirements for detection accuracy and real-time performance. How to design a computing model that can harness the growing power of multicore systems for online learning and detection while maintain high sensitivity and specificity to abnormal events is an urgent research topic. In this paper, we present AnRAD, a bio-inspired detection framework that mimics the human decision-making and probabilistic inferences. We leverage the mutual information between the features and develop a self-structuring procedure that is able to learn a succinct confabulation network from the unlabeled data. This network is capable of fast incremental learning, which continuously refines the knowledge base from the data streams. Compared to several existing anomaly detection methods, the proposed approach provides higher detection performance and excellent introspection capability. Furthermore, we exploit the massive parallel structure of the AnRAD framework. Our implementation of the recall algorithms on the graphic processing unit (GPU) obtains over 500X intra-model speedup over the sequential baseline implementation on general-purpose microprocessor. The framework can provide real-time services to concurrent data streams of diversified knowledge contexts, which is the key requirement for inter-model scalability. Experimental results demonstrate high computing performance and memory efficiency of the AnRAD framework.

72. An Approach to Distributed Multi-type Resource Allocation

Qinyun Zhu, 4th year Ph.D.
Advisor: Jae C. Oh

We study algorithms for distributed computational entities that can process big data collaboratively. To satisfy users needs and effectively utilize computing resources, fair resource allocation is necessary. We study the multi-type resource allocation problem in distributed computing environment. Existing approaches that guarantee the conditions of Dominant Resource Fairness (DRF) are centralized algorithms. However, in a highly distributed environment with small computing entities that must process a huge amount of data, such as cyber physical systems, distributed algorithms that satisfy conditions of DRF are in demand. We propose a distributed algorithm that nearly satisfies the DRF conditions. According to our simulation results, our distributed dominant resource allocation
algorithm outperforms a naive distributed extension of DRF. We are currently developing a game theoretical solution for resource allocation under the distributed environment that assumes the computational entities are selfishly rational. We believe this approach will bring a stronger result in satisfying the DRF conditions.

73. On ARQ-based Wireless Communication Systems in the Presence of a Strategic Jammer

Ragheed El-Bardan, Sid Nadendla
Advisor: Professor Pramod K. Varshney

We investigate the design and performance of ARQ-based systems for wireless point-to-point (P2P) communication links with perfect feedback channels in the presence of a strategic jammer over an additive white Gaussian noise channel subject to InterSymbol Interference (ISI). We define system-latency as the number of transmission attempts at the transmitter to achieve a successful transfer of a data packet to the receiver. We attempt to minimize it by modeling this as a constrained optimization problem where the system-latency is minimized such that the probability of successfully receiving a data packet at the receiver satisfies a prescribed guarantee. A game-theoretic formulation is provided. Numerical results are presented for illustration purposes.

74. Network Sampling to Identify Sets of Key Players in Large Social Networks

Chulaka Gunasekara, 4th year Ph.D.
Chilukuri K Mohan, Kishan Mehrotra
Advisor: Kishan Mehrotra

A major drawback with key player identification algorithms in social networks is their high computational complexity. This makes the task of identifying key players in large social networks challenging. Multiple network sampling methods have been proposed over the years to reduce the time complexity of algorithms applied to large social networks. We propose a sampling method based on degree centrality, to reduce the time complexity of multi objective key player identification. Comparison of the sets of key players identified on the sampled networks in terms of multiple objectives of interest demonstrates that the degree centrality based sampling outperforms the previously proposed sampling methods. We also show that the multi objective key player sets identified on the degree centrality based sample outperforms previous key player identification algorithms when applied to Eventual Information Limitation problem.
75. SABLE: A Formally Verified Secure Loader

Scott Constable, 1st year Ph.D.
Advisor: Steve Chapin

The Syracuse Assured Boot Loader Executive (SABLE) aspires to be the world’s first formally verified, and independently formally verifiable secure loader. Currently, other secure bootloaders such as tboot and OSLO take advantage of trusted hardware technologies like Intel TXT and AMD-V to perform a measured launch. This type of boot uses hardware-backed cryptographic techniques to ensure that malicious software cannot be launched without the user’s knowledge. Yet this strategy is not immune to bugs stemming from programmer error or faulty protocols. The presence of even a single imperfection can undermine the integrity of the entire system. In higher-level software, the past decade has seen rapid progress in the area of formal verification, i.e. mathematical proofs of code correctness. For example, the seL4 team at NICTA used formal verification to guarantee that an L4 microkernel is free from common vulnerabilities such as buffer overflow. Unfortunately their implementation still relies on precarious assumptions about the underlying boot loader and hardware. The SABLE project is an attempt to bridge the gap between trusted hardware and formal verification, hence excluding all of the aforementioned attack vectors. Our design couples AMD-V trusted hardware with the formal verification techniques pioneered at NICTA to build a secure root of trust for a modern computer system.

76. Sensor Selection with Correlated Measurements for Target Tracking

Sijia Liu, 4th year Ph.D.
Makan Fardad
Advisor: Pramod K. Varshney

In this poster, we study the problem of adaptive sensor management for target tracking, where at every instant we search for the best sensors to be activated at the next time step. In our problem formulation, the measurements may be corrupted by correlated noises, and the impact of correlated measurements on sensor selection is studied empirically. To be specific, we adopt an alternative conditional posterior Cramér-Rao lower bound (C-PCRLB) as the optimization criterion for sensor selection, where the trace of conditional Fisher information matrix is maximized subject to an energy constraint. We demonstrate that the proposed sensor selection problem can be transformed into the problem of maximizing a convex quadratic function over a bounded polyhedron. This optimization problem is NP-hard in nature, and thus we employ a linearization method and a bilinear programming approach to obtain locally optimal sensor schedules in a computationally efficient manner.
77. Quantized Consensus by the ADMM: Probabilistic Versus Deterministic Quantizers

Shengyu Zhu, 4th year Ph.D.
Advisor: Biao Chen

This paper develops efficient algorithms for distributed average consensus with quantized communication using the alternating direction method of multipliers (ADMM). We first study the effects of probabilistic and deterministic quantizations on a distributed version of the ADMM. With probabilistic quantization, this approach yields linear convergence to the desired average in the mean sense with bounded variance. When deterministic quantization is employed, the distributed ADMM converges to a consensus within $3 + \lceil \log_{1+\delta} \Omega \rceil$ iterations where $\delta > 0$ depends on the network topology and $\Omega$ is a polynomial of quantization resolution, agents’ data and the network topology. A tight upper bound on the consensus error is also obtained, which depends only on the quantization resolution and the average degree of the graph. This bound is much preferred in large scale networks over existing algorithms whose consensus errors are increasing in the range of agents’ data, quantization resolution and the number of agents. We finally propose our algorithm which combines the probabilistic and deterministic quantizations. Simulations show that the consensus error of our algorithm is typically less than one quantization resolution for all connected networks with agents’ data of arbitrary magnitudes. This is so far the best known result for quantized consensus.

78. A Kernel Based Nonparametric Test for Anomaly Detection Over Line Networks

Shaofeng Zou, 4th year Ph.D.
Yingbin Liang, H. Vincent Poor
Advisor: Yingbin Liang

The nonparametric problem of detecting existence of an anomalous interval over a one-dimensional line network is studied. Nodes corresponding to an anomalous interval (if one exists) receive samples generated by a distribution $q$, which is different from the distribution $p$ that generates samples for other nodes. If an anomalous interval does not exist, then all nodes receive samples generated by $p$. It is assumed that the distributions $p$ and $q$ are arbitrary, and are unknown. In order to detect whether an anomalous interval exists, a test is built based on mean embeddings of distributions into a reproducing kernel Hilbert space (RKHS) and the metric of maximum mean discrepancy (MMD). It is shown that as the network size $n$ goes to infinity, if the minimum length of candidate anomalous intervals is larger than a threshold which has the order $O(\log n)$, the proposed test is asymptotically successful. An efficient algorithm to perform the test with substantial computational complexity reduction is proposed,
and is shown to be asymptotically successful if the condition on the minimum length of candidate anomalous interval is satisfied. Numerical results are provided, which are consistent with the theoretical results.

79. Simultaneous Wireless Information and Power Transfer using Non-Uniform Probability Distribution for Finite Alphabets Input

Tewodros Zewde, 3rd year Ph.D.
Advisor: Prof. Mustafa Cenk Gursoy

Simultaneous information and power transfer (SIPT) targets effective usage of available, but limited, resources i.e., capacity and energy. In this paper, we study a novel approach that applies non-uniformly probability distribution to improve rate-energy trade-off for SIPT. We consider point-to-point communication system where a receiver has co-located information decoding (ID) and energy harvesting (EH) blocks in which power splitting scheme is applied to carry out operations, concurrently. The source transmits from a set of finite alphabets that are not deterministic. According to probability-energy relation, these alphabets probabilities can be dynamically adjusted using two techniques, namely static slop characteristics and dynamic slop characteristics, given minimum harvested energy constraint. Intuitively, advantage of one approach over the other depends on the response of power splitting factor when high energy alphabets get more likelihood. In order to determine optimal solution, we formulate an optimization problem and develop an algorithm taking care of key parameters, i.e., splitting factor and alphabets’ probabilities. Numerical results are provided to justify theoretical frameworks considering $16$-QAM$.$

80. Secure Distributed Inference in the Presence of Eavesdroppers

Sid Nadendla, 6th year Ph.D.
Advisor: Pramod K. Varshney

The distributed detection framework comprises of a group of distributed sensing units which acquire observations about a phenomenon of interest (PoI) and send processed data to a central node called the fusion center (FC) where a global inference is made about the presence or absence of the PoI. This framework has a wide range of applications in domains such as communication systems, stock-market forecasting, anomaly detection, psychology, human decision-making and medical instrumentation. The sensitivity of these application-domains to information-leakage drives us to investigate security in the framework of distributed detection networks. In this work, we analyze and design a distributed detection network in the presence of an eavesdropper.

We consider the problem of designing binary quantizers at the sensors for a distributed detection network under a secrecy constraint imposed on the eavesdropper. The performance metric chosen is the Kullback-Leibler Divergence at both the fusion center (FC) and the eavesdropper.
First, we consider the problem of secure distributed detection in the presence of identical sensors and channels. We prove that the optimal quantizer can be implemented as a likelihood ratio test, whose threshold depends on the specified secrecy constraint on the Eve. We present an algorithm to find the optimal threshold in the case of Additive White Gaussian Noise (AWGN) observation models at the sensors. In the numerical results, we discuss the tradeoff between the distributed detection performance and the secrecy constraint on the eavesdropper. We show how the system behavior varies as a function of the secrecy constraint imposed on Eve. Finally, we also investigate the problem of designing the binary quantizers for a distributed detection network with non-identical sensors and channels. We propose a greedy algorithm by decomposing the problem into N sequential problems, where each individual problem has the same structure as the scenario with identical sensors and channels. Optimum binary quantizers are obtained and numerical results are presented for illustration.

81. Sparse Sensor Selection for Nonparametric Decentralized Detection via L1 Regularization

Weiguang Wang, 4th year Ph.D.
Yingbin Liang, Eric P. Xing, Lixin Shen
Advisor: Yingbin Liang

Sensor selection in nonparametric decentralized detection is investigated. Kernel-based minimization framework with a weighted kernel is adopted, where the kernel weight parameters represent sensors’ contributions to decision making. $L_1$ regularization on weight parameters is introduced into the risk function so that the resulting optimal decision rule contains a sparse vector of nonzero weight parameters. In this way, sensor selection is naturally performed because only sensors corresponding to nonzero weight parameters contribute to decision making. A gradient projection algorithm and a Gauss-Seidel algorithm are developed to jointly perform weight selection (i.e., sensor selection) and optimize decision rules. Both algorithms are shown to converge to critical points for this non-convex optimization problem.

82. Kalman filter’s analysis of noise measurement and harmonics in power systems.

Xiaoyu Guo, 2st year Master’s
Anirban Ganguli
Advisor: Tomislav Bujanovic

In power systems, electricity is generated and distributed as a set of three-phase sinusoidal voltages characterized by frequency, magnitude, phase, and waveform. These characteristics are subject to continuous variations during the normal operation of a supply system due to chang-
es of load, disturbance generated by equipment and power system faults. These variations are to certain extent random and unpredictable. Due to this general context, the use of a suitable signal processing tool for the complete characterization of voltage supply is very important for power systems. Some main signal processing tools such as the root mean square method, the Fourier analysis and the symmetrical components have been used widely for estimation of voltage supply characteristics. But to improve the performance of the analysis of non-stationary signals, Kalman filter has been proposed in recent years. Kalman filter is a set of mathematical equations that provides a recursive method to estimate the state of a process in a way that minimizes the mean square error. The aim of this poster is to show the performance of Kalman filter’s analysis of noise measurement and harmonics in power systems.

83. Understanding and Mitigating Security Hazards in Android Applications Uninstallation

Xiao Zhang, 5th Year’s Ph.D.
Zhenshen Qiu, Kailiang Ying, Yousra Aafer
Advisor: Wenliang Du

Uninstalling an application from mobile devices is among the most common user practices in smartphone’s daily usage. It may sound trivial, but the entire process involves each system component coordinating to remove data belonging to the application being uninstalled. With its universality and complexity, little has been done, however, to understand the security risks of the application’s uninstallation process. In this project, we report the first security analysis of Android’s data clean up mechanism after application is removed, which reveals the pervasiveness of subtle yet significant security flaws in them, leading to multiple data residue instances. Each instance is connected back to one specific system service’s data mishandling, and it can be further utilized to launch DoS, privilege escalation and data hijacking attacks. To mitigate this threat, we provide guidelines that helps Android framework developers correctly clean up data from each system service after application is removed. We show that, by following our guideline to existing system services, all data residue instances can be resolved.

84. Consensus-Based Community Detection and Clustering in Large-Scale Networks

Xi Zhang, 5th year Ph.D.
Advisor: Makan Fardad

Community detection and clustering algorithms are of interest in a wide range of biological, social, and technological networks; examples include the identification of proteins groups that collectively serve a certain
function within the cell, the detection of criminal organizations using cell phone metadata, and the clustering of synchronized generators in a power grid. Clustering problems are inherently combinatorial and require approximations or heuristic algorithms to make them tractable. We consider networks in which links are weighted and directed, and nodes iteratively update their values by taking weighted averages of the values of nodes they interact with. Using quadratic forms to measure deviations from consensus, we derive a performance objective that quantifies the efficiency with which clusters or communities in the network converge toward consensus within themselves. We then formulate an optimization problem that uses the consensus-based performance objective to seek the best clustering of the network into communities across different spatial scales. We use convex relaxations and the alternating direction method of multipliers to separate the problem into optimization subproblems that can be efficiently solved. Finally, we compare the performance of our detection algorithms against the most prominent methods in the literature.

85. Define-Use Vulnerabilities in Android

**Yousra Aafer, 4th year Ph.D.**
Xiao Zhang, Zhongwen Zhang, Nan Zhang
Advisor: Wenliang Du

In this poster, we present a new class of Android vulnerabilities. The vulnerability is present when a privileged app uses resources on the device that might not be present without a strong identification mechanism. This creates attack opportunities for malware writers to squat these resources and thus achieve various damages. We develop a detection mechanism for this type of vulnerabilities that looks for our predefined rules in system apps within a specified Android image statically. Using our tool, we conduct a large scale investigation on tens of collected system images and apps from various vendors such as Google, LG, Moto, Samsung and HTC and show that this new vulnerability is actually prevailing in several of them. We also verify some of the identified vulnerabilities to demonstrate the imposed risks in real world scenarios. We were able to achieve various damages ranging from denial of service, intent redirection, and squatting system apps. Finally, we propose a lightweight protection mechanism to defend against the define-use vulnerability.

86. Wireless Vs Wired Power line Communication

**Yasha test Chaturvedi,**
Morgan Thomas
Advisor: Dr. Tomislav Bujanovic

The current electrical system is perhaps the most versatile system available in 21st century. Interconnectivity and communication between various distributed energy resources can guarantee improved energy efficiency. A reliable and secure two-way communication between the utility and
consumer will not only provide increased incentives but will also increase the quality of service.

To upgrade the current power system, there are multiple wired and wireless technology options being currently researched to satisfy the communication need. A plausible way to achieve robust network architecture is Power line communication (PLC), which allows data flow over a wide range of frequencies and can be deployed over existing power lines as compared to wireless. In addition, PLC establishes end-to-end connectivity which provides more secure and reliable communication.

However, PLC faces challenges in transmission through channel impairment, impulsive noise, lack of automation and physical maintenance. Whereas wireless technology has proven to be efficient, low maintenance and robust.

A wireless network is not compatible with the existing system developed over the last 60 years. Another unavoidable challenge with wireless is security.

Therefore, both wired and wireless technology should be explored for communication in the future smart grid.

87. Classification of Binary Data Stream with Concept Drifting Using Conjunction Rule base Boolean Classifier

Yiou Xiao, 4th year Ph.D.
Kishan Mehrotra, Chilukuri Mohan
Advisor: Kishan Mehrotra

Recent data mining research focuses on streaming data/big-data. Significant characters of streaming data are that (a) Only a small portion of data is typically stored and (b) analysis is to be performed as new data points arrive. For example, automated log data, sensor data and financial data are generated in large volume rapidly.

Efficient classification on high-speed data streams remains to be challenging because of the resource restraints and concept drifts. We proposed a conjunction rule based classification technique that has good classification performance, is simple, automatically identifies important attributes, and is extremely fast. Due to these properties the classifier is most suitable for streaming data. Empirical study, using multiple datasets, shows that time complexity, compared with other classifiers, is faster by several factors, especially for large number of attributes without sacrificing accuracy.
88. Mobile Surgeon Navigation System

Yu C Zheng, 3rd year Ph.D.
Koray Ozcan
Advisor: Senem Velipasalar

In this work, we propose a navigation system, by processing CT/MRI scan image, we could reconstruct 3D model and visualize it on mobile platforms. Instead of million dollar's ceiling mounted system, this project is designed to work on mobile platform such as an smart phone or a tablet. With the help of markers on the patients, we are able to perform medical image alignment to navigate in the surgeon.

89. GStorm: GPUenabled Highthroughput Online Data Processing in Storm

Jimmy Zhenhua M. Chen,
Jielong Xu, Jian Tang, Kevin Kwiat and Charles Kam
Advisor: Dr. Jian Tang

The Single Instruction Multiple Data (SIMD) architecture of Graphic Processing Units (GPUs) makes them perfect for parallel processing of big data. In this paper, we present design, implementation and evaluation of G-Storm, a GPU-enabled parallel system based on Storm, which harnesses massively parallel computing power of GPUs for high-throughput online stream data processing. G-Storm has the following desirable features: 1) G-Storm is designed to be a general (rather than application-specific) data processing platform as Storm, which can handle various applications and data types. 2) G-Storm exposes GPUs to Storm applications while preserving its easy-to-use programming model. 3) G-Storm achieves high-throughput and low-overhead data processing with GPUs. 4) G-Storm accelerates data processing further by enabling Direct Data Transfer (DDT) between two executors that process data at a common GPU. We implemented G-Storm based on Storm 0.9.2, with JCUDA, CUDA 6.5 and the NVIDIA Quadro K5200 GPU. We tested it using three different applications, including a continuous query application, a matrix multiplication application and an image resizing application. Extensive experimental results show that 1) Compared to Storm, G-Storm achieves over 7x improvement on throughput for the continuous query application, while maintaining reasonable average tuple processing time. It also leads to 2:3x and 1:3x throughput improvements on the other two applications, respectively. 2) DDT significantly reduces data processing time.
90. Completion and Parsing Chinese Sentences Using Cogent Confabulation

Zhe A Li, 1st year Ph.D.
Qinru Qiu
Advisor: Qinru Qiu

Sentence completion and prediction refers to the capability of filling missing words in any incomplete sentences. It is one of the keys to reading comprehension, thus making sentence completion an indispensable component of machine reading. Among different languages’ sentence completion and parsing, Chinese is of great difficulty. Chinese words are not naturally separated by delimiters, which imposes extra challenge. In this work, a brain-inspired inference model is applied to complete sentence in Chinese. Incorporating trained knowledge in parts-of-speech tagging and Chinese word compound segmentation, the model does not only fill missing words in a sentence but also performs linguistic analysis of the sentence with a high accuracy. Moreover, mutual information assisted mathematical formulation gives an improvement on the performance. We further investigate the optimization of the model and trade-offs between accuracy and training/recall complexity. Experimental results show that the optimized model improves recall accuracy by 9% and reduces training and recall time by 18.6% and 53.7% respectively.

91. Energy Storage Systems

Zachary J Gallagher, Master’s
Advisor: Tomislav Bujanovic

The current electrical power grid faces many challenges with the evolution of technology and customer demands. Energy storage devices are one area that currently can be used to enhance the capabilities of the electrical power grid. Energy storage devices allows for the electrical power grid to handle the disturbances of randomly and rapid changes in load. Energy storage devices can be used to allow better penetration of renewable energy resources, decrease energy waste, and increase frequency stability. By charging of energy storage devices during periods of below base load, energy demand and high renewable power generation energy losses can be minimized. These energy storage device can also replace the need for peaking power plants by discharging them during peak loading periods. This study analyzes the current implemented energy storage systems as well as the systems in research and development. Each energy storage device has different efficiencies, costs, and environmental factors. Research and implementation of energy storage devices can help the electrical power grid meet and face the current and future demands of loading on the power grid with less environmental damage. This work will compare possible energy storage systems for power grid implementation.
92. Demand Side Management in Smart Grid

Zhengyan Wang, 2nd year Master’s
Advisor: Tomislav Bujanovic

During past decades, generation side control for power grid is commonly used to ensure stability and efficiency. However, generate-purpose control is no longer enough if large amount of renewable energy resource (RES), which has intermittent nature, is integrated to the grid. Demand-side management (DSM) is presented in this poster to take over part of the control to improve reliability and benefits for both utility company and public. Firstly, Real-time pricing (RTP) strategies, which is one method of DSM, is modeled and analyzed. RTP will induced more uncertainty to the grid so that it is insufficient to stand large amount of RES. Secondly, direct load control (DLC) strategies and digital direct load scheduling (DDLS) are proposed. These methods are able to bring more controllability for the grid but it is pointed out that scheme and standards for DLC and DDLC need to be study. Thirdly, integration architectures for distributed resources is presented with the concept of utilization of electric vehicle and micro-grid. In the last part, this article emphasize that the ability of communication and control for appliance and EV is the basis for future DSM and signal processing will pave the way for a greener future for the grid.

93. Swarm Robotics

Zhi Xing, 4th year Ph.D.
Gajendranath Gaurav Roy Puli
Advisor: Jae C. Oh

We study swarm robotics, where a large number--perhaps thousands--of robots must cooperate to achieve common goals. The key challenges are scalability and robustness in the absence of centralized controls. Many swarm robotics researchers use the foraging problem as a test bed for new algorithms. Foraging problems can represent a variety of problems including search and rescue. In this problem, robots must find locations of ‘food? without any previous knowledge or a centralized control. Our approach uses completely distributed and autonomous robots that can dynamically assume useful roles, either being explorers or guiders, by utilizing their local information only. Because our solution is completely distributed and localized, it is expected to scale out very well even with an extremely large number of robots. We also developed a robot hardware prototype that can be used for general swarm robot research. The hardware utilizes the Arduino Mega 2560 board and infrared emitters and receivers for communication and obstacle detection. The key difficulty of designing the robot is the communication protocol, which currently is implemented as a state machine running as Interrupt Service Routines. Many robotics research efforts stop at simulation work; however, we
believe that robotics algorithms must be developed to work in the physical world. The challenge is to design algorithms that work in the physical world not only in a simulated world. The lessons learned in this research will help us to design cyber-physical systems that require the seamless integration of computational algorithms and physical components.

94. Ensemble Algorithms for Unsupervised Anomaly Detection

Zhiruo A Zhao, 2nd year Ph.D.
Chilukuri Mohan
Advisor: Kishan Mehrotra

Many anomaly detection algorithms have been proposed in recent years, including the density-based and rank-based algorithms. The main problem with these algorithms is that they are best suited to capture specific types of anomalies for which they are designed and fail to capture multiple types of anomalies that may exist in a dataset. In this paper, we evaluate two types of ensemble methods to improve the performance of recently proposed six individual anomaly detection algorithms. First ensemble method is to aggregate the outputs of the algorithms. Aggregate method can be performed in multiple manners. For example, aggregate may be the simple average of all of anomaly scores or the minimum rank over all six ranks assigned by the algorithms to each object in the dataset. Second ensemble method is sequential where one detection method is followed by the other. To find the best pair of algorithms to be used in the sequential method, we propose to use correlation coefficient as a measure of similarity among all six algorithms. We use several datasets to evaluate the performance of the proposed ensemble methods. Our results show that the sequential methods significantly improve the ability to detect anomalous data points.

95. Frequency Measurement for Quartz Crystal Monitor (QCM) Applications

T. McLeod, Senior, A.K Mahabalagiri, K. Ahmed, 3rd year Ph.D.
J.T. Spencer, K.S. Sweder
Advisor: F.H. Schlereth

In Biotech applications it is desirable for QCM response time (time to measure a frequency change Df) to be as short as possible. New instrumentation for making rapid frequency measurements which is orders of magnitude faster than presently available instruments is described. For a 5 MHz crystal a conservative estimation time for a Df of 0.1 Hz is in the order of 1 msec; three orders of magnitude faster than presently available instrumentation. An added feature of the new instrumentation is the ability to measure pressure and concentration level in the sensor environs in addition to just the mass deposited on the crystal as is the case for pres-
ently available instrumentation. This is accomplished, in part, by using uncoated or functionalized crystal sensors, as the application demands, and extends the range of applications of QCM technology to environmental monitoring, snifffers for explosives, and intrusion detection. The cost of the new instrument, actually three instruments in one, is of the same order as presently available instrumentation.

References:
1. S. Shill, Thin Film Products http://www.inficon.com/Inficon
4. Maria Dolores Valedes, Iria Villares, Jos Faria, Maria Jos Moure, FPGA-based Frequency Measurement System for High Accuracy QCM Sensors, Department of Electronic Technology, University of Vigo, Spain.

DEPARTMENT OF MECHANICAL AND AEROSPACE ENGINEERING

96. Crack Growth Mechanisms under Anti-Plane Shear in Composite Laminates

Allison Johnston,
Advisor: Barry D. Davidson

The effects anti-plane shear (mode III) loading has on delamination initiation and propagation in composite laminates is studied using the split-shear torsion (SST) test. The SST test utilizes a unidirectional split-beam specimen sandwiched between load tabs, to which both a shear force and restoring moment are applied, resulting in a global mode III loading. In previous studies, the authors traced a dependency of apparent delamination toughness on geometry to transverse cracking in the composite matrix material. However, the details of how transverse cracks initiate and propagate, and how they interact with planar delamination growth is not clear. To examine this, a series of SST specimens of varying geometries were manufactured and tested. Tests were conducted to various percentages of the displacement at which macroscopic growth occurred, and a select number of tests were conducted to an extended
amount of delamination growth. Specimens were then examined via sectioning and optical microscopy or through X-ray computed tomography (CT). It has been found that transverse cracking occurs prior to the onset of planar delamination growth, and it has been shown that these two forms of crack growth are intrinsically coupled. Further, the extent and rate of transverse cracking can be related to the torsional rigidity of the specimens, further explaining the dependency of apparent toughness on geometry. These results are used to draw inferences on the application of standard toughness test and delamination prediction methodologies to laminated composites.

97. Design & Characterization of Low Friction Zwitterionic Hydrogel for use as Articular Cartilage Replacement

Allen Osaheni, 2nd year Ph.D.
P attic T. Mather, Rebecca A. Bader
Advisor: Michelle M. Blum

Treatment of focal chondral defects is a widespread and intractable problem; especially with people living longer, or accumulating damage from progressive debilitating diseases such as osteoarthritis. In response, use of hydrogels has been investigated to repair this necrotic tissue in an inexpensive, non-invasive manner. These investigations routinely focus on mimicking the biomechanics of the natural tissue or the fluid pressurization mechanism. However, these approaches neglect the surface boundary lubrication mechanism, making these potential load-bearing substitutes incompatible with natural cartilage, resulting in construct wear, failure, and healthy cartilage damage. Therefore, there is a need to develop a material with combined mechanical and tribological properties comparable to articular cartilage. Poly (vinyl alcohol) (PVA) hydrogels are an attractive option due to their inherent biomimetic properties. However, their use for weight bearing applications is limited due to inferior tribological properties. This presentation outlines the effectiveness of two fabrication approaches to enhance the tribological properties of PVA hydrogels. The first approach consists of blending ratios of PVA with zwitterionic polymer, 2-(Methacryloyloxy) ethyl]dimethyl-(3-sulfopropyl) ammonium hydroxide) (MEDSAH) to form a hydrogel blend. In the second approach poly(MEDSAH) is functionalized to the surface of PVA hydrogels, resulting in the formation of a zwitterionic brush layer. The structure-property relationships of the hydrogels were investigated by evaluating the chemical composition (ATR), physical properties (water content, contact angle), elastic compressive modulus and coefficient of friction. Preliminary results suggest the functionalization of these zwitterionic polymers result in as much as a 40% reduction in average coefficient of friction.
98. Ignition Correlation for HCCI Engine Design and Control

Apeng Zhou, 2nd year Ph.D.
Ting Dong
Advisor: Prof. Ben Akih-Kumgeh

Some advanced combustion engine concepts, such as Homogeneous charge compression ignition (HCCI), rely on chemical kinetics for proper operation. Prediction and control of auto-ignition induced by chemical reactions are therefore key issues. Detailed models can be developed for various fuels but real-time application is limited by the high computational cost required. Comprehensive ignition correlations can help in this case.

Here, a correlation approach is used to simplify the process of estimating chemical time scales during simulations of kinetically controlled combustion events. Large chemical kinetic mechanisms are used to generate a database from which the correlations are developed taking into account complex ignition behavior such as negative temperature coefficient (NTC) regions which vary significantly with reactor pressure. HCCI engine control currently uses reduced chemical kinetic models and the Livengood-Wu (LW) ignition integral for ignition predictions. We evaluate the performance of the LW integral using one of the ignition correlations developed in this study, comparing it with the ignition prediction of a single-zone adiabatic internal combustion model using the detailed chemical kinetic model from which the correlation is derived.

It is found that the simplified correlations accurately reproduce the predictions of the detailed chemical kinetic models at an insignificant computational cost relative to the detailed simulations. The correlation approach is also applicable to experimental ignition data, obtained in a manner that statistically covers a wide range of the relevant parameters. This work contributes toward incorporation of realistic chemical kinetic effects in the computational analyses and control of kinetically controlled combustion processes.


Andrew Magstadt, 2nd year Ph.D.
Matthew Berry
Advisor: Mark Glauser

In a test campaign studying jet noise, simultaneous far-field acoustic measurements and near-field particle imaging velocimetry (PIV) data were sampled from a supersonic underexpanded axisymmetric jet operating at a Reynolds number of $1.3 \times 10^6$. Using overlapping snapshots from three adjacent cameras, separate images of the velocity field were stitched together to form an uninterrupted window. Centered about the axis of the jet, the effective field of view spanned two jet diameters in the
cross-stream direction $r$ and seven diameters in the streamwise direction $z$. This area proved to be sufficiently large to capture important scales of supersonic flow relevant to noise generation. Specifically, Proper Orthogonal Decomposition (POD) has extracted particular energy modes thought to be associated with the large-scale instability wave, shock cells, and turbulent mixing characteristic of supersonic noise. As example, time-dependent modal correlations present evidence linking the existence of shock cells to screech tones. From the data gathered, these experimental and analytical techniques are thought to be valuable tools in isolating energy-based flow structures relevant to noise generation. Preliminary data from a newly-installed advanced nozzle concept, which merges the designs of Single Expansion Ramp Nozzles (SERNs) and multiple-stream flows for increased performance and noise-reduction, are additionally presented.

100. Measurement of Contact Angle of Vapor Bubble in Boiling

An Zou, 4th year Ph.D.
Ashish Chanana, Amit Agrawal, Peter C. Wayner
Advisor: Dr. Maroo

Boiling process is highly related to the liquid-vapor interface behavior: bubble nucleation, growth and departure. Contact angle plays an important role in boiling heat transfer by affecting these interface behaviors. However, only equilibrium or advanced/receding contact angles of a drop on solid surface at room temperature are used in the models related to boiling heat transfer; the knowledge about bubble contact angle, especially in boiling process is still lacking. Here we present our experimental results of measurement of contact angle of the bubble during nucleate boiling on surfaces with varying wettability, the history of bubble growth and contact angle, and an approximation of heat transfer coefficient and width of evaporation region in subcooled nucleate boiling. The bubble contact angles with regular DI water are $\sim 32^\circ$ on hydrophilic SiO2 surface, normal SiO2 surface, which is similar to that of a drop on normal SiO2 surface, independent on the laser power. It varies from $\sim 70^\circ$ to $\sim 44^\circ$ with degased DI water, depending on the laser power.

101. A Holonic Architecture for Agile Evolvable Assembly System

Bicheng Zhu, 3st year Ph.D.
Advisor: Utpal Roy

Agile manufacturing requires high responsiveness at all levels of a company, but is especially challenging on the shop floor level. We present the idea of Evolvable Assembly Systems (EAS): “assembly modules modelled as agents and can be seamlessly integrated into existing systems, or removed at any instant”, as a promising solution. Our goal is to make the manufacturing assembly system act like a human society with
increasingly self-managing behaviors: 1) to easily and quickly produce a new or re-configured assembly system each time a new product order arrives or each time a failure or weakness arises in the current assembly system and 2) to maintain production also under degraded conditions. The key components in the EAS are a set of ontology models which specify the concepts of product, process and system and their interrelationships. The use of ontologies and explicit semantics enable performing logical reasoning to infer sufficient knowledge on the classification of processes that assembly equipment offer, and on how to execute and compose those processes to carry out assembly orchestration autonomously.

This research work is not restricted to the assembly domain and can be applied into the whole manufacturing system if needed. It could serve as the prototype or preliminary work towards a future smart manufacturing system.

102. Adaptive Mesh Refinement in Overset Grid Interpolation

Benjamin Henry, 1st year Master’s
Advisor: John Dannenhoffer

The use of Overset meshes is a common practice within the Computational Fluid Dynamics (CFD) community to yield high accuracy solutions in large CFD calculations. The use of multiple structured meshes allows for both the precise resolution of complicated geometry, and control of grid points in areas of interest within the domain of the solution. The interpolation schemes used to transfer data about the solution from one grid to another, however, are not based on the physics of the problem, and can introduce non-conservative errors to the solution.

The best practices in overset meshing state that in regions where meshes overlap the area ratios of their cells should be comparable in order to mitigate the effect of interpolation on the overall simulation. With the complexity of modern hyperbolic meshing methods, and many of the geometries that are considered in these cases, having comparably sized cells in interpolation regions is often a difficult idealization to attain. The purpose of this project is to develop and implement a method to automatically identify locations inside the interpolation regions of Overset meshes where the ratio of cell areas is greater than a certain tolerance, and then refine the mesh in order to increase its resolution, and to assess its impact on the error introduced by interpolation within the CFD solver.
103. Identification of Turbulent Structures in Premixed Reacting Flows

Eileen Haffner, 1st year Ph.D.
Dr. Elaine Oran
Advisor: Dr. Melissa Green

Many studies have been conducted on the best ways to quantitatively characterize the turbulence-flame interaction in reacting flows. It has been observed that increased turbulence intensity both wrinkles and broadens the flame front throughout the preheat zone and reaction zone. A Lagrangian coherent structures analysis is used to identify the individual coherent turbulent structures as the maximizing ridges of the Finite-Time Lyapunov exponent scalar field (FTLE). This method provides different information than Eulerian criteria which have predominantly been used in previous reacting flow studies. Preliminary results show that LCS ridges exhibit a clear qualitative correlation to the contour of the fuel mass-fraction of the flame. Previous studies have shown that, in addition, the flame diminishes turbulent structures, and changes their orientation. The physical mechanism of this interaction is still unclear. An Eulerian criteria (specifically Q criteria) analysis is preformed to allow the tracking of structures through the flow, and to provide a visual of the vortex transformation through the flame. A quantitative characterization of the turbulent structure and flame interaction will allow for a better understanding of how the flame brush affects these structures, and could lead to improved efficiency in particular engines.

104. Hyperbolic Field Grid Generation

Han Li, 1st year Ph.D.
Advisor: John Dannenhoffer

The poster mainly studies how to achieve field grid generation by using hyperbolic grid equations. The fundamental concepts of field grid generation by using hyperbolic grid equations are given. The poster also introduces method to use numerical techniques to solve the governing equations based upon the fundamental concepts. When the cell size is very small or concavity and convex appear, the grid lines will overlap with each other. In this poster, specification of cell sizes, grid smoothing mechanisms are given to solve these problems when using hyperbolic field grid generation scheme. When this scheme is applied on airfoil, the outer boundary has oscillations since aspect ratio of the cell becomes very small (the distance between two grid points is very short). This is the difficulty to implement this scheme. In the end, this poster shows future work, such as the combination of elliptic scheme and hyperbolic scheme and how to make the grid line correct in complicated cases.
105. A Semantic Similarity Based Dispatching Rule Selection System For Job Shop Scheduling With Multiple Production Objectives

Heng Zhang, 3rd year Ph.D.
Utpal Roy
Advisor: Utpal Roy

Job shop scheduling is an important activity which properly assigns production jobs to different manufacturing resources before production starts. Compared to other scheduling approaches that use optimal branch and bound algorithms, meta-heuristics, etc., the dispatching rule based approach has been widely used in the industry because it is easier to implement, and it yields reasonable solutions within a very short computational time. The dispatching rule based approach uses a selected single dispatching rule (e.g. Shortest Processing Time or Earliest Due Date) or a rule combination depending on the current production objective like maximizing productivity, minimizing makespan or meeting the due dates. However, a dispatching rule or a pre-set rule combination always pursues a single and fixed production objective. Additionally, when multiple objectives are pursued at the same time, the previous approach cannot appropriately suggest the suitable dispatching rule or a rule combination. This characteristic confines the flexibility of the scheduling system in practice. In order to address this issue, this study proposes a semantic similarity-based dispatching rule selection system that can achieve the intelligent selection of dispatching rules. The intelligent selection is addressed by measuring the semantic similarities (based on ontology) between the user selected production objectives and the characteristics of the dispatching rules. A rule combination can then be constructed by combining individual dispatching rules with similarity values based weights. A proof-of-concept demo has also been provided as a case study for this poster.

106. Proper Orthogonal Decomposition: A Lagrangian Approach

Jack Rossetti, 1st year Ph.D.
Advisor: John F. Dannenhoffer III

A new method of applying snapshot proper orthogonal decomposition (POD) is presented. Snapshot POD has been widely used as a means of analyzing turbulent flows. Generally an Eulerian frame is used to capture the data. It is proposed that using a Lagrangian frame of reference can greatly improve the information obtained by applying snapshot POD to the same data set. To illustrate this point, photographs of similar faces are presented and analyzed in both frames. The photos have been placed in random locations on a strip to simulate the Eulerian frame. The faces in these pictures must then be shifted to a reference point so each face is in the same location on the strip; this creates the Lagrangian frame. The
pictures will be analyzed in both frames using snapshot POD so a comparison can be made.

107. Experimental Study of Spanwise Wake Compression of a Trapezoidal Pitching Panel

Justin King, 1st year Ph.D.
Advisor: Melissa Green

Stereoscopic particle image velocimetry was used to characterize the highly three-dimensional flow created by a rigid, trapezoidal pitching panel used to model an idealized fish caudal fin. Previous work has demonstrated that spanwise compression of the wake occurs until the wake ultimately breaks down as it convects downstream. However, quantitative verification of the spanwise velocity relevant to the structure of this compression was not evaluated in the prior work. Experiments were conducted over a range of Strouhal numbers from 0.17 to 0.56 at 25 locations along the spanwise extent of the wake. Recent stereo PIV measurements confirm spanwise flow in the wake toward the midspan, which agrees with the previously observed linear spanwise compression as the wake moved downstream.

108. High-temperature Auto-ignition Studies of 2,5-dimethylfuran, 2-ethyl Furan, and Iso-octane

Mazen P Eldeeb, 3rd year Ph.D.
Dr. Benjamin Akih-Kumgeh
Advisor: Dr. Benjamin Akih-Kumgeh

The ignition behavior of two furan isomers, 2,5-dimethyl furan (2,5-DMF) and 2-ethyl furan, is investigated using the shock tube technique at pressures of 5 and 12 atm, to establish the relative reactivity of the isomers. The results show that 2,5-DMF ignition delay times are up to 5 times longer than those of 2-ethyl furan. Further, we investigate the relative ignition behavior of 2,5-DMF and iso-octane as well as blends of these. Ignition delay times are measured over a temperature range from 1009 to 1392 K and pressures up to 12 atm for lean, stoichiometric, and rich mixtures of fuel, oxygen, and argon. It is observed that 2,5-DMF generally has longer ignition delay times than iso-octane when the equivalence ratio $\phi$, the argon-to-oxygen ratio D, and pressure p are kept constant over a range of temperatures, T. Ignition delay times of a blend of 2,5-DMF and iso-octane of equal liquid volume proportions are measured and compared to those of the pure fuels at stoichiometric and rich conditions and pressure of 12 atm. It is observed that the reactivity of the blend is intermediate between the two pure fuels, with closer alignment to iso-octane. A combined model for 2,5-DMF and iso-octane combustion is assembled from recent literature models for the pure components. Further modifica-
tions are carried out to improve agreement with the current and previous ignition data. The resulting model captures the ignition trends of the pure and blended fuels, which is further explained through reaction pathway analysis and species sensitivity analysis.

109. Countertop Commercial Appliance Emissions

Meng Kong, 2nd year Ph.D.
Jianshun Zhang, Yan Zhang and Beverly Guo
Advisor: Dr. Jianshun Zhang

During the last two decades, the proper design for commercial kitchen hoods has been of great interest in the industry. So is the code enforcement because cooking processes generally produce much smoke, volatile organic compounds (VOC), grease particulate matters and grease vapor, which can adversely affect the indoor air quality, human health, comfort and performance, especially for cooks and occupants in the buildings. In order to get these contaminant out of the kitchen, hood exhaust systems (Type I hood) are required to be installed for smoke and grease generating appliance. But for light appliances which only generate heat and moisture, either no hood or only Type II hood is required. Hood exhaust systems not only prevent the contaminant from spreading out but also remove heat directly from them via the suction power of the exhaust fan. However due to the lack of knowledge of the emission and energy generation rate of the appliances, it is still vague that under what circumstances a Type I or Type II hood is necessary from the IAQ and energy point of view. This work is aimed at providing ASHRAE a better understanding of impacts when determining whether an appliance should be un-hooded or hooded.

110. A Lagrangian Coherent Structures Analysis of the Unsteady Wake Behind a Circular Cylinder

Matthew Rockwood, 3rd year Ph.D.
Advisor: Melissa Green

Previous simulations of a circular cylinder in cross-flow at a Reynolds number of 100 were compared with experimental results at a Reynolds number of 9000 to study the location and evolution of coherent structures, or vortices in the near wake region. This understanding is critical to the control of vortex shedding from bluff bodies, which is often accompanied in aerospace applications by the onset of oscillating body forces and increased noise. The Eulerian Q-criterion was applied along with a Lagrangian coherent structures (LCS) analysis to determine the properties of the wake. The LCS results reveal new details of the initial vortex rollup behind the cylinder. Quantitatively identifiable events occur before the rollup is visible using Eulerian techniques, potentially allowing for the
ability to delay or mitigate the shedding of vortices from the cylinder. Additional insight into the vortex shedding behavior is gathered by tracking the location of the saddle points of the LCS. The saddle point behavior offers a new criterion for determining when a vortex has shed from the bluff body.

111. Laser Ignition Studies of Methane and Biogas

Nathan Peters, 2nd year Ph.D.
Henry Morrow
Advisor: Benjamin Akih-Kumgeh

Laser-induced ignition is a promising technology for combustion initiation in gas turbines and internal combustion engines. There is renewed interest in this technology in recent years due to its ability to ignite lean mixtures which are desirable for cleaner combustion. Apart from fossil fuels, such as methane and propane, biofuels are increasingly considered for applications in combustion systems in an attempt to improve energy sustainability. One of these bio-derived fuels is biogas. Unlike natural gas that consists mostly of methane, biogas contains a high percentage of carbon dioxide in addition to methane and other trace gases. The high carbon dioxide content can hinder flame propagation which in some cases may lead to quenching of the flame kernel near the ignition source. This clearly has further implications in the laser energy requirement for biogas ignition, which warrants investigation.

In this work we study laser-induced ignition of natural gas and biogas. A Nd:YAG laser is used to induce breakdown and ignition of fuel/air mixtures in a cylindrical stainless steel vessel, equipped with 6 optical accesses. Plasma formation, flame initiation, quenching, and successful flame propagation are captured using a high speed Schlieren imaging system and laser interferometry. These imaging techniques allow for a detailed investigation of differences between the fuels as well as fully ignited and quenched cases during the early stages of flame formation. Minimum pulse and minimum ignition energies are determined for a wide range of equivalence ratios, also permitting the determination of flammability limits.

112. Leading Edge Embedded Fan Airfoil Concept – New Powered High Lift Technology

Nhan Phan, 4th year Ph.D.
Advisor: Thong Dang

The LEEF airfoil concept is a powered high-lift airfoil concept capable of generating very high lift coefficient at high angle-of-attack (AoA). This technology is developed for Extremely Short Take-Off and Landing (ESTOL) aircraft applications. Unlike existing powered high lift systems, the
LEEF airfoil uses a local high-pressure air source from cross-flow fans, does not require ducting, and is able to be deployed using distributed electric power systems for general aviation aircrafts. In addition to lift augmentation, the LEEF airfoil can provide additional thrust during take-off and landing operation to supplement the primary cruise propulsion system. Two-dimensional and three-dimensional CFD simulations of original NACA 63-3-418 airfoil/wing and LEEF airfoil/wing were carried out to evaluate the advantages of and the cost associated with implementing the LEEF concept. An experimental study of the LEEF concept was also performed to validate the concept. Finally, the LEEF technology is applied for a Remote Control model and DARPA's Aerial Reconfigurable Embedded System. Tiltrotor aircrafts have wing-mounted ducted rotors that can be tilted to enable VTOL capability while providing high-speed cruising flight. One challenge is the potential loss of aircraft control during the transition period between horizontal flight and hovering period. The LEEF technology presents a potential solution for this problem.

113. Ontological Knowledge Based System for Design Requirements and the Choice of Material Properties

Omer Yaman, 2nd year Ph.D.  Advisor: Utpal Roy

The material and material process selections for any product have always been a challenging job during the product design phase. Matching the performance specifications of a product with an appropriate material or a group of materials is not a trivial task; it needs specialized domain knowledge. When we talk about choosing materials for a component, we take into account many different factors such as requirements, process, shape and environmental factors which must be addressed through proper choice of a material (s). The information about material, processes, shape, requirement and environmental factors is available but it is not linked relationally among each other for complex decision making purposes. In order to formalize and share knowledge about these factors and materials a higher level standardization is required. Also, it is very important to find out how these criteria are directly or indirectly related to material properties. In this study, with the help of ontologies, we explore the possibility of laying down a knowledge-based approach to map system requirements to material properties that will essentially lead to the development of an efficient computational technique for material selection. In order to achieve this goal, we first discuss the creation of appropriate information models for requirements and material properties, and then the development of “relationship mapping” between the two with examples.
114. Parametric Geometry Regeneration Based on Cloud of Points Through Optimization Methods

Pengcheng Jia, 3rd year Ph.D.
Advisor: John Dannenhoffer

For design the parametric geometry configuration, we need to know these parameters of primitives. But in general case, we only have a cloud of points from some legacy system, but do not know the parameters. Thus, the gradient optimization method has been used in the process for selecting parameters for a parametric model. The Levenberg-Marquardt (LM) algorithm has been applied for parametric geometry regeneration. This algorithm minimize the each a least square objective function at each point separately instead of minimizing the sum of them at once. Consequently, the number of iteration steps is much lower, comparing with the Newton method. In a addition, we provide gradients which are used in the Jacobain matrix analytically instead of using finite difference at each step. The benefit of this is saving the running time. Moreover, because all of the derivatives are zeros except the parameters for generating the current point, the Jacobain matrix is very sparse. Therefore, we save the Jacobain matrix as sparse matrix which can save a lot of memory space and reduce a lot of CPU time. Re-sorting the initial guess based on the points cloud is a good method for avoiding getting stuck at a local minimum. Every time the process of optimization reaches the minimum, we re-sort the results based on the points cloud and do the iterations again. If we get the same answer, it means that the correct parameters has been gotten. If not, do the loop again until we get the correct result. This method can also reduce the number of iterations to converge because of the reasonable initial guess. This algorithm can be applied into any kind of parametric geometry. In this poster, parameters of rectangle, super ellipse and 3D wing have been used as the demonstrations.

115. Testing and Improving Algorithm for Near- and Far-Field Pattern Recognition of High Speed Jet

Pinqing P Kan, 2nd year Ph.D.
Hua Huang, Jacques Lewalle
Advisor: Dr. Jacques Lewalle

Jet noise related to aircraft engines has become a growing concern for environmental and health-related reasons. To provide noise reduction strategies, we need to identify and control the near-field (NF) structures that produce far-field (FF) noise. We focus on one set of experimental data from Mach 0.6 jet. It consists of 10kHz TRPIV measurement and pressure sampling in both NF and FF. An algorithm has been designed to identify events that act as the main correlation contributors of NF and
FF signals. The testing of the algorithm is first performed using WGN signals and phase-randomized signals and it verifies that the algorithm has captured potential events. Synthetic signals are also used and the result reveals certain deficiencies that could be improved. An attempt of improving the algorithm is shown which compares Q criterion signals at different NF locations to FF Microphone signals inside the cone of coherence. Potential events extracted are interpreted as part of the large coherent structures that correlate with the FF. The properties of these events are examined, including time and frequency of occurrence and magnitude. The NF localization and time sequencing of these potential event clusters are compared to event lists acquired using other algorithms. This work has been funded by Spectral Energies LLC through an Air Force Research Lab SBIR and Syracuse University. We are grateful to members of the Glauser group at SU for the data acquisition and processing and many discussions, particularly with Kerwin Low, Zachary Berger, Patrick Shea and Matthew Berry.

116. Flame-assisted Fuel Cell Furnace for Combined Heating and Micro-Power

Ryan L Milcarek, Ph.D.
Kang Wang, Breezy Knight, Dr. Jeongmin Ahn
Advisor: Dr. Jeongmin Ahn

Increased electricity consumption in the United States has been a growing problem that is only expected to increase in the future. Combating this problem will require new solutions that improve the efficiency of the conversion from thermal energy to electrical energy. In this project, we propose to integrate flame-assisted fuel cells (FFCs) in a gas-fired up-flow furnace to enable the generation of both electricity and heat from the fuels, transforming the furnace into a FFC micro CHP system (FFF-μCHP). The FFCs will be integrated with the furnace burners in a modified setup to allow staged combustion with a slightly rich 1st stage/FFC, then a leaner 2nd stage to complete combustion in the flues. Combustion in both stages will produce the heat needed for the heat exchanger as well as the heat needed for SOFC operation. The system will extract ~ 1 kWe of power from a 60,000-100,000 Btu/h furnace. The application of this technology in a typical residential size furnace has the potential of making this a commercially viable option for households. To achieve the goal of the proposed research project, three specific research objectives will be accomplished: 1) examine and characterize the in-shot burner of a typical furnace; 2) fabricate and test planar FFCs using model fuels of the in-shot burner exhaust to investigate its electrochemical behaviors and 3) fabricate, test and evaluate tubular FFCs performance. We will examine and characterize in order to quantify the operating temperature, the composition of the exhaust and the operating window of the furnace to ensure compatibility with FFC operation; inves-
tigate how FFCs behave in model fuels comparable to the exhaust of an in-shot burner; and demonstrate the feasibility of the FFC-µCHP power generation system.

In this poster, the results of stage 1, the flame characterization for a typical in-shot burner, and stage 2, the fabrication and testing of planar SOFCs, will be discussed.

117. A Ceramic-Membrane Based Methane Combustion Reactor with Tailored Function of Simultaneous Separartion of Carbon Dioxide from Nitrogen

Ryan Falkenstein-Smith,
Pingying Zeng
Advisor: Dr. Jeongmin Ahn

There is an increasing pressure for the industry to reduce carbon dioxide emissions from combustion processes, resulting in an increased interest in the development of methods to sequester and recycle the carbon dioxide from flue gases. Current methods available to separate nitrogen and carbon dioxide for environmental benefit, such as chemical looping combustion (CLC) and pure oxygen combustion are expensive at the high flow rates encountered in industry. This creates an urgent need to find alternative combustion approaches. One potential alternative is a ceramic membrane catalytic reactor, which produces pure oxygen and simultaneously conducts oxy-fuel combustion; thus, CO2 in the product stream could be successfully separated from the nitrogen in air. This work investigates the performance of a perovskite-type SrSc$_{0.1}$Co$_{0.9}$O$_{3-d}$ (SSC) and La$_{0.6}$Sr$_{0.4}$Co$_{0.2}$Fe$_{0.8}$O$_{3-d}$ (LSCF6428) membrane reactors for the combustion of methane in various configurations. The ceramic membranes exploited here are oxygen semi-permeable, dense ceramic membranes based on the composite oxides with mixed oxygen ionic and electronic conductivity at high temperatures. The prepared SSC and LSCF6428 hollow fibre membranes with catalysts were used to perform reaction with a methane fuel. The oxygen permeability feasibility of the membrane reactors were studied and confirmed. The CO2 selectivity at various test conditions were also reported with the maximum selectivity achieved for SSC was 85.4% while LSFC achieved 88.0% selectivity.

118. Mechanical Design of a Six Axis Computer Numerical Control Tribological Bioreactor for Near Physiological Testing of Synthetic Materials and Natural Constructs

Ryan Olson,
Gabriel J. Smolnycki
Advisor: Dr. Michelle Blum

Wear mechanisms operating in natural joints have not been well characterized due to the complications of controlling and isolating experimental
variables, as well as the difficulties of appropriately measuring wear rates. Attempts to simulate physiological conditions typically concentrate on controlling independently varying factors, such as the geometric contact areas and contact forces, without directly attempting to duplicate *in vivo* conditions (fluid temperature, chemical composition, physiological motion). Also, conventional techniques for measuring material wear, such as recording the weight loss of the specimen or dimensional changes, are not accurate for quantifying cartilage wear, because such small amounts of cartilage become removed. Chemical analysis of the lubricant is a proven technique for measuring cartilage wear. Bioreactor systems have been developed to mimic the mechanical environment for very fundamental contacts such as the hip system, but there is currently no cost effective system which mimics the complex kinematics of a knee joint. The *objective* of this project was to design a system with the capability to simultaneously examine degradation of natural tissue (such as cartilage and synthetic materials) as they articulate against each other in a physiologically relevant environment. The tribological bioreactor provides the unique capability of coordinating various and interrelated movements and conditions according to the tribological environments in the naïve joint. It allows us to overcome some of the deficiencies in soft tissue *in vitro* wear testing by providing greater control of important variables (temperature, pressure, gas content) with simultaneous control over motion (rolling, sliding, and combinations of both). Multidimensional tribolological experiments using translation and rotation of the upper and lower bearing surfaces of the tibiofemoral joint bearing surfaces have been shown to cause different wear characteristics than those using a single axis of motion.

**119. MPI for Elliptic Grids Generation**

**Ruoxi Xu, 2nd year Master’s**  
Advisor: Dr. Dannenhoffer

Grid generation in Computational Fluid Dynamics (CFD) can be very time consuming, especially in large projects. Message Passing Interface (MPI) has been used to generate grids in parallel by solving elliptic equations, using Successive Over-Relaxation (SOR) and Alternating Direction Implicit (ADI) methods. Examples of airfoil with different parameters including grid numbers, processor numbers, area divisions, have been tried. Comparing with non-parallel computation, the parallel computation has the same accuracy, but higher efficiency in SOR, and similar results are expected in ADI which will be done soon.
120. Desalination of Sea Water via the Nanopore of the Tobacco Mosaic Virus.

Srikumar Krishnamoorthy, 1st year Ph.D.
Shalabh Maroo
Advisor: Shalabh Maroo

The efficacy of using the central pore of the Tobacco Mosaic Virus for desalination of salt solutions is studied using continuum simulations. Previous molecular simulations have shown the pore surface to be negatively charged, thus resulting in an electric field in the pore. The motion of ions in the presence of this electric field can result in the formation of electric double layers on the surface over which the salt solution flow occurs. In curvilinear geometries such as cylindrical geometries, the size of the Debye length relative to the radius of the cylindrical system can result in an overlapping double layer, in which the movement of the diffuse layer is restricted, thus preventing the motion of ions in the axial direction. Different ionic concentrations of sodium chloride solutions corresponding to different salinity levels are to taken as the participating medium. The fundamental governing equations—Namely, the Poisson-Boltzmann equation which governs the distribution of Electric Potential in the geometry due to the surface charge, the Nernst-Planck equation which governs the radial transport of ions in the presence of an Electric field, and the Stokes equation which governs the pressure-driven axially directed flow will be coupled bi-directionally, and solved using the software COMSOL Multiphysics.

The characteristics of the system such as distribution of concentration of ions, distribution of potential are obtained and visualized, and evaluations regarding the efficacy of using the aforementioned system for desalination are made.

121. Contact Angle Estimation Algorithm for Molecular Dynamics Simulations

Sumith DYD,
Advisor: Shalabh C. Maroo

It is important to study contact angle of a liquid on a solid surface to understand its wetting properties, capillarity and surface interaction energy. For transient molecular dynamics (MD) simulations it requires to keep track of the time evolution of contact angle. This is a tedious effort to do manually or with image processing algorithms. In this work we propose a new algorithm to estimate contact angle from MD simulations accurately and computationally efficient way. The algorithm segregates the droplet molecules from the vapor molecules using Mahalanobis distance (MND) technique. This is further smeared to a 2D density grid using B-spline interpolation function. The selected vapor-liquid interface molecules
using density filtering are used to fit a circle using Landau method. The equation of this circle is solved for obtaining the contact angle. We have applied this algorithm to a number of studies which involves the MD simulation of water with different wall interaction potentials and also with different thermostatting methods.

122. Multi-layer Structured Electrolyte for All-Solid-State Lithium Ion Batteries

Wei Liu, Ph.D.
Ryan Milcarek
Advisor: Jeongmin Ahn

All-solid-state lithium ion batteries (ASSLIBs) have many advantages over traditional lithium ion batteries with liquid electrolytes. The solid electrolyte is the key component needed to build practical ASSLIBs. However, it is difficult to simultaneously meet the physicochemical and electrochemical requirements for a single type electrolyte layer. We propose a multi-layered electrolyte which can combine the advantages from different electrolyte materials.

In this study, a multi-layer structure solid electrolyte (SE) for all-solid-state electrolyte lithium ion batteries (ASSLIBs) was fabricated and characterized. The SE was fabricated by laminating ceramic electrolyte \( \text{Li}_{1.3}\text{Al}_{0.3}\text{Ti}_{1.7}(\text{PO}_4)_3 \) (LATP) with polymer (PEO)\(_{10}\)-Li(N(CF\(_3\)SO\(_2\))\(_2\) electrolyte and gel-polymer electrolyte of PVdF-HFP/ Li(N(CF\(_3\)SO\(_2\))\(_2\). The interfacial resistance is generated by poor contact at the interface of the solid electrolytes. The lamination protocol, material selection and fabrication method play a key role in the fabrication process of practical multi-layer SEs. Also, the as-prepared gel-polymer type electrolyte was applied in assembling a whole coin cell. The charge/discharge as well as the impedance properties of the coin cell were also investigated.

123. Design Sensitivity Calculations on Elliptic Grids

Xiaogang Wang, 2nd year Master’s
Advisor: John Francis III Dannenhoffer

Design sensitivity calculations directly on CAD-based geometry focuses on helping compute the sensitivity of the objective function with respect to the driving parameters. The results will become a bridge between design parameters and computable grids, which will strongly support the method of multi-disciplinary analysis and optimization (MDAO). Comparing to algebraic methods, the partial differential equation methods are considered to be more practical. The advantage is that the solution of grid generating equations can be exploited to generate the mesh. Elliptic scheme is one of the most widely used PDE methods. Contained herein are two cases of computing configuration sensitivities
directly on parametric, CAD-based geometries with Laplace equation method grids. The first simpler case is a typical elliptic grids case. All the boundary values can be directly computed with the design parameters. The results shown in several figures give an overlook of how the technique works. The efficiencies of different iteration techniques are also discussed. Then it goes to a more complex one, which is an airfoil in a box. The results show the performance in a practical case with periodic boundary conditions.

124. Biaxial Stability of Vascular Tissues with Application to Arterial Wall Mechanics

Xinyu Zhang, 1st year Ph.D.
Advisor: Alan Levy

Biaxial stability of healthy medial arterial tissue and its constituents, subject to initial geometrical and/or material imperfections, is investigated based on the long wavelength approximation. This particular geometry is considered because it can model an artery provided i) the thin walled assumption is employed and ii) the nominal loading is interpreted as resulting from both the internal pressure of blood together with an axial tethering force. The study employs existing constitutive models for elastin, collagen and vascular smooth muscle which comprise the medial layer of large elastic (conducting) arteries. A fourth, composite constitutive model, is presented based on the concept of the musculoelastic fascicle which is taken to be the essential building block of medial arterial tissue. Nonlinear equations governing the evolution of the principal stretch imperfection growth quantities are obtained and solved numerically. Results reveal a complexity of behaviors depending on the constitutive relation, the kind of imperfection (e.g., geometrical or material) and the ratio of in-plane nominal loads. Because the character of incipient imperfection growth in diseased arteries is a precursor to aneurysm growth and development, some comments are provided as to how such a process might evolve.

125. Detection and Tracking of Vortex Phenomena Using Lagrangian Coherent Structures

Yangzi Huang, 2nd year Ph.D.
Advisor: Melissa A. Green

Coherent structures are a key component of unsteady. The detection of vortices benefits the design of high-lift devices, mixing progress in power engines, or artificial adaptation of biological flexible control surfaces. The vortex dynamics in two vortex-dominated flows around an actuated flat plate are studied to develop a better method of identifying and tracking coherent structures in unsteady flows. The work automatically
processes data from the 2D simulation of a flat plate undergoing a 45° pitch-up maneuver, and from experimental particle image velocimetry (PIV) data in the wake of a continuously pitching trapezoidal panel. The Eulerian $\Gamma_1, \Gamma_2$, and $Q$ functions, as well as the Lagrangian finite-time Lyapunov exponent are applied to identify both the centers and boundaries of the vortices. The multiple vortices forming and shedding from the plates are visualized well by these techniques. Tracking of identifiable features, such as the Lagrangian saddle points, is shown to have potential to identify the timing and location of vortex formation, shedding, and destruction more precisely than by only studying the vortex cores as identified by the Eulerian techniques. Using both cases, we demonstrate the benefit of including the LCS analysis in order to detect both shedding and breakdown phenomena of the vortex structures. The methods presented here can be applied to both numerical and experimental data. In the future, this could be used to either promote or delay the phenomena of vortex shedding or vortex breakdown.

126. Fan System Modeling

Yinbo Mao, 1st year Ph.D.
Advisor: Thong Q Dang

This project is focusing on modeling the fan system of turbofan engine using a throughflow method. Unlike most of the other throughflow methods, ours has to be able to model the blade effects (pressure increase, work input, loss, etc.) imposed on the flow field with no blade geometry but only some parameters inputs. Results shown here are of use and validation of the method on NASA Rotor 67, which is a rotor designed by NASA specifically for CFD validation purpose and current available in the public domain. The results consists mainly 2D axisymmetric results and some preliminary 3D results. For the coming year, we will be working on more refinements on our method and the 3D validation of it.

127. A Data Management Information Model for “Smart Products”

Yunpeng Li, 2nd year Ph.D.
Advisor: Prof. Utpal Roy

In the era of connected “Smart Products” (or “Internet of Things”), the growth of embedded electrical/electronic components and software applications in a product is shifting the nature of the traditional development process for product design and manufacturing. Specifically, data analytics techniques are now widely employed in products and their operations to monitor the performances, and enable stakeholders to make appropriate decisions for predictive actions as required. The more
“software-driven” even “data-driven” products have different paradigms of engineering changes and maintenances from the traditional “more physical” products; thereby it requires a more complex lifecycle management. This calls for the integration and synchronization of Product Lifecycle Management (PLM) and Application Lifecycle Management (ALM), as well as intensive information sharing and exchange between them. This study focuses on the product data management issues in composition of physical components and software data analytics models in a product. An enhanced Engineering Bill of Materials (EBOM) has been proposed to incorporate data analytics models in the master record of the product as “parts” of the product. The classical product development process has also been revisited, and it is further enriched with the standard knowledge discovery and data mining (KDDM) process in order to take advantage of the newly available “data-rich” product and process information models. The industrial standards, such as ISO 10303 STEP, PMML and CRISP-DM, have been advocated for the integration of these product and process models. A prototype has been partially implemented as the proof-of-concept in an open source PLM platform.

128. Kulfan Airfoil User-Defined Primitive

Yafei W Mei, 2nd year Master
Advisor: Prof. John F. Dannenhoffer, III

Kulfan developed a parametric geometry representations for aircraft component shapes. The mathematical description of a airfoil having a round nose and pointed aft-end is a continuous but non-analytic function because of the infinite slope at the nose and the corresponding large variations of curvature over the surface. Consequently, a large number of coordinates are typically required to describe the geometry. But the ‘Kulfan Method’ includes the introduction of a simple analytic and well behaved “shape function” that describes the geometry. The “shape function” provides the ability to directly control key geometry parameters such as leading edge radius, trailing edge boattail angle, and closure to a specified aft thickness. At the same time, a “class function” is defined that generalizes the method for a wide variety of geometries. This research focuses in two areas. In the first, a technique for finding the Kulfan parameters that match a standard shape was developed. In the second, I will write a Engineering Sketch Pad (ESP) user-defined primitive (UDP) for creating a Kulfan airfoil. Finally, I will compute the sensitivity of the Kulfan airfoil coordinates with respect to the driving parameters and modify the ESP UDP to return sensitivities when requested by the user.