JUNE 2011
ISSUE 2

FENN RESEARCH

Fenn College of Engineering

Cleveland State University

MESSAGE FROM THE DEAN

I am delighted to share with you our second issue of Fenn Research. In this issue, in addition to our graduate level research, we have included some of the outstanding scholarly work by our undergraduate students. Fenn College faculty and students have continued their efforts to discover new findings and to share those discoveries with their peers and the scientific community.

As I pointed out recently, during my 2011 State of the College Address, we have continued to adhere to our five-year strategic plan and have exceeded our own expectations in many areas. Among those, the chemical and biomedical engineering department faculty have successfully launched a master's in Biomedical Engineering and all departments have implemented 4 + 1 accelerated programs.

Moreover, even during these challenging financial times that the College had to respond to several significant budget cuts, we continued to invest in our future by hiring new faculty in some of our important strategic areas. The quality of applicants for our positions in transportation and biomedical engineering is a testimony to the national reputation that Cleveland State University's Fenn College has attained to be able to attract such talented candidates.

I hope you enjoy reading our second issue of Fenn Research.

BAHMAN GHORASHI, PH.D.
DEAN, FENN COLLEGE OF ENGINEERING

MESSAGE FROM THE INTERIM ASSOCIATE DEAN OF OPERATIONS

I welcome you to the 2011 issue of the Fenn Research magazine.

Along with the cutting-edge research of our faculty, in this issue we have included selected research projects performed by our highly skilled and motivated undergraduate students who have been instrumentally supervised by our faculty. Our gratitude is to Cleveland State University, federal, state, local, and private funding agencies, for sponsoring such research projects that provide our students with the invaluable opportunity to actively be involved in our research.

This issue also contains information from the recent Ohio Aerospace Institute (OAI) Industry Day at Fenn College. A significant amount of time and energy was dedicated to the planning and organization of this event aiming at bringing industry and academia even closer and motivating additional collaborations. OAI Industry Day was a success attracting not only the regional industry but also companies from all over the State of Ohio. Industrial visitors had the opportunity to learn about the high-quality and significance of our research through selected faculty research presentations, student posters, and laboratory tours.

Please read through the following pages and see why we are so proud to be part of the community of the Fenn College of Engineering at Cleveland State University.

GEORGE P. CHATZIMAVROUDIS, PH.D.
INTERIM ASSOCIATE DEAN OF OPERATIONS, FENN COLLEGE OF ENGINEERING

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Cleveland State University
engaged learning

Load Capacity Enhancement of Structures and Liquid-Gas Separation in Space

Professor Khan's research is in soil remediation, soil stabilization, porous media flow and fuel cells. He has worked extensively with the Electrokinetic Decontamination Method of clay soils, developed a new method ('CEHIXM') for extracting metal contaminants from grandular soils and also developed a porous media-based phase separation system for selective liquid phase separation in terrestrial as well as reduced gravity environments.

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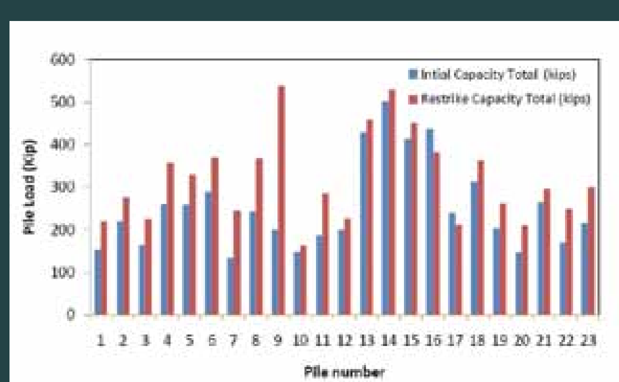
PILE SET-UP IN OHIO SOILS

The Ohio Department of Transportation (ODOT) typically uses small diameter driven pipe piles for bridge foundations. When a pile is driven into the subsurface, it disturbs and displaces the soil. As the soil surrounding the pile recovers from the installation disturbance, a time dependant increase in pile capacity often occurs due to pile set-up. A significant increase in pile capacity could occur due to the set-up phenomenon. For optimization of the pile foundations, it is desirable to incorporate set-up in the design phase or predict the strength gain resulting from set-up so that piles could be installed at a lower End of Initial Driving (EOID) capacity.

In order to address the set-up phenomena in Ohio geology, research was conducted by compiling pile driving data in Ohio soils obtained from ODOT and GRL, an engineering company dedicated to dynamic pile load testing, located in Cleveland, Ohio. The set-up data of twenty three piles was compiled along with time, pile length, and pile diameter. The liquid limit, plastic limit, average clay and silt content, and average SPT value were compiled along the pile length. In 91 % cases of the driven piles, some degree of set-up was observed. Correlations among several soil parameters and pile capacities were explored. The following equation was proposed to correlate the final and initial load capacities of the piles as a function of time and was shown to be in good agreement with the strength gains of driven pipe piles in Ohio soils:

$$Q = 0.9957 * Q_{ot}^{\ 0.087}$$

where: Q is the pile capacity (kip) after time *t*
Q_0 is the EOID pile capacity (kip),
t is the time in hours



Comparison of initial and restrike total and shaft capacities

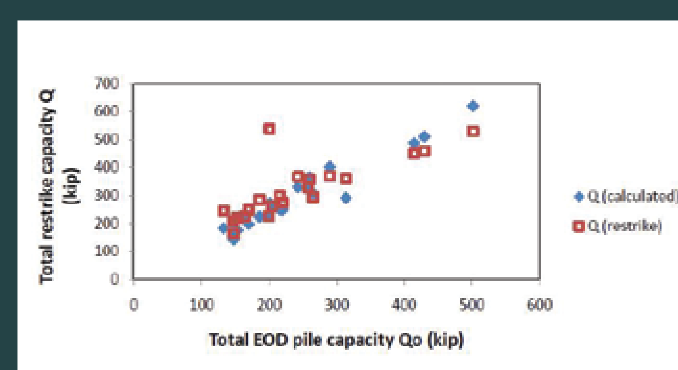
A NOVEL METHOD FOR INCREASING CAPACITY AND ENHANCING SET-UP OF STEEL PILES IN CLAY SOIL

A significant increase in the load capacity is often observed in driven piles over a period of time due to set-up. Although frequently observed, no technology exists to control or enhance mechanisms associated with set-up. A research was initiated at Cleveland State University to investigate the set-up mechanism in clay soils and explore the possibility of accelerating the process by electrokinetic method. The system chosen for the study consisted of laboratory scale steel piles driven in kaolinite clay under controlled conditions. Tests were also conducted at varying moisture contents and various clay-sand mixtures.

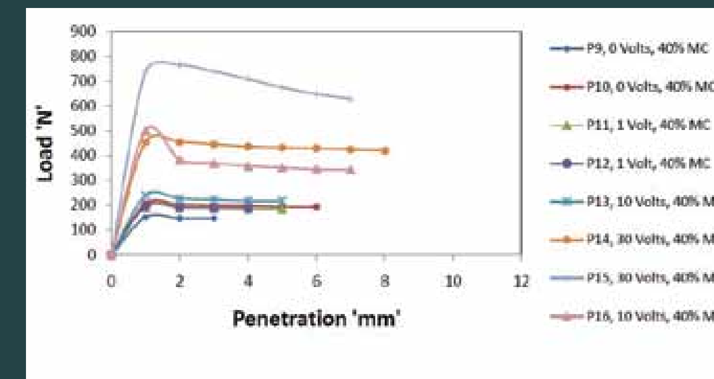
On the basis of laboratory results, it was concluded that capacities of steel piles in clay could be considerably accelerated, and above all, the ultimate load bearing capacities could be significantly increased by the proposed method.

TEST PILE

Static Load Test of Piles



Comparison of restrike total capacity with the calculated pile capacities plotted against the EOID values.

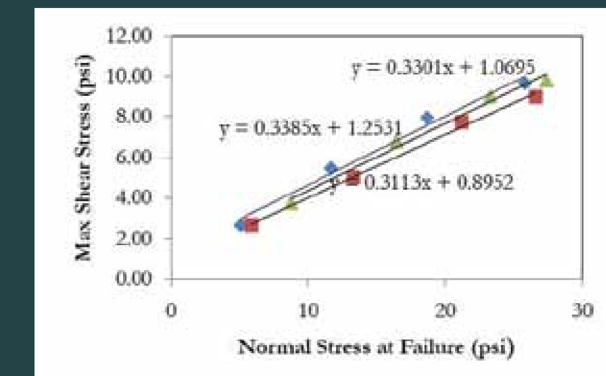


Load capacities of EK conditioned test piles.

EVALUATION OF GEO-FABRIC IN MSE UNDERCUT WALLS

Compaction of granular base materials at sites with fine grained native soils often causes unwanted material loss due to penetration. In 2007, ODOT began placing geotextile fabrics in the undercut of MSE walls at the interface of the native soil and the aggregate fill to facilitate construction. It is probable that the sliding resistances of the retaining walls are affected by this practice. At this time, it is unknown how the frictional resistances at the base of the MSE walls change by the addition of geotextiles at the soil/stone interface and if the factor of safety (FS) against sliding failure is compromised. It is essential to verify the reliability of this practice because serious financial and safety consequences could result if these walls should fail. To address this issue, a systematic investigation of the frictional resistance change due to the introduction of geotextile sheets between granular backfill material and native base soils was conducted by the Direct Shear test. The objective of the research was to determine how the presence of geotextile fabrics affected the shear strength parameters, primarily the friction angle, at the MSE wall undercuts. To evaluate this, the shear strength parameters were evaluated between geotextile fabric and stone and were compared with those of base soil and stone interface. The investigation was carried out by means of a series of a Large Scale Direct Shear (LSDS) apparatus fabricated at Cleveland State University.

Large Scale Shear Device (LSDS) device fabricated at CSU.

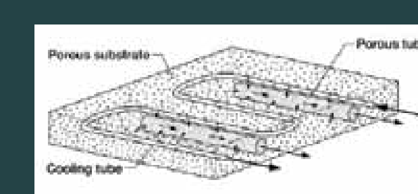


Maximum shear stress vs. normal stress for Geofabric B / Stone C interface.

GRAVITY INDEPENDENT PHASE SEPARATION BY COMPOSITE POROUS MEDIA

The use of porous media has enormous potential for thermal management and phase separation in terrestrial, micro, Lunar and Martian gravity environments. A composite porous media Condenser Heat Exchanger for space systems was developed in collaboration with NASA-Glenn to utilize capillary pressure for collecting and removing water from the condensing unit. This eliminates the need for rotary devices for phase separation under microgravity environments. Experiments were conducted with a composite porous system comprised of porous graphite block and porous ceramic tubes. It was demonstrated that the liquid phase could be preferentially separated from the unsaturated porous graphite block as proposed.

The Condenser Heat Exchanger (CHX) consisted of a porous substrate with embedded porous tubes placed at regular intervals and connected to a suction device via a header assembly. The porous substrate also contained cooling copper tubes through which chilled water is circulated. Condensation of air moisture could occur inside and on the porous substrate when cooled below the dew point. The porous plate absorbed the surface condensate by capillary action. The accumulated water remained within the porous plate until removed by the embedded porous tubes. Air penetration into the porous tubes was avoided by selecting tubes with high bubble pressure relative to the porous substrate. To maintain selective withdrawal, the porous tubes were required to be operated at a suction pressure below bubble pressure.



Conceptual design of Condensing Heat Exchanger (CHX)

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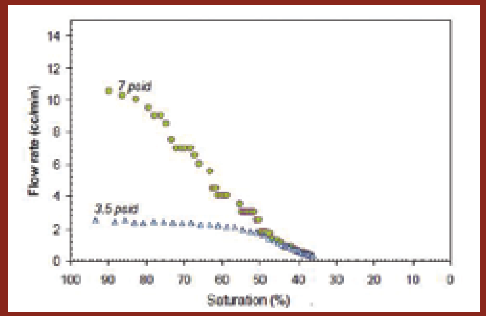
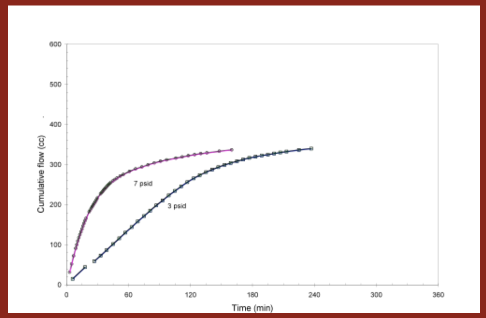
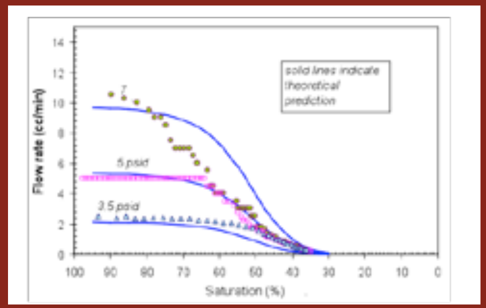
The 3-T apparatus for selective phase separation experiments.



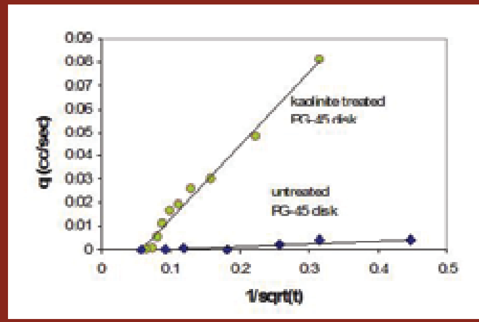
Water extraction from PG-45 Graphite at 3.5 and 7 psid.



Cumulative flow in gradually unsaturating PG-45 Graphite at DP=3.5 psid and 7 psid. The initial saturation was about 95 %.



Theoretical prediction of selective phase separation in PG-45 porous graphite at 3.5, 5 and 7 psid suction using proposed equation.



Imbibition rate in treated and untreated PG-45 Graphite sample as a function of $1/\sqrt{t}$

The selective phase separation aspect of the proposed CHX was verified in a bench scale investigation. It was demonstrated that water could be preferentially withdrawn from an unsaturated porous graphite substrate by saturated ceramic tubes. The limiting saturation to which PG-45 could be reduced to under 3.5, 5 and 7 psid pressures coincided at 35%. This was consistent with the expected critical saturation of PG-45 graphite. Apparently an activation pressure in the range of 2.5 psid was required to initiate flow in the unsaturated porous graphite. Taking this activation pressure into account, the flow characteristics of the composite system could be represented by a simple model which agreed well with the experimental data.

The water withdrawal rate from the porous graphite was sufficient to meet the requirements of the full scale condensing heat exchanger design for space based humidity control systems. In general, the system may be relevant to any micro or reduced gravity application such as distillation, water purification and fuel cells, where phase separation is necessary. The proposed system has been shown to be effective and reliable in separating water from a liquid-gas mixture without the use of rotary devices. Further experimental work with different combination of porous substrate and porous withdrawal tubes are in progress to generalize the applicability. Long term stability studies of the system including the control of biomass growth on the porous substrates are required.

ENHANCEMENT OF WETTABILITY OF HYDROPHILIC SUBSTRATE BY CLAY MINERALS

A strongly hydrophilic porous substrate is essential for condensing and trapping water vapor from the airstreams for composite porous media CHX research. However, most porous media which have good thermal characteristics are poorly wetting to water. This poses a significant obstacle in the development of the porous media-based condensing heat exchanger. In response to this problem, a kaolinite clay-based process was developed for improving the wettability of non-wetting and partially wetting porous media.

The kaolinite treatment was demonstrated to be an effective method to increase the wettability of hydrophobic graphite and stainless steel porous media. Kaolinite deposition in the range of 2 – 3% by weight was adequate for the purpose. The pressure-saturation curve indicated an increase in capillary pressure in the porous graphite matrix after the kaolinite sorption. Condensing heat exchanger plates were successfully treated to make them hydrophilic. The wettability of the porous stainless steel disks could also be enhanced by the kaolinite treatment. The hydraulic conductivity of the treated porous graphite decreased following the treatment. The proposed process is stable for long durations of time. Repeated wetting and drying does not affect the stability of the deposited kaolinite particles.

Diffusion of Hydrocarbons in Zeolites

Professor Shah's research is in the areas of adsorption and diffusion in zeolites. He has been able to obtain a new insight into the transport of gases in these microporous solids. By using large zeolites crystals, he has resolved many of the discrepancies in the literature over the values of diffusion coefficients. He has used the pulse chromatographic and gravimetric techniques to determine the pure component and binary sorption equilibria and diffusion coefficients of various adsorbates in zeolites.

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Zeolites are crystalline aluminosilicates that possess pores of uniform size and of molecular dimensions (Figure 1). Hence, they can be and have been used to separate chemical species based on the size, shape and configuration of molecules. Industrial zeolite separation processes (to separate say A from B) are either performed in packed beds or as membrane separators with membranes synthesized out of zeolites. However, before the zeolites can be used for any separation process, one needs to know 1) their capacity to adsorb A and B at given conditions of pressure and temperature and 2) how fast they diffuse in the interior pores of the zeolite, i.e. their diffusivities. Professor Shah has used a variety of experimental techniques to measure the diffusivities of different hydrocarbons in zeolites. These techniques can be classified as macroscopic, mesoscopic and microscopic depending on the length scale of the samples used for investigative studies.

MACROSCOPIC TECHNIQUES

The samples used in a macroscopic technique are a collection of zeolite crystals (perhaps 15-30 crystals) and the sample size is of the order of a few milligrams. These macroscopic methods are easier to conceptualize and easier to build experimental setups for, but careful data analysis is required to obtain accurate values of micropore diffusivities.

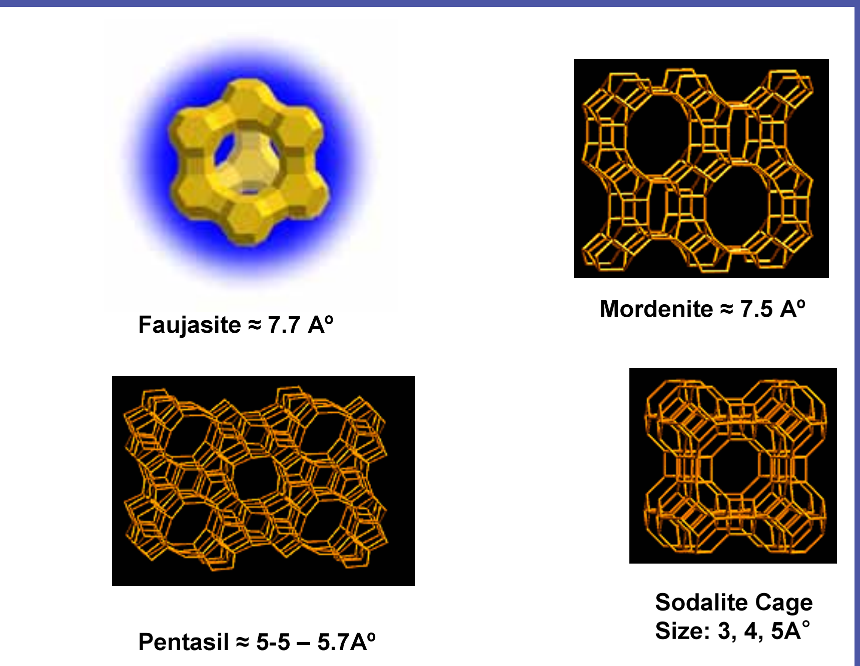

Figure 1. Crystalline structures of some of the commonly occurring zeolites

GRAVIMETRIC METHOD

In this method, a small amount of zeolite sample (about 15 mg) is uniformly spread over a sample pan in a standard Cahn 1000 microbalance. The sample is activated in vacuum at high temperature to remove moisture and other impurities from the sample. A predetermined amount of sample gas is then injected into the sample chamber. As the gas diffuses through the porous structure of zeolite, it is adsorbed in the zeolite sample. The weight of the sample increases with time as more and more gas is adsorbed until the equilibrium is reached. This increase in weight is monitored continuously with time. This curve is referred to as an uptake curve. Uptake curves are typically characterized by an initial rapid weight gain followed by a much more gradual uptake until the equilibrium is reached. A variety of techniques can be used to analyze the uptake curves to determine the micropore diffusivity of gas in the sample. The uptake curve can be analyzed in the initial and long time regions to determine the transport diffusivity. One can also use a mathematical model to describe the entire uptake curve and use the model to obtain the diffusivity. The use of different methods to calculate transport diffusivity enables one to check for the consistency of the transport diffusivity values. One additional advantage of this method is that it not only allows us to determine the diffusivity, but also the adsorption capacity from the readings at equilibrium.

CHROMATOGRAPHIC METHOD

In this method, the zeolite sample is packed in a column as a stationary phase and a mobile phase consisting of an inert gas stream is allowed to flow through the column. A pulse of component A or B is introduced into the mobile phase. The component A or B undergoes a series of adsorption and desorption steps as the pulse passes through the column. When the pulse comes out of the column, it is much more dispersed and is generally skewed. The retention time of the peak is determined by the strength of the component adsorption on zeolite sample. The pulse retention time of a strongly adsorbed component is much higher than a weakly adsorbed component. The shape of the response peak is generally determined by all the mass transfer resistances present in the column including the one characterized by the micropore diffusion. By performing experiments under carefully chosen conditions, it is possible to determine the micropore diffusivity. The method has been successfully used to determine micropore diffusivities of hydrocarbons in different zeolites.

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MESOSCOPIC TECHNIQUES

In such methods, only one crystal of zeolite is used rather than a collection of crystals for experiments. This eliminates the ambiguity and uncertainties associated with defining the nature of intercrystalline boundaries and how the component diffuses across such boundaries. Here the scale of the experiments is in microns rather than mm or cm.

STATIC SINGLE CRYSTAL MEMBRANE TECHNIQUE

A single crystal membrane (SCM) is fabricated as is shown schematically in Figure 2. The membrane is then placed in a diffusion cell that can be evacuated to low pressure. The feed side of the membrane is subjected to a step change in the adsorbate gas pressure while the permeate side is held at a low pressure. The pressure rise on the permeate side resulting from the permeation of the adsorbate gas is monitored continuously with time. The pressure rise initially is nonlinear but becomes linear in the long time region. The slope of the long time response and its intercept on the time axis provides information on both the adsorption capacity and the micropore diffusivity. Figure 3 illustrates these concepts.

DYNAMIC SCM TECHNIQUE

This technique is very similar to the static technique described above. Rather than using closed systems at the feed and the permeate sides, here gases continuously flow past the two sides of the membrane. A gas containing component A flows continuously on the feed side and an inert gas flows on the permeate side. As component A diffuses from the feed side to the permeate side, its concentration in the inert stream increases and is continuously monitored until it reaches a constant value. The rise in concentration on the permeate side is analyzed to determine the micropore diffusivity. One advantage of the dynamic system over the static technique is that binary diffusion can also be studied using this method. Figure 4 gives a schematic representation of this method.

MICROSCOPIC TECHNIQUES

INTERFERENCE MICROSCOPY

A single zeolite crystal is subjected to a change in adsorbate concentration at its surface and the development of the concentration profile in the interior of the zeolite crystal is monitored as a function of time with a newly developed method called interference microscopy. This method uses the principle that optical density of light passing through a transparent crystal is dependent on the nature and amount of guest molecules present in the crystal. Two light beams are used: one passing through the sample and the other passing through the surrounding atmosphere. The analysis of interference patterns emerging from the superposition of these two beams provides the concentration profile. Figure 5 shows the evolution of the concentration profile when the surface concentration of the crystal is step changed. The internal diffusion process is described in the form of a differential equation which is solved subject to appropriate boundary conditions. The simulated profiles are compared with the experimentally observed profiles to arrive at the micropore diffusivity values.

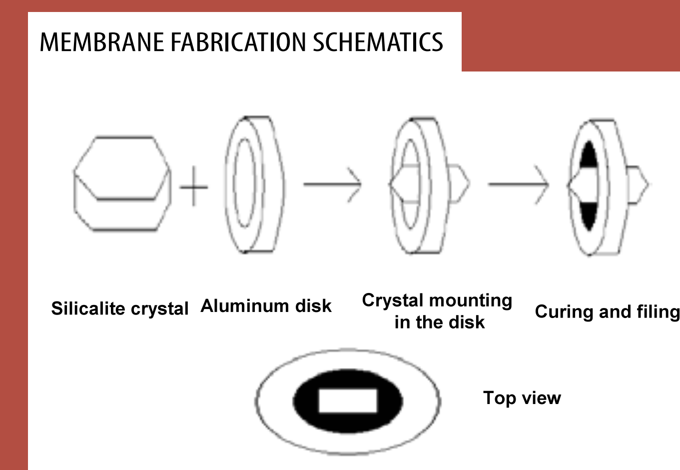

Figure 2. How a single crystal membrane is fabricated.

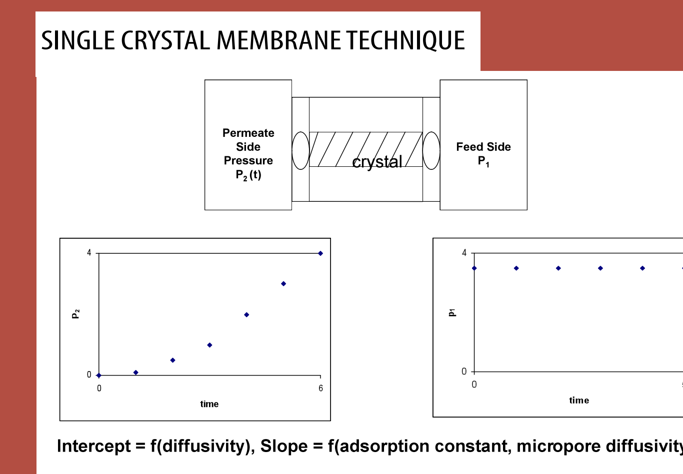

Figure 3. Schematics of the use of SCM method to determine micropore diffusivity

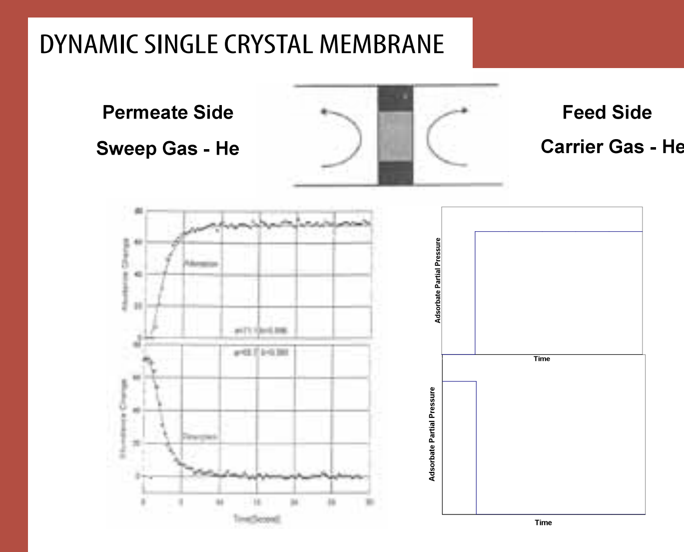

Figure 4. Dynamic single crystal membrane technique

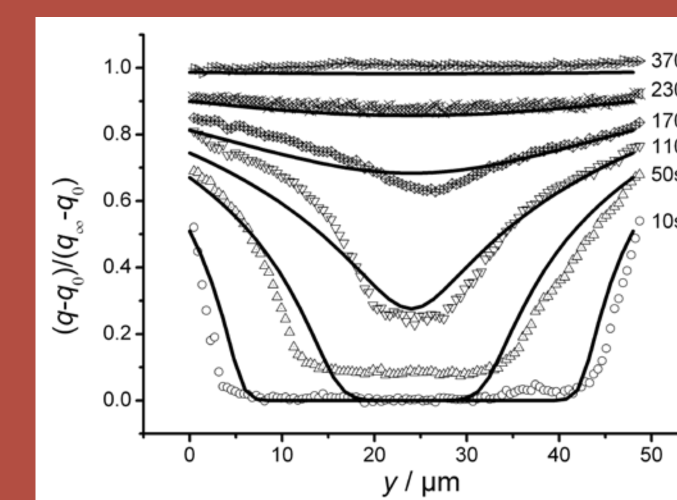

Figure 5. Evolution of internal concentration profile as measured by interference microscopy when a crystal surface is subjected to a sudden jump in concentration.

Process Systems Engineering

Professor Ungarala's research in process systems engineering tackles operational problems such as process modeling, estimation, control and optimization in chemical process plants. His work focuses on the operations of nonlinear dynamic systems, has been funded by the National Science Foundation through multiple grants and has been published in many prestigious journals.

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Professor Ungarala's research in process systems engineering tackles operational problems such as process modeling, estimation, control and optimization in chemical process plants. The results are generally applicable to dynamic systems in other engineering and science disciplines. The US chemical process industry continues to target performance improvements in the face of competition in global markets, high energy costs, and economic/legislative demands for environmentally friendly operations. Consider the $22 billion US glass industry, among the most productive in the world, facing stiff competition from imports. The glass fiber segment produces 1.15 million tons of product a year valued at $2.3 billion, along with 100-200 kilotons of waste discharged into landfills. Apart from the adverse environmental effects, the lost energy during processing is estimated at 6.8-11 MBTU/ton. Improving product quality and minimizing waste and energy consumption are some of the operational problems tackled in Process Systems Engineering (PSE). Professor Ungarala's research is focused on the operations of nonlinear dynamic systems through improved techniques in the observation and estimation of system states and optimal control systems. This research, funded by the National Science Foundation through multiple grants, has been published in journals such as Automatica, Industrial and Engineering Chemistry Research, Journal of Process Control and Computers and Chemical Engineering.

STATE ESTIMATION

Many chemical engineering systems tend to be nonlinear in nature and the uncertainties in their modeling may be characterized by non-Gaussian probability density functions. Moreover, chemical engineers encounter a vast range in scale: quantum scale for subatomic processes, nanoscale for molecular interactions, microscale for particulate processes, mesoscale for process equipment, macroscale for process plants and megascale for the environment. Different levels of discretization of time and space reveal different features of continuum and the performance attributes of a process become scale dependent during control and optimization operations.

Estimation of the state of a chemical process is a fundamental element of operations because it provides the knowledge for implementing process monitoring, control, optimization and safety related tasks. The estimation problem was posed in a Bayesian statistical framework at least five decades ago. However, it is impossible to physically realize this general solution because it is infinite dimensional, except for special cases such as linear Gaussian systems. Much of the early research in linear systems theory had a significant impact on trajectory estimation problems in the Apollo missions to the moon. These algorithms are now routinely applied in forecasting problems in missile guidance, meteorology, ocean dynamics, financial markets and supply chain logistics.

Professor Ungarala and his graduate students have developed the cell filter to numerically implement the general nonlinear Bayesian filter. The approach has been shown to be orders of magnitude faster than several existing nonlinear estimators or filters. The cell filter is a combination of cell-to-cell mapping to study nonlinear dynamics and Bayesian statistical inference, which is ideally suited for online tracking of state variables. Professor Ungarala and his coauthors reported the use of sequential Monte Carlo based particle filter for the estimation of temperatures and concentrations in chemical reactors. Process systems are typically subject to constraints such as material and energy balances around units. Constrained state estimation frequently entails computationally expensive optimization routines, that are burdensome for online tracking of the system state. Professor Ungarala demonstrated that cell filter and particle filters can be significantly faster for constrained estimation as opposed to the use of online optimization.

Professor Ungarala proposed a multiscale approach to modeling and estimation by combining Bayesian statistics, Monte Carlo simulation, wavelet analysis and applied mathematics. The Bayesian approach allows for general nonlinear models (including black box models), non-Gaussian distributions and applicable constraints on state estimation. The generality of the decision-theoretic approach is attractive to solve a wide variety of problems in forecasting ranging from the weather to chemical reactions and separations. The Monte Carlo approach is a computationally feasible way to solve an otherwise intractable online estimation problem. Professor Ungarala's proposed multiscale framework resolves state space and time at multiple scales to effectively use data collected at multiple resolutions in space and time for multiscale estimation such as the state of crop grains measured with terrestrial sensors and satellite imagery.

Professor Ungarala's research is aimed at efficiencies gained in film and sheet manufacturing processes such as paper, metal foil and polymer film processing that are equipped with scanning sensor systems to measure sheet properties such as thickness, moisture and other surface qualities. The sensor traverses along the width of the sheet while the sheet is drawn from the machine in the horizontal direction. The scanning systems measure only about 2-3% of the sheet surface in zigzag patterns. Processing this data is a typical example of a multiscale problem both in state space and time. A recent report on research needs by the Technical Association of Pulp and Paper Industry placed the cross-direction scanning problem at number two in importance. The goal is to achieve 100% measured surface area by developing novel digital imaging sensors as well as

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algorithms for improved mapping of limited data to the entire sheet. Professor Ungarala's multiscale sensor fusion approach, adapted from recent advances in the fusion of satellite and terrestrial altimetry data, is well suited for this problem.

OPTIMAL CONTROL

General model predictive control (MPC) solves an open-loop optimal control problem in a finite horizon based on the prediction of future dynamics originating from the current state of the process. Only the first control action is implemented and a new control profile is obtained at the next sampling time based on updated state information. However, directly measuring the entire state vector may not be economical or even feasible. Using available measurements and dynamic models, an estimation algorithm is used to reconstruct the state vector, which is then used as feedback to the MPC regulator. Since the quality of prediction and the optimality of control profile are dependent on the initial condition fed back, both the accuracy and speed of estimation are critical for the performance of the regulator. The major challenge is the execution of nonlinear estimator-regulator solution in real-time, which can have a strong influence on the stabilizing properties of the regulator. Professor Ungarala's students have demonstrated that the cell filter, when used for feedback, significantly reduced the online computational demand on MPC algorithms as well as improved their performance. The team recently published the results for optimal control of agricultural pests using parasitic biological species as an attractive alternative to traditional chemical pesticide based programs due to their longterm effects on agricultural runoff. By minimizing the cost of the damaged crop and the cost of the parasite population introduced, a control policy was developed for managing the larvae population of the crop damaging pest insect.

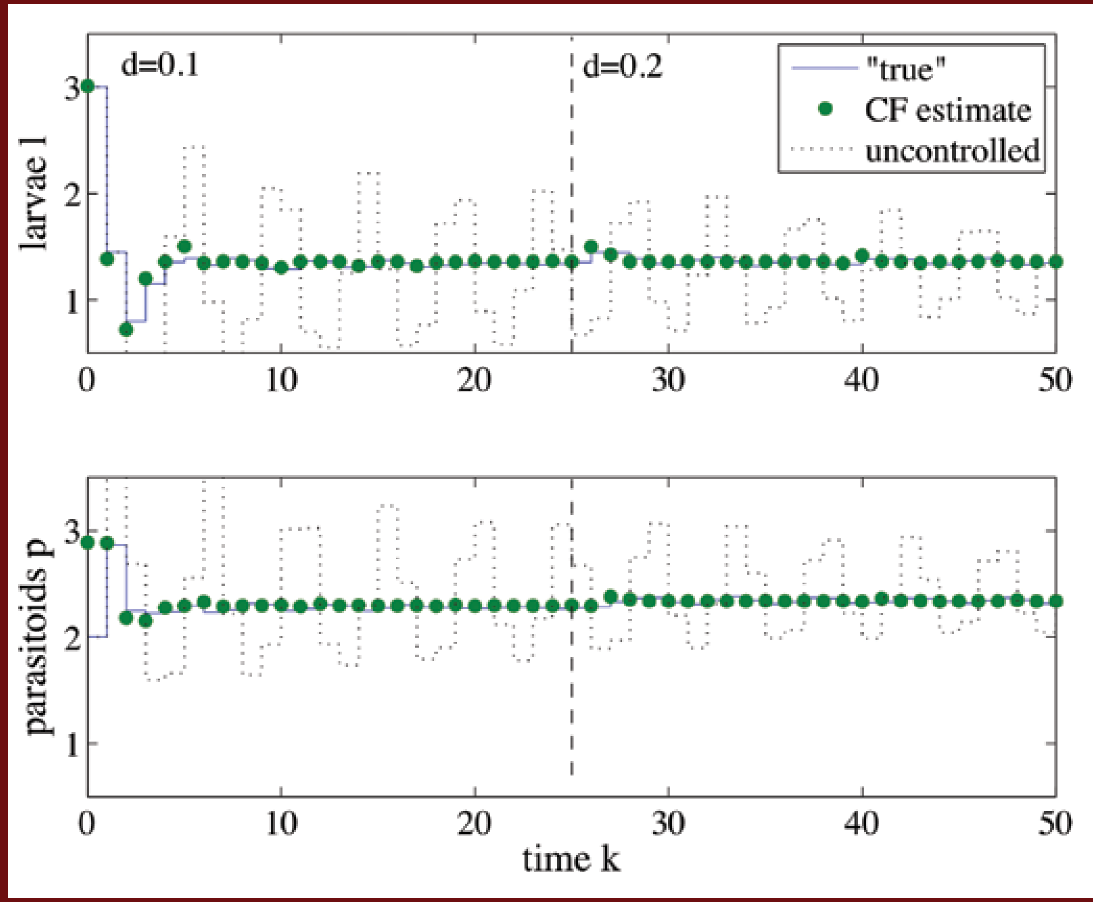

Figure 1: Populations of pest larvae of crop damaging insects and the larvae feeding parasitoids under cost

In theory, optimal control problems may be studied by analytical techniques such as calculus of variations, Pontryagin maximum principle, Bellmans principle of optimality and the Hamilton-Jacobi-Bellman equation. However, in the presence of strong nonlinearities and constraints, very few closed-form solutions are found. Alternatively, numerical techniques tend to be both cumbersome and computationally prohibitive for on-line implementations.

In an NSF funded project, Professor Ungarala investigated the application of dynamic programming in discrete time and space to solve time optimal control problems using nonlinear programming. The backward search algorithm coupled with iterative search provides a computationally feasible way to first find the coarse resolution optimal control policy, which is subsequently fine tuned online. In the operation of continuous stirred tank reactors (CSTR), it is desired to bring the reactor conditions to their steady state targets as soon as possible from the startup conditions. The solution is a switching curve that determines the optimal control policy to minimize the time, which is typically not available in analytical form. Professor Ungarala's team devised numerical algorithms to effectively compute switching curves for any given startup condition for the CSTR. Professor Ungarala's research in estimation and control of dynamic systems is also applicable for problems in managing traffic in various networks and controlled drug delivery in biomedical engineering.

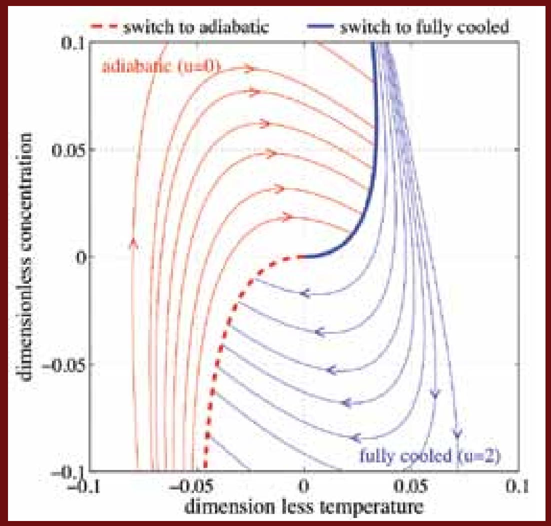

Figure 2: Switching curve for time optimal control of a CSTR

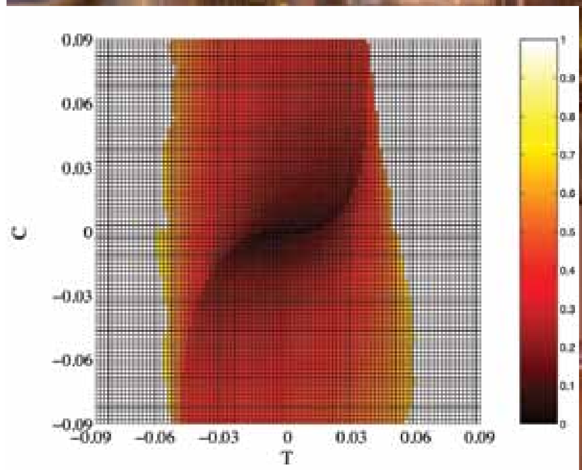

Figure 3: Switching curve for time optimal control of a CSTR revealed by coarse cell dynamics and nonlinear programming

Mobile Computing and Networks

Professor Yu's research interests include wireless networks, sensors networks, mobile computing and parallel and distributed systems. He leads the Mobile Computing Research Laboratory (MCRL) at Cleveland State University. His work focuses on designing autonomous mobile networks, where sensory and adaptation capabilities work in harmony to realize agile behaviors.

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Innovations and improvements have long been made in personal communications to essentially increase the communication bandwidth truly observing the Moore's Law-like advances for more than two decades (1200bps V.22 Hayes modem in 1983 and 600Mbps 802.11n wireless modem in 2009). Owing to its unprecedented growth, wireless networking is creating new horizons for communication beyond the Internet.

Extrapolating from the phenomenal success of social network services such as Facebook and Twitter, it is not unrealistic to anticipate that mobile social networks (MSNs) would play an important role in the near future. A spontaneous communication network is formed at a marketplace, a sports event, or a conference to chat and exchange comments among the participants. Vehicular ad hoc networks (VANETs) will become an important part of future ubiquitous communication infrastructure as they support the last-mile solution for drivers on the wheel. As ground transportation is considered one technological area in which change is long overdue, a break-through can be achieved through a well-designed VANET infrastructure. For example, a VANET can allow a vehicle to deliver an urgent message to the next bumper(s) so that they can avoid involving in an accident.

A common and unique characteristic of the above-mentioned emerging wireless networks is multi-hop communication. A user data travels through a number of intermediate laptops/smart phones before reaching a destination. There has been a tremendous amount of work on multi-hop networks during the last decade due to their clear advantages such as energy efficiency and better channel utilization. On the other hand, they exhibit characteristics that deviate significantly from the traditional multi-hop wireless networks in terms of scale, traffic intensity, node density, and/or speed. For example, MSN scenarios typically envisaged around crowd spots, where the number of laptops/smart phones within range could be hundreds or thousands.

A similar high density scenario has been already observed in Wi-Fi-based hot spots in US cities such that the number of other access points (APs) within interference range of an AP is as many as 85. Warning message applications in a VANET make sense when vehicles are dangerously close, e.g., within 1.0 seconds or 100 feet.

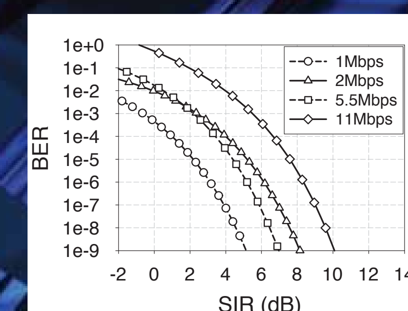
The Mobile Computing Research Laboratory (MCRL) at CSU, led by Professor Chansu Yu, has been developing algorithms and protocols for multi-hop wireless networks for a decade in the following four concentration areas.

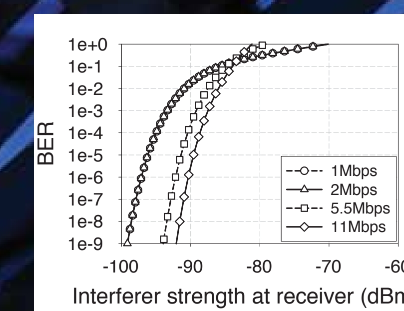
PERFORMANCE, SCALABILITY AND SPECTRAL EFFICIENCY OF A WIRELESS NETWORK

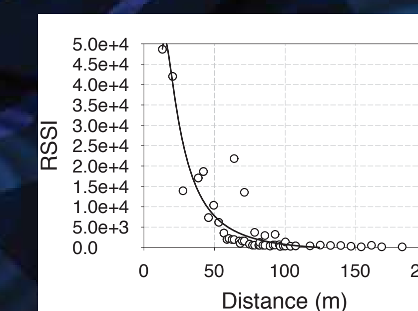
Multi-hop wireless network is a temporary network that can be established on demand and disappears when there is no need. Although some basic concepts have been identified and elaborated during the last decade, it is still in its early stage of research and development. Multi-hop communication with dynamic topology caused by mobility poses interesting but unique challenges ranging from the network-layer connectivity problem to the link-layer capacity issue. And, it should not be considered as a natural extension of infrastructure-based networks, such as cellular networks and Wi-Fi hot spots. Professor Yu's goal of this research is to investigate the performance of multi-hop wireless networks in highly stressed environment and to seek novel methods to survive the stress and achieve a reasonable performance. Research in this area resulted in a number of journal and conference papers. Two book/journal editorials are mostly based on this research subjects. Investigation of the work becomes one of three research projects that are being supported by the Major Research Instrumentation (MRI) program of National Science Foundation (NSF).

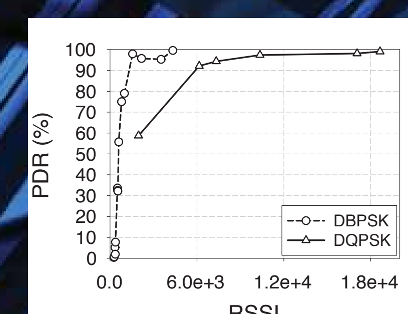
COOPERATIVE COMMUNICATION IN WIRELESS NETWORKS

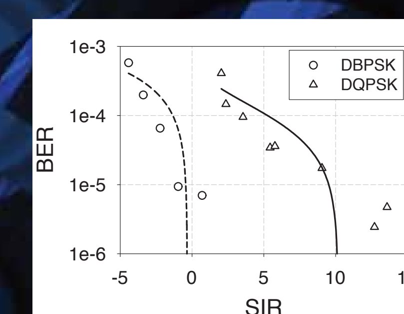
The broadcast nature of wireless communication limits the effective use of channel bandwidth because of mutual interference. However, it also allows an opportunity for multiple terminals in the proximity to cooperate so as to enhance the communication reliability or to increase the collective throughput. This is particularly true in multi-hop wireless networks where a faster communication can be traded in favor of smaller number of hops to the destination. Professor Yu's research work published in ACM MobiHoc Conference and IEEE Transactions on Mobile Computing has been used as a key reference paper in courses from other universities including University of South Carolina and University of Illinois, Urbana-Champaign.

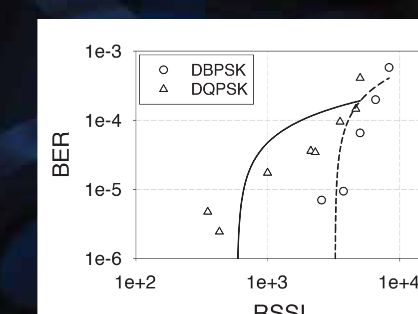


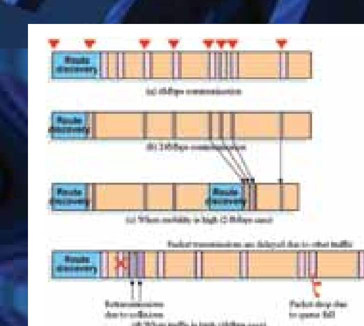


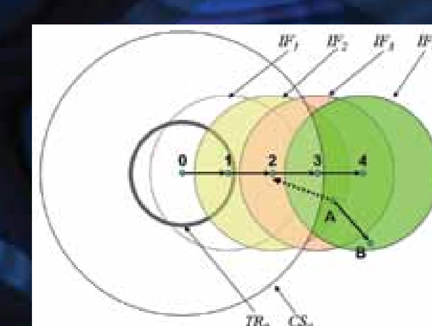


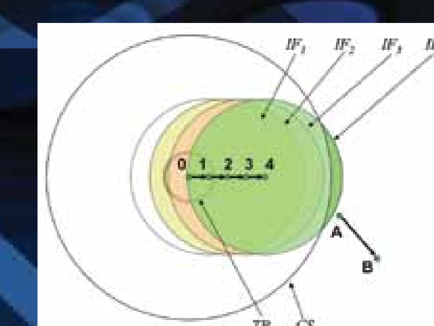


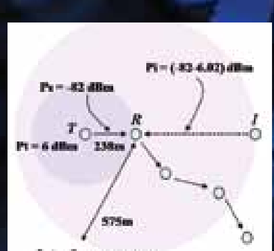


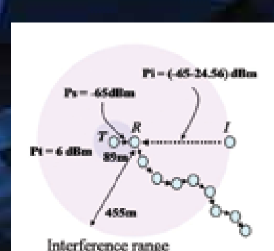


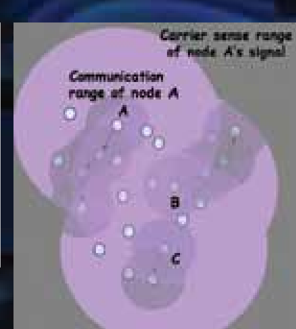


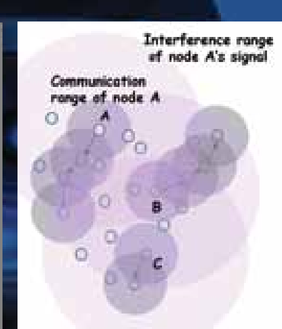


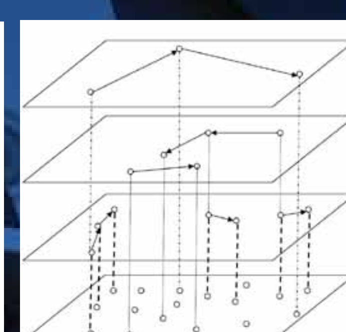












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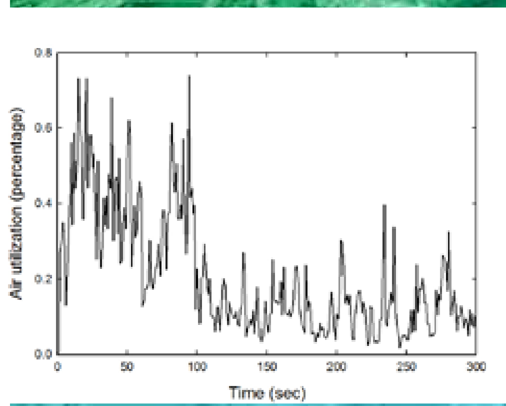
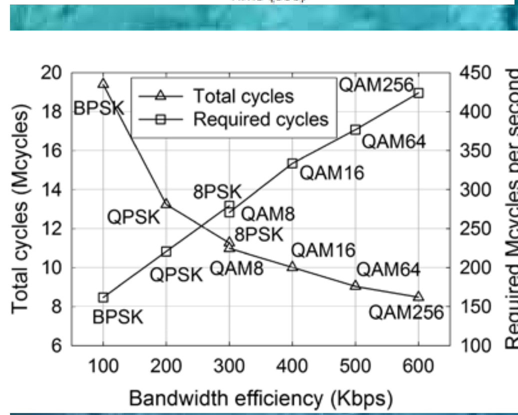
INNOVATIVE COMMUNICATION METHODS BASED ON SOFTWARE DEFINED RADIO

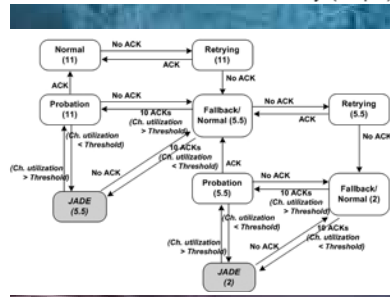
Radio communication is inherently vulnerable to attacks such as eavesdropping, message synthesis and jamming attack. Spread spectrum technology has originally been developed for anti-jam communication by spreading a narrow-band into a wide-band signal. The signal spreading is an effective anti-jam measure because a jammer signal is not able to jam the wide-band signal unless it knows the spread sequence or the key and algorithm for generating the spread sequence. A longer spread sequence must be employed in order to enhance the jam resistance. However, it reduces the communication efficiency accordingly because a wider bandwidth is utilized to deliver the same amount of data bits. Professor Yu's group researches physical layer-based security and authentication mechanisms using software defined radio (SDR). SDR is a new radio communication system which implements most of wireless communication functions in software so that it can tune to any frequency band and receive any modulation across a large frequency spectrum by just clicking different software. Professor Yu recently received a research grant from ETRI based on the research results in this area. This work is in line with Mobile Computing course, where SDR platforms are intensively used for educating numerous cross-cutting subjects.

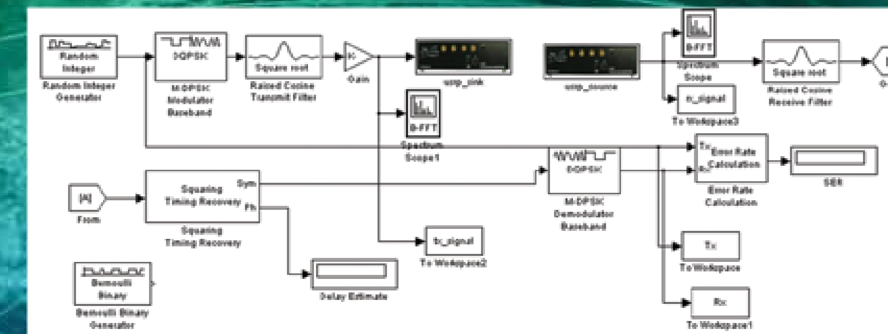
IMPACT OF MOBILITY IN WIRELESS NETWORKS

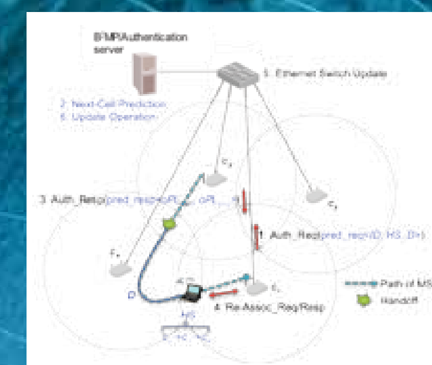
Mobility is a major challenge in mobile, wireless networks. However, most of previous works on mobility models do not consider any explicit rationale behind the mobility behavior. However, in reality, a node does not make a move without referring to a certain demand for the move. Professor Yu has studied the mobility rationale that nodes tend to move towards a certain waypoint where more nodes are already present. The resulting network can be summarized as scale-free network, which is becoming a very popular and important subject in solving complex network systems such as terrorist networks, power grid networks, etc. Another important extension of this work is vehicular networks, where mobility is a bigger challenge due to vehicles' high speed. Professor Yu was recently awarded a research grant from NSF through the NeTS program (Networking Technology and Systems). The project title is "Exploring Data Access in Internet-based Wireless Mobile Networks."

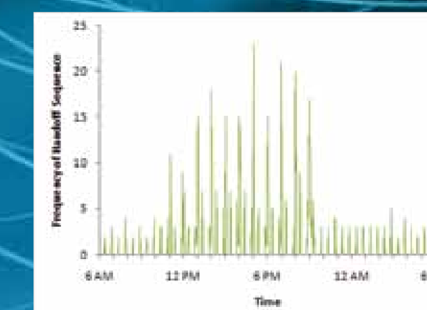


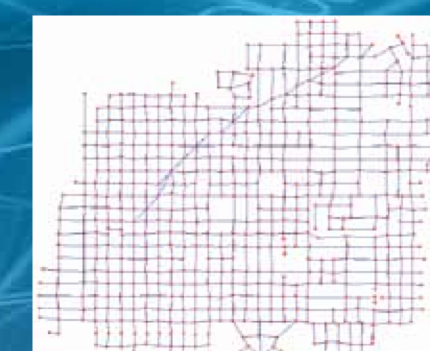


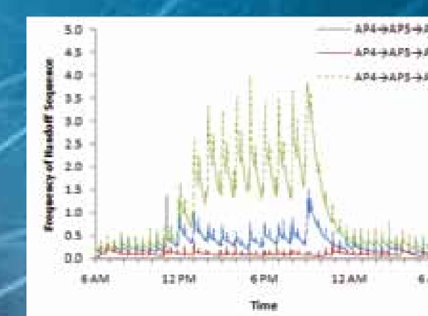


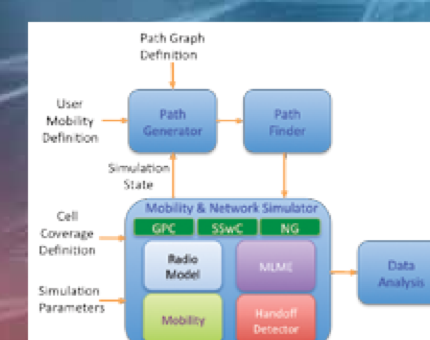












Building Secure and Dependable Distributed Systems

Professor Zhao's research goal is to investigate ways of building highly dependable and secure distributed systems. Over the past several years, his focus has evolved from building fault tolerance systems using reliable group communication toolkits to the integration of replication and transaction processing, to state machine replication based on the Paxos algorithm and to Byzantine fault tolerance.

WENBING ZHAO
Ph.D., UNIVERSITY OF CALIFORNIA, SANTA BARBARA
ASSOCIATE PROFESSOR, DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

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Distributed computing systems are playing an increasingly important role in our society and our lives. Such systems are behind many services on which we depend, such as financial (e.g., online banking and stock trading), e-commerce (e.g., online shopping), civil infrastructure (e.g., electric power grid and traffic control), and entertainment (e.g., online gaming and multimedia streaming). Quite naturally, the dependability expectations for these systems are becoming higher and higher. Such services pose a great challenge to systems builders: how do we design and implement distributed systems that are highly dependable, without sacrificing significant runtime performance and without imposing unrealistic restrictions on the applications?

Over the past several years, thanks for the funding from the National Science Foundation (CNS-0821319), Professor Zhao and his students have investigated several fundamental issues in Byzantine fault tolerance computing, and its application to various distributed systems, mostly notably in the Web services paradigm. Byzantine fault tolerance (BFT) is a technique that relies on sufficient redundancy (each copy is referred to as a replica) and sophisticated coordination algorithms to ensure that a system can continue providing correct services to its users even when various hardware and software failures occur, and when the system is under intrusion attacks.

RECONCILIATION OF STRONG REPLICA CONSISTENCY AND REPLICA RANDOMNESS

Practical applications often exhibit various non-deterministic behaviors. If not controlled, the non-determinism might render the state of different replicas divergent. A particularly challenging issue is on how to achieve integrity-preserving strong replica consistency. There has been a large body of work on how to render replicas deterministic in the presence of replica non-determinism under benign fault models. However, when the replicas can be subject to Byzantine faults (which is the case for many Internet-based systems), most of the previous work is no longer effective. Furthermore, the determinism (or rendered-determinism) of the replicas is often considered harmful from the security perspective and, for many applications, their integrity is strongly dependent on the randomness of some of their internal operations (e.g., random numbers are used for unique identifier generation in transactional systems and for card-shuffling in online poker games). If the randomness is taken away by a deterministic algorithm to ensure replica consistency, the identifiers or the hands of cards can be made predictable, which can easily lead to exploits. This calls for new approaches towards achieving strong replica consistency while preserving the randomness of each replica's operations. In this project, Professor Zhao explored two alternative approaches towards the goal. The first one is based on Byzantine agreement (BA-algorithm, for short) and the other on a threshold coin-tossing scheme (CT-algorithm). Both approaches rely on collective determination for decisions involving randomness, and the determination is based on the contributions made by a quorum of replicas, to avoid the problems mentioned above. They differ mainly in how the collective determination is carried out. In the BA-algorithm, the replicas first reach Byzantine agreement on the set of contributions from replicas, and then apply a deterministic algorithm to compute the final random value. The CT-algorithm uses the threshold coin-tossing scheme introduced in to derive the final random value, without the need of a Byzantine agreement step.

PROACTIVE RECOVERY USING SERVICE MIGRATION

BFT algorithms assume that only a small subset of the replicas can be faulty. When the number of faulty replicas exceeds a threshold, they may fail. Castro and Liskov proposed a proactive recovery scheme that periodically reboots replicas and refreshes their state, even before it is known that they have failed. As long as the number of compromised replicas does not exceed the threshold within a time window (referred to as window of vulnerability), all replicas can be proactively recovered, the integrity of the BFT algorithm holds and the services being protected remain highly reliable over the long term. However, the reboot-based proactive recovery scheme has a number of issues. First, it assumes that a simple reboot (i.e., power-cycle the computing node) can successfully repair a compromised node, which might not be the case. Second, even if a compromised node can be repaired by a reboot, it is often a prolonged process (typically over 30s for modern operating systems). During the rebooting step, the services might not be available to its clients (e.g., if the rebooting node happens to be a non-faulty replica needed for the replicas to reach a Byzantine agreement). Third, there is a lack in coordination among replicas to ensure that no more than a small portion of the replicas are undergoing proactive recovery at any given time, otherwise, the services may be unavailable for extended periods of time. The static watchdog timeout also contributes to the problem because it cannot automatically adapt to various system loads. The staggered proactive recovery scheme is not sufficient to prevent this problem from happening. In this research, Professor Zhao's group explored an alternative proactive recovery scheme that avoids the above problems. The scheme requires the availability of a pool of standby computing nodes in addition to the active nodes where the replicas are deployed. Periodically, the replicas initiate a proactive recovery by selecting a set of active replicas, and a set of target standby nodes for service migration. At the end of the service migration, the active nodes to be swapped out will be put under a series of preventive sanitizing and repair steps (such as rebooting and swapping in a clean hard drive with the original system binaries) before they are assigned to the pool of standby nodes, and the target nodes are promoted to the group of active nodes. The unique feature of this design is that the sanitizing and repair step is carried out off the critical path of proactive recovery, and consequently, has minimum negative impact on the availability of the services being protected.

INCREASING THE CONCURRENCY LEVEL OF REPLICATED SYSTEMS

Software Transaction Memory (STM) is a concurrency control mechanism, and has recently been considered as a powerful alternative to lock-based synchronization to develop concurrent applications for multi-core architectures. This mechanism not only simplifies the concurrency control interfaces that a software developer has to deal with, it opens the door for much better concurrency obtainable when strong replica consistency is required. In particular, the replication and scheduling mechanisms can be incorporated seamlessly into the middleware/library layer designed for STM. To increase the concurrency level of replication systems, Professor Zhao's group is investigating the possibility of incorporating the commit barrier scheduling method and the operational transformation method. The former method can possibly increase the concurrency level by enabling the replicas to process more requests concurrently, while the latter may significantly reduce the abort-rate by transforming the transactions that would otherwise be aborted. There is also plan to explore the application of different isolation schemes in building highly efficient STM-based BFT systems.

TRUSTWORTHY COORDINATION FOR WEB SERVICES ATOMIC TRANSACTIONS (WS-AT)

Transaction processing is the basis of many business applications, which increasingly are being provided over the distributed environment of the Internet, using service oriented computing technology, such as Web Services. In this project, Professor Zhao's group is designing and implementing a Byzantine fault tolerance (BFT) system that comprises a suite of protocols and mechanisms that protect the services and infrastructure of typical Transaction Processing (TP) monitors against Byzantine faults. The key innovation in this research is the introduction of a decision certificate. A decision certificate, which includes a set of registration records and a set of voting records from participants, is used to facilitate the coordinator replicas to reach a Byzantine agreement on the

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outcome of each transaction. The certificate also limits the ways a faulty replica can use towards non-atomic termination of transactions, or semantically incorrect transaction outcomes. The Byzantine fault tolerant WS-AT framework developed in this research will be useful for business applications that are based on transactional Web Services and that require a high degree of dependability, security and trust.

TRUSTWORTHY COORDINATION FOR WEB SERVICES BUSINESS ACTIVITIES (WS-BA)

The Web Services Business Activities (WS-BA) specification and the Web Services-Business Activity-Initiator (WS-BA-I) extension protocol make it possible for a third party to offer Coordination services to enterprises that wish to conduct Web Services Business Activities. However, for such Coordination services to be widely adopted, they must be trustworthy, i.e., provide a high degree of dependability, security and reliability for their users. In this research, Professor Zhao's group conducted a comprehensive study of the threats to the WS-BA Coordination Service and explored solutions to mitigate such threats. A careful analysis of the state model of WS-BA reveals that, to provide trustworthy coordination of Web Services Business Activities, it suffices to use a lightweight BFT algorithm that avoids the expense of delivering request messages in total order and delivers them, instead, in source order, i.e., the order in which the sender sent them. Professor Zhao's group have developed a lightweight BFT algorithm for the WS-BA Coordination Service, and have incorporated the algorithm and associated mechanisms into an open-source framework that implements the WS-BA specification and the WS-BA-I extension protocol.

NEW RESEARCH DIRECTIONS

Byzantine fault tolerance computing, despite its huge popularity in the research community, has yet to be widely adopted in practical systems. Aside from the relatively high runtime overhead incurred by BFT algorithms, the main roadblock is that the replicas are assumed to fail independently under intrusion attacks. The main goal of this research is to investigate novel, effective methods to build practical highly dependable distributed systems. In this research, Professor Zhao chose to follow a strategy that is radically different from the state-machine BFT approach. The basis for this strategy is the separation of application logic execution from state management. As shown in Figure 1, the research employs the following core mechanisms for high dependability.

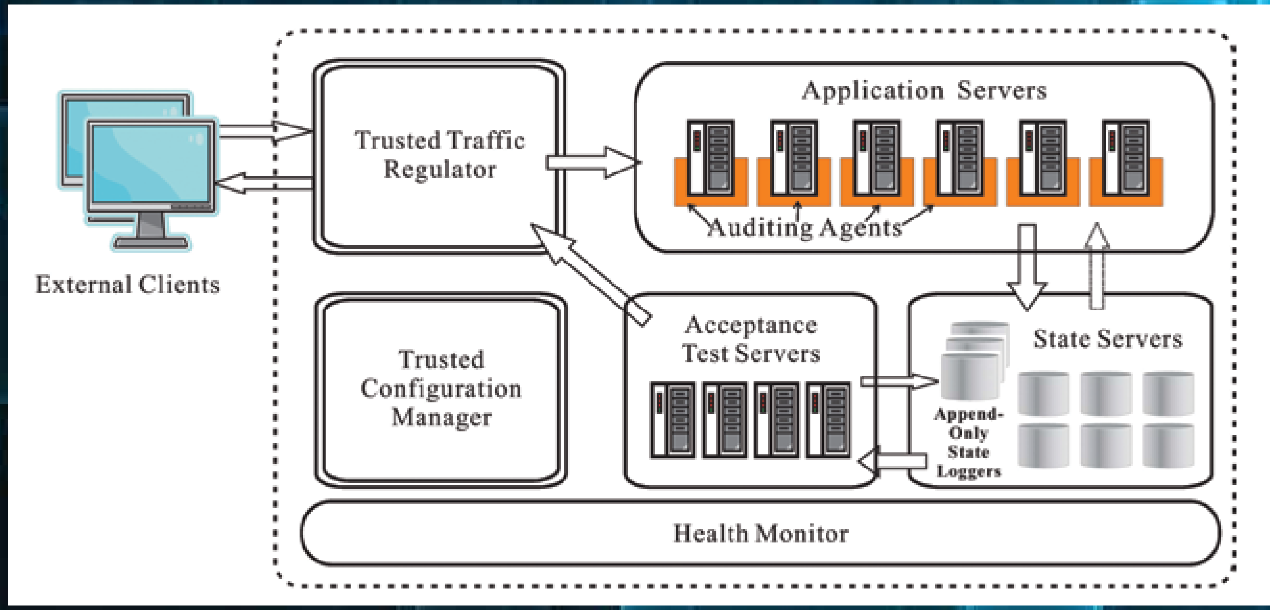


Figure 1. Component diagram of the proposed high dependability framework.

SINGLE APPLICATION SERVER WITH HIGHLY DEPENDABLE STATE REPLICATION

One should refrain from actively replicating the execution of application logic, i.e., an application request is processed by only a single application server because replicating request processing does not seem to increase intrusion resilience under the presence of correlated faults. This approach has many benefits: greater runtime performance and scalability, fewer restrictions on the type of applications that can be protected (e.g., multithreaded applications can run at their designed concurrency level without the burden of inter-replica coordination), and simpler fault-tolerance mechanisms. For increased intrusion resilience, an append-only state logging mechanism is to be employed. Once a state update is received, it is appended to the state log and the previously logged state is not overwritten. In effect, once a state is entered into the state log, it becomes read-only. This design prevents a compromised application server from corrupting or deleting the system state. When a fault is detected, the system always has a valid state to which to revert.

ACCEPTANCE TESTING TO ENSURE THE INTEGRITY OF EXECUTION

BFT replication cannot offer a correctness guarantee to the client in the presence of correlated faults, because the way to decide on which response to deliver to the client is simply to count the number of consistent responses sent by different server replicas. Therefore, it is essential to validate the request processing. Acceptance testing will be used to complement other application-level intrusion detection mechanisms to ensure the integrity of application executions.

FAST AND AUTOMATED FAULT RECOVERY

Once a compromised application server has been detected, the system must take appropriate recovery actions. Such recovery actions will involve the following steps: (1) identifying other affected application servers that have dependencies on the compromised server, and all affected data items; (2) constructing compensating operations transparently to the applications (facilitated by append-only state logging), and applying them to restore the application to a correct state; (3) retrying all affected "innocent" requests due to the intrusion attack, and blocking the sender of the malformed request.

Undergraduate Student Research in the Fenn College of Engineering

Fenn College's rich research activities are reflected by the large number and high quality of our undergraduate research projects. These projects were funded by Cleveland State University and external funding sources. Below is a sample of such projects.

OPTIMIZATION OF DIGESTATE MEDIA COMPOSITION FOR MAXIMAL LIPID RECOVERY

Undergraduate Student Involved: Brittany Studmire
Faculty Supervisor: Dr. Joanne Belovich, Chemical and Biomedical Engineering

The need for a sustainable fuel has become more apparent over the years as concerns about the limited amounts of crude oil continue to increase. One such source of a sustainable alternative fuel is microalgae. The standard 3N-BBM media in which algae is grown is not feasible on a large industrial scale due to high chemical costs. Thus, a more cost effective media is needed. The use of digestate, which is the byproduct from methane production from dairy farm waste, as a possible source of nutrients for algal growth, was proposed. Experiments were done to determine the minimum concentration of digestate in water that would help maximize biomass recovery and lipid content. Results showed that a value of about 1.25% digestate (v/v) in water was the lowest concentration possible that helped maximize biomass recovery and lipid content. Future testing can be done to further fine tune this number, which will help cut costs and increase productivity.

BIODIESEL FROM MICROALGAE

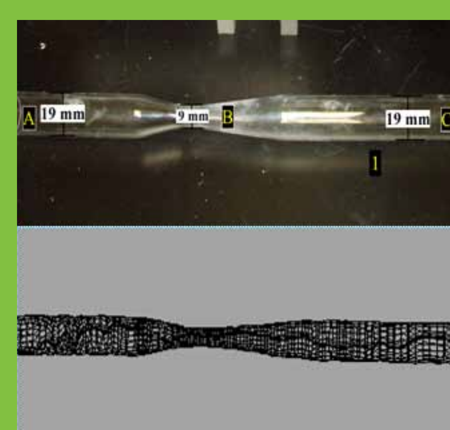
Undergraduate Student Involved: Colin Welter
Faculty Supervisor: Dr. Joanne Belovich, Chemical and Biomedical Engineering

With the projected "peak oil" of fossil fuel becoming visible, there has been an increasing trend towards deriving these oil feedstocks from renewable bio-sources. While common food crops such as soybean, sunflower, and canola have an extensive history of cultivation, several other alternatives have been receiving renewed interest, most notably microalgae. Scenedesmus dimorphus, an oliagenous microalgae, was grown autotrophically in the lab under controlled conditions to establish baseline characteristics of cell growth and maintenance. S. dimorphus showed good overall growth characteristics under varying protocols. Ultimate cell density in two media (modified Basal-Bold and enriched) did not exceed $5x10^7$ cells/mL. In eight trials in 1.5 L volumes, under identical conditions, the growth rate of the cells in the modified Basal-Bold media exceeded the growth rate in enriched media. Further studies will further optimize the media and growth parameters to achieve higher cell densities. S. dimorphus shows good early promise as a microalgae candidate for biodiesel production due to its growth rate in basic media and high sedimentation velocity.

IMAGE-BASED CONSTRUCTION OF COMPUTATIONAL MODELS OF CARDIOVASCULAR DISEASE

Undergraduate Student Involved: Cathleen O'Grady
Faculty Supervisor: Dr. George Chatzimavroudis, Chemical and Biomedical Engineering (co-supervisor: Dr. Randolph Setser, Imaging Institute, Cleveland Clinic)

The future of health care is in personalized medicine. One of the most appealing fields of cardiovascular research has lately been to develop patient-specific computer models of the cardiovascular system, which would help the clinician design a successful treatment strategy, specific for each patient. To determine the potential of image-based model construction, experimental models of a stenosed artery and of the left ventricle of the heart, which were developed at Cleveland State University, were scanned in an MRI scanner at the Cleveland Clinic. The models were mounted on a flow loop to simulate the physiologic blood flow environment. A set of sequential images were acquired to provide information about the anatomy of the models. The images were transferred to Cleveland State University for processing with specialized software packages. The real wall of the models was first identified in the images and its spatial coordinates per imaging slice were determined. Processing this information for all images collectively resulted in the complete computational reconstruction of the real experimental models. Comparison between the experimental and the computational models showed agreement, suggesting that image-based CFD has great clinical potential.



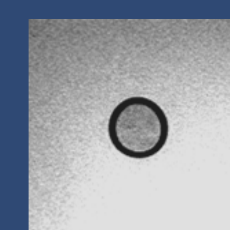
EXPERIMENTAL GLASS MODEL (TOP) AND CORRESPONDING RECONSTRUCTED COMPUTATIONAL MODEL (BOTTOM)

Graduate students Navneeth Lakkadi and Sahitya Pidaparthi also participated

THE EFFECT OF SPATIAL RESOLUTION ON MEASUREMENTS OF AORTIC COMPLIANCE USING MAGNETIC RESONANCE IMAGING

Undergraduate Student Involved: Cathleen O'Grady
Faculty Supervisor: Dr. George Chatzimavroudis, Chemical and Biomedical Engineering (co-supervisor: Dr. Randolph Setser, Imaging Institute, Cleveland Clinic)

A reduction in arterial compliance is an indicator of arterial disease. Being able to accurately measure changes in arterial compliance may help to identify individuals who are at risk. The purpose of this study was to examine the effect of spatial resolution on the ability to accurately measure compliance with MRI using an in vitro model of a compliant blood vessel. A compliant flow phantom was constructed and incorporated in a pulsatile flow loop at Cleveland State University. Cross-sectional magnetic resonance images of the elastic tubing of the phantom were obtained for five, typical clinically-used spatial resolutions (0.7x0.7 - 2.0x2.0 mm^2) under two pulsatile flow conditions (mean flow: 2.0 and 3.5 L/min) at the Cleveland Clinic. No appreciable difference was observed in the cross-sectional area measurements over the range of spatial resolutions used in this study. The change in distension was consistent across all spatial resolutions for both flow rates, indicating that MRI can determine aortic distension with equal accuracy for the range of spatial resolutions used in this study.



CROSS-SECTIONAL MAGNETIC RESONANCE IMAGE OF THE COMPLIANT ELASTIC TUBE FOR A SPATIAL RESOLUTION OF 0.7 X 0.7 mm^2

Graduate students Navneeth Lakkadi and Sushma Srinivas also participated

FIELD IMPLEMENTATION OF PERVIOUS CONCRETE PAVEMENT TECHNOLOGY

Undergraduate Students Involved: Tom Hyatt and Dan Fabriziana
Faculty Supervisor: Dr. Norbert Delatte, Civil and Environmental Engineering

Pervious concrete pavement technology has important potential green building, sustainable development, and storm water mitigation benefits. It allows water to flow directly through the pavement into soil or a holding system, rather than running off across the surface. Portland Cement Pervious Concrete (PCPC) has an excellent performance history in the Southeastern U.S., but until recently has seen little use in environments with significant freeze thaw cycles. Therefore, assessment of actual field performance is important. Previous CSU research documented field observations and nondestructive testing results of PCPC sites located in the states of Ohio, Kentucky, Indiana, Colorado, and Pennsylvania. PCPC is most often used as a pavement for parking lots. CSU installed two pervious concrete pavement demonstration sites on campus, Parking Lot D in summer 2005 and Administration Building in summer 2007. Field performance depends on the quality of the mixture as well as proper control of construction and curing. In addition to field observations and nondestructive testing, laboratory testing may be performed on cores removed from test sites. Cores were extracted from four different test sites in Northeast Ohio and tested extensively in the laboratory. Drainage of the two existing CSU sites was also tested.

USE OF STEEL SLAG AS AN AGGREGATE IN CONCRETE PAVEMENT

Undergraduate Students Involved: Anne Clark and Sarah Zander
Faculty Supervisors: Dr. Norbert Delatte and Dr. Paul Bosela, Civil and Environmental Engineering

Ohio is the 2nd largest producer of steel in the United States, and steel slag is a recycled material produced in Ohio as a byproduct of the steel industry. The use of steel slag as a replacement for natural aggregate in Portland cement concrete pavements would save the use of natural aggregate, a limited natural resource most of which is currently imported from out of state, and improve the competitiveness of our steel industry by increasing the value of a major byproduct of that industry. There is a general perception, based upon earlier use, that steel slag aggregate concrete exhibits unacceptable durability problems, due to the expansive characteristics of some of its constituents. Steel slag today is now aged to alleviate its expansive characteristics, and proper mix proportions may alleviate some of the perceived problems.

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LEARNING FROM FAILURES

Undergraduate Student Involved: Jeff Bazzo
Faculty Supervisor: Dr. Norbert Delatte, Civil and Environmental Engineering

Lessons learned from case studies have substantially affected the practice of civil engineering and other engineering disciplines. The development of practice is largely dependent upon studying past failures, both imminent and actual, and of the changes to designs, standards and procedures made as the result of timely interventions or forensic analyses. In addition to technical issues, concepts such as professional and ethical responsibility are highlighted by the cases. For undergraduate students, researching case studies provides a unique opportunity to apply critical engineering thought in order to discriminate between possible failure modes and their causes. New case studies have been developed on the Minneapolis I-35W Bridge collapse of August 1, 2007, and the St. Francis Dam failure of March 12, 1928. These, and other case studies, can be incorporated into undergraduate engineering curricula as a means of stimulating student interest and awareness. Several of these case studies have been presented at CSU and other universities as classroom lectures, followed by a survey of the participating students. The survey results are compiled and used to gauge the effectiveness of the case studies on students' interest and understanding of the material.

SUSTAINABLE CONSTRUCTION PROCESSES

Undergraduate Student Involved: Mike Ritossa
Faculty Supervisors: Dr. Norbert Delatte and Dr. Paul Bosela, Civil and Environmental Engineering

Sustainable development has certainly captured the imagination and focus of the U.S. development industry. The US Green Building Council initiated the Leadership in Energy and Environmental Design (LEED) certification program for new construction in 2001. By 2004, 257 buildings had been certified. At the conclusion of 2007, over 16,000 buildings have been registered or certified, and LEED has been expanded to include a total of 9 categories of facilities. Major professional and trade organizations (PTOs) in the construction industry including such prestigious and large organizations as the American Concrete Institute (ACI), Portland Cement Association (PCA), American Institute of Steel Construction (AISC) and numerous others have announced full support of major efforts to promote sustainable development within the industry segments they represent. A significant portion of the criteria used to determine how well a project rates on the environmental scale is comprised of how much of and what type of energy is used, and the negative effects such as pollutants that result from using it. Resource consumption is especially crucial in the concrete aspect of any construction project due to the immense amount of energy and raw materials used in the production and transportation of the product worldwide. Therefore in order to be sustainable in the construction industry, sustainable developments must be made in the concrete industry.

REVOLUTION COMPOSITE DRUM: This innovative concrete mixing drum gives ready mix producers the competitive advantage by being able to carry more concrete per load. It is also two thousand pounds lighter and has twice the durability of similar steel drums. The end result being that fuel is conserved and jobs are getting done faster.

FEASIBILITY OF EXPANDING USE OF STEEL SLAG AS A CONCRETE PAVEMENT AGGREGATE

Undergraduate Student Involved: Brad Fronik
Faculty Supervisor: Dr. Norbert Delatte, Civil and Environmental Engineering

Meeting the ever increasing global demand for concrete in the future is becoming more challenging with each passing year. Since more than three quarters of the volume of concrete is commonly composed of aggregates and the realization that the Earth's resources are finite, finding suitable alternatives to natural aggregates has become increasingly important. Steel slag has the potential to alleviate that demand, if barriers to its use can be overcome. In 2006 the United States saw the production of 21.5 million tons of iron and steel slag of which 40% would be classified as steel slag. Although steel slag is currently used as an aggregate in Hot Mix Asphalt surface applications, there is a need for additional work to determining the feasibility of utilizing this industrial by-product more widely as a replacement for both fine and coarse aggregate in conventional concrete mixtures. Prior research at Cleveland State University examined the effects on the fresh and hardened properties of concrete caused by replacing a percentage of the volume of both fine and coarse aggregate with steel slag available in the Northeastern Ohio area. The basis for comparison was the Ohio Department of Transportation Class C option 1 concrete paving mixture. Three types of aged and conditioned steel slag were utilized. Fresh concrete properties of workability, air content and unit weight, and hardened properties of compressive, splitting tensile, and bending strength, freeze-thaw durability, and expansion were examined per standard ASTM guidelines. This preliminary investigation demonstrates that the specifications called for by the Ohio Department of Transportation can be met. Further study is necessary to assure that the performance of the finished pavement is not degraded.

SYNTHESIS OF METABOLIC PATHWAYS USING THERMODYNAMIC CONSTRAINTS

Undergraduate Student Involved: Frank Marealle
Faculty Supervisor: Dr. Jorge Gatica, Chemical and Biomedical Engineering

In order to understand quantitatively how metabolic processes work, a mechanistic model is often formulated through biochemical mass balances and reaction kinetics. The resulting dynamic model is a highly nonlinear distributed parameter system with model equations that combine several chemical species, reactions and biochemical fluxes. Due to the difficulty in physically obtaining reaction rate constants for individual biochemical reactions, flux balances are often employed to reduce the number of unknown parameters. Although flux balances can be valuable predictive tools, their use with the inclusion of proper thermodynamic constraints in pathway analysis can be used to more reliably estimate biochemical reaction rate parameters, and yield a robust dynamic model. The integration of these principles within a parameter estimation methodology was demonstrated in this work. The modeling of a recognized, although not fully characterized yet, metabolic pathway was selected as an illustrative case study for this project: the astrocyte-neuron lactate shuttle in mammalian brain metabolism. Extension to other biomedical and biotechnology applications was also discussed.

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CHARACTERIZATION OF THIN FILMS DEPOSITION PROCESSES BY CALORIMETRIC AND SPECTROSCOPIC METHODS

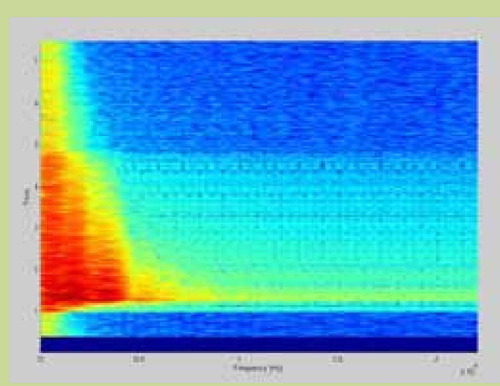
Undergraduate Students Involved: Charles Tillie and Andrew Snell
Faculty Supervisor: Dr. Jorge Gatica, Chemical and Biomedical Engineering

Corrosion resistance and energy efficiency have long been driving forces to substitute low-carbon steels by advanced materials in the manufacture of car body parts. As a result, attention has been directed towards aluminum alloys as one of the prime candidates for this replacement. The use of materials in the automobile industry and other applications, frequently involve painting for corrosion protection or decorative purposes. Most materials, however, will exhibit poor paint adhesion properties without proper surface modification. For many years, chromate-based coating processes have been used by industry to generate protective coatings on metallic surfaces to ensure the success of subsequent applications. These processes possess a threat for significant environmental impact and have, therefore, been subject to strict regulations under the Clean Water Act and other environmental initiatives. This project focused on formulating a new coating technology, which could provide alternative practical options to meet EPA mandates. The activities planned under this REU complemented a long-term research project aiming at elucidating the effect of transition metals on reaction mechanisms leading to protective coatings. In this phase, an experimental protocol for the preparation of precursor solutions was developed, and characterization of the coating process by differential calorimetry was formulated. The use of surface spectroscopy as a complementary tool to characterize the chemical interaction of precursors with different transition metals was also demonstrated. Proof-of-concept deposition experiments were also major components in promoting engaged student learning through Research and Creative Activities. The principal phases are: deposition experiments complemented by spectroscopic and calorimetric characterization of the precursor, coatings, and mathematical modeling.

THE COLOR OF SOUND, ANALOG AND DIGITAL PROCESSING

Undergraduate Student Involved: Timothy Wilmot
Faculty Supervisor: Dr. Murad Hizlan, Electrical and Computer Engineering

The purpose of this project was to analyze the analog and digital processing of audio in the music industry. The processing of musical audio is very much an art as well as a science. What makes a sound pleasurable to listen to over another sound is a difficult science to fully describe and it varies from person to person. In order to look at this problem from an engineer's perspective, it is important to investigate how the two processes work and how they affect the audio signal. In this project, several samples of recorded audio were processed with several stages of an analog equipment. The same initial audio samples were then processed with the digital version of the analog equipment and the results were compared on a spectrograph to study the differences in frequency content. Although the analog and digital devices were designed to perform the same task on the incoming audio, in reality, analog and digital processing performs the same task in different ways and the results are not the same. The different results obtained constitute the reason why some people prefer one sound over another. The project provided an overview of the controversy between digital and analog audio, and discussed the pros and cons of each process. The essentials of how the two processes work were discussed as well as the psychoacoustics on how this affects what we hear. The project also discussed what future work on digital audio is necessary in order to bridge the gap between the analog and digital worlds and how they sound to us.



SPECTROGRAM OF A DIGITALLY PROCESSED G CHORD ON THE GUITAR

ANTIFREEZE PROTEINS

Undergraduate Students Involved: Haider Malik, Mark Nasca*, and Jonathan Allen**
Faculty Supervisor: Dr. Nolan Holland, Chemical and Biomedical Engineering

Antifreeze proteins have been investigated for their applications in the areas of tissue and organ preservation, as well as for stabilizing ice slurries. Dr. Holland's approach is to design more highly active antifreeze proteins by creating novel antifreeze protein molecular constructs through genetic engineering and bioconjugation techniques. Undergraduate students have assisted in preparing these new constructs. They also have performed studies to optimize production of the proteins in bacterial expression systems and characterized their interactions with ice and lipid vesicles.

This research was presented at the following meeting:
H Malik, A Ghoorchian, Ö Can & NB Holland, "Thermal Hysteresis Activities of Novel Antifreeze Protein Constructs," 238th American Chemical Society National Meeting, Washington, DC, August 16-20, 2009.

* Colgate University
** Dept. of Chemistry, CSU

ELASTIN-LIKE POLYPEPTIDES

Undergraduate Students Involved: James Hayes, James Kuhel, Ciara Seitz, Ian Conant and Kaitlin Vandemark*
Faculty Supervisor: Dr. Nolan Holland, Chemical and Biomedical Engineering (co-supervisor: Dr. Kiril Streletzky, Dept. of Physics)

Elastin-like polypeptides have been studied in Dr. Holland's laboratory in order to design better responsive materials from nanoscale particles to bulk hydrogels. The applications of these new materials are primarily in the medical field, including drug delivery vehicles and tissue engineering scaffolds. Dr. Holland's team has been using recombinant DNA technology to design polypeptides that respond as individual units. These responsive building blocks will be assembled in various ways to generate more effective materials. Several undergraduate students have been involved in this project, primarily in using molecular biology techniques to build the genes for the new constructs.

This research was presented at the following meetings:

- A Ghoorchian, C Sietz, KA Streletzky, T Hugel, NB Holland, "Controlling the size of thermally responsive micelles using mixtures of linear and three-armed star polypeptides," 241st American Chemical Society National Meeting, Anaheim, CA, March 27-31, 2011.
- KA Streletzky, K Vandemark, A Ghoorchian & N Holland, "Exploring Structure, Shape, and Dynamics of Elastin-like Polypeptide Nanoparticles," American Physical Society March Meeting 2011, Dallas, TX, March 21-25, 2011.
- JA Hayes & NB Holland, "Expression of protein based poly(GVGVP) for nanoscale transducers," 235th American Chemical Society National Meeting, New Orleans, LA, April 6-10, 2008.

* Dept. of Physics, CSU

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TURNING CHEMISTRY UPSIDE DOWN: IDENTIFICATION OF REAL COMPOUNDS FROM MOLECULAR MODELS

Undergraduate Student Involved: John Tatarko
Faculty Supervisor: Dr. Rolf Lustig, Chemical and Biomedical Engineering

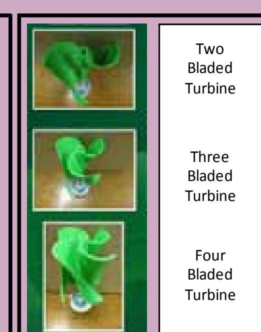
To facilitate process design, knowledge about thermodynamic and transport properties, collectively called thermophysical properties, is necessary. Unfortunately, performing laboratory experiments to determine such properties for a wide range of conditions is a major and expensive undertaking. A very powerful and significantly less expensive alternative is molecular simulation: real molecules of a substance are represented by models and the substance itself is approximated by a system of 100 to 1000 of such model molecules. The microscopic behavior is then simulated on a computer. Any thermophysical property can be rigorously measured using statistical mechanics. Traditionally, molecular simulation aims at explaining macroscopic behavior of substances. If a molecular model yields agreement with available experimental data, it may be used with confidence for predictions. However, the strategy may be reversed. One may investigate molecular models and then "build" a realistic representative if the models promise new or improved process designs. Innovative strategies (e.g., identifying alternative working fluids in refrigeration, heating, or power generating cycles) must be verified by as many case studies as possible. This project has been devoted to the class of hexagonal molecules. Information for about 50 compounds has been collected and has been employed in large scale molecular simulation for the probable design of alternative compounds with desired thermophysical properties.

THE EFFECT OF BLADE NUMBER ON A HELICAL-SAVONIUS VERTICAL-AXIS WIND TURBINE

Undergraduate Student Involved: James Reeher
Faculty Supervisor: Dr. Majid Rashidi, Engineering Technology

Although there has been research done on standard Savonius Vertical-Axis wind turbines (VAWT), there has been very little study on Helical-Savonius VAWT. This work presents the results of an undergraduate summer research program conducted on a set of scaled-down VAWT system. This work was aimed to investigate how the number of blades may affect the efficiency of the helical VAWT. The turbines that were designed and examined consisted of two, three, and four blades. The research included a design phase in which the three dimensional geometry of three VAWTs were developed using SolidWorks software. The SolidWorks models were then uploaded to a rapid-prototyping machine to fabricate the VAWTs. The projected areas of the VAWTs were 4" x 4". A test setup was designed and developed to examine the performance of the scaled-down turbines. A 1.1 KW floor fan was used to simulate wind flow in the laboratory for testing the turbines. A flow straightener was also designed and developed in order to minimize the turbulent flow of air at the discharge opening of the floor fan. The test results show that the 3-bladed rotor design is the most efficient one. Under the same wind speed conditions the 3-bladed turbine produced 18% more power compared to the 2-bladed turbine, whereas the 3-bladed turbine produced 30% more power compared to the 4-bladed turbine.

EXPERIMENTAL SETUP

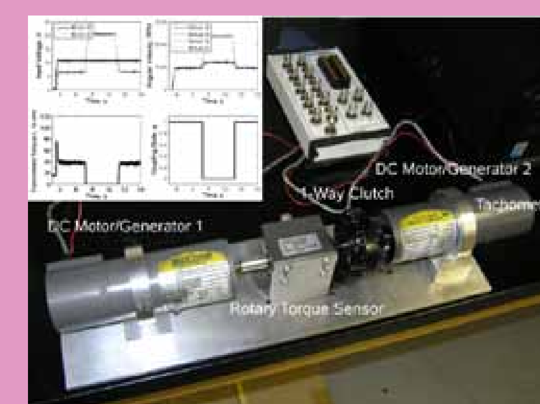


HELICAL-SAVONIUS VAWT WITH 2, 3 AND 4 BLADES

HYBRID-DYNAMICAL MODELING, CHARACTERIZATION AND EXPERIMENTAL VALIDATION OF A FREE-WHEELING CLUTCH

Undergraduate Student Involved: Rachel Maynard
Faculty Supervisor: Dr. Hanz Richter, Mechanical Engineering

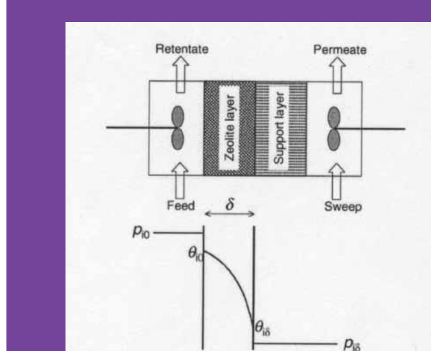
In this project, experimental and analytical studies were conducted to obtain an accurate yet simple mathematical model of a one-way clutch, also known as free-wheeling or overrunning clutch. The device is typically used in mechanical transmissions where rotation must be allowed in one direction, while inhibiting torque propagation in the other. Heavy-lift helicopters such as the Apache use these clutches to isolate the twin turboshaft engines and allow torque sharing. Small clutches are also installed on the rear wheel of bicycles to prevent unwanted pedal rotation when coasting. The research activity produced a hybrid-dynamical model which was successfully validated using a custom-built test setup. The results of the research were published in the Journal of Systems and Control Engineering in 2010.



ZEOLITE MEMBRANE PERMEATION - MODELING AND VALIDATION

Undergraduate Students Involved: John Beard and Joshua Davis
Faculty Supervisor: Dr. Dhananjai B. Shah, Chemical and Biomedical Engineering

Zeolites are crystalline aluminosilicates that possess pores of uniform size and molecular dimensions. Hence, they can be and have been used to separate chemical species based on the size, shape and configuration of molecules. Industrial zeolite separation processes are either performed in packed beds or as membrane separators with membranes synthesized out of zeolites. The feed gas made up of components A and B is allowed to flow through the feed side. The two components permeate through the zeolite membrane at different rates based on their molecular size and shape, different adsorptive characteristics and selectivity due to different diffusion rates. As a result, one component permeates faster than the other and the permeate stream will be richer in that component. In this work, a simplified transport model was used to describe the above zeolite permeation process. The model describes the rates of permeation of the two components through the zeolite membrane in terms of their adsorptive and diffusive properties. This required using binary adsorptive and diffusive behavior in the model. The expressions for binary adsorption and diffusion were determined from the respective pure component properties. The model was solved numerically for different types of chemical mixtures with differing adsorptive and diffusive properties. The results were interpreted in terms of size of the zeolite pores vis-à-vis size of the diffusing molecules. The results were also validated with previously published results in the literature.



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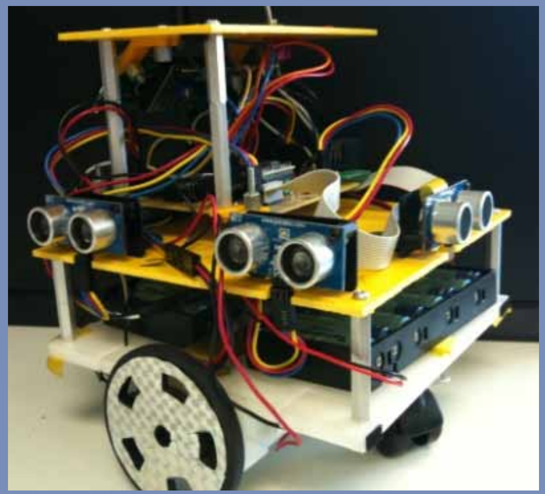
BIOGEOGRAPHY-BASED OPTIMIZATION FOR ROBOT CONTROLLER TUNING*

Undergraduate Students Involved: Paul Lozovyy and George Thomas
Faculty Supervisor: Dr. Dan Simon, Electrical and Computer Engineering

This research involved the development of an engineering test for a newly-developed evolutionary algorithm, called biogeography-based optimization (BBO), and the development of a distributed implementation of BBO. The BBO algorithm is based on mathematical models of biogeography that describe the migration of species between habitats. BBO is the adaptation of the theory of biogeography for the purpose of solving general optimization problems. In this research, BBO was used to tune a proportional-derivative control system for real-world mobile robots. It was shown that BBO can successfully tune the control algorithm of the robots, reducing their tracking error cost function by 65% from nominal values.

*Published in "Computational Modeling and Simulation of Intellect: Current State and Future Perspectives (B. Igelnik, editor) IGI Global, 2011".



INTELLIGENT ROBOTICS

Undergraduate Students Involved: George Thomas and Paul Lozovyy
Faculty Supervisor: Dr. Dan Simon, Electrical and Computer Engineering

This project involved the following components: (a) taking steps towards improving the reliability of robots by using infrared (IR) range-finding sensors to find distances and designing new printed circuit boards (PCBs) to use these sensors; (b) implementing fuzzy logic control in the robots to improve their performance and create a better optimization test for BBO; and (c) developing a distributed implementation of BBO that runs on the robots themselves and requires no centralized processing. It was concluded that the IR rangefinders produce a signal with less noise than ultrasonic sensors, the fuzzy controller has a better response to changing conditions than proportional-derivative control, and distributed BBO can be used in conditions that prohibit centralized processing.

EVOLUTIONARY ROBOTICS

Undergraduate Students Involved: George Thomas, Paul Lozovyy and Rob Morabito
Faculty Supervisor: Dr. Dan Simon, Electrical and Computer Engineering

This research was a proof of concept trial for BBO in a real-world environment. The purpose was to integrate the robots with a BBO application in order to refine their operational parameters. This allowed the robots to correct their tuning parameters and decrease their tracking time and deviation. BBO was used to tune a proportional-integral-derivative based control system for mobile robots. The robots were programmed to start at an initial distance from a wall and converge to a specified final distance as they proceeded. Robot performance was measured with a cost function based on tracking error and the amount of time the robot took to reach the desired distance from the wall. This research determined that BBO is a viable optimization algorithm in noisy conditions.

DISTRIBUTED LEARNING WITH BIOGEOGRAPHY-BASED OPTIMIZATION*

Undergraduate Student Involved: Carre Scheidegger
Faculty Supervisor: Dr. Dan Simon, Electrical and Computer Engineering

This project involved hardware testing of a BBO algorithm and extended it to distributed learning. The new BBO algorithm, called distributed BBO, does not need a centralized computer to optimize. BBO and distributed BBO have been developed by observing nature. This has resulted in an algorithm that optimizes solutions for different situations and problems. Fourteen common benchmark functions were used to simulate results of BBO and distributed BBO and both algorithms were applied to optimize robot control algorithms. Simulation results were combined with experimental results using BBO to optimize the control algorithms of a swarm of mobile robots. The results showed that centralized BBO gives better solution results for a problem and would be a better choice compared to any of the new forms of distributed BBO. However, distributed BBO allows the user to find a less optimal solution to a problem while avoiding the need for centralized, coordinated control.

Graduate student Arpit Shah also participated

*Presented in "Conference on Industrial, Engineering and Other Applications of Applied Intelligent Systems, Syracuse, NY, June 2011".

DC/DC CONVERTER FOR COMMERCIAL REFRIGERATION LED LIGHTING

Undergraduate Student Involved: Nina Scheidegger
Faculty Supervisor: Dr. Ana Stankovic, Electrical and Computer Engineering

A DC/DC converter for refrigeration display lighting product using light emitting diodes as the lighting source was proposed. This project focused on the 4th generation of Refrigeration Display Lighting (RDL) product by the General Electric Lumination Company. The history of these products and their contributions to the RDL systems were reviewed and the mechanical and optical design of the 4th generation product was studied. The focus of the project was on a PWM DC/DC Converter designed to drive the LEDs in the 4th generation product. This DC/DC Converter was designed using an IC driver provided by the company MPS in a buck-boost configuration. This design allowed for high efficiency, current control of the LEDs, and dimming functionalities.

WIND TURBINE EMULATION AND VERIFICATION

Undergraduate Student Involved: Aimee Bogner
Faculty Supervisor: Dr. Ana Stankovic, Electrical and Computer Engineering

Renewable energy sources are defined as those which generate energy from natural resources that can be replenished such as wind, sunlight, water, etc. Renewable energy sources have been a popular topic in the last decade because of their low impact to the environment and their lack of dependency on imported energy. Wind turbines are a leading technology among renewable energy sources in industry today. With the rise in popularity of "green" energy and wind turbines, many researchers have been discovering new, more efficient control strategies and power electronic converters. To assist in this research effort, engineers from around the world have developed various wind turbine emulators that essentially simulate the characteristics of a real wind turbine without the dependence of natural wind or even an actual wind turbine. This allows researchers to evaluate and perfect their methods before testing on a real wind turbine, which saves both time and money. Most wind turbine emulators use either a DC motor or an induction motor to simulate the characteristics of a wind turbine. In this research project, a DC motor wind turbine emulator was simulated by using MATLAB Simulink. In the future, these simulation results will be compared to results obtained from the Lab-Volt Solar/Wind Energy Training System. This training system, which is located at the Fenn College of Engineering at Cleveland State University, also uses a DC motor to emulate a wind turbine.

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TOUCH-BASED PERVASIVE COMPUTING EXPLORATION

Undergraduate Students Involved: Jason Goode, Masato Hayashi, Mikey McLaughlin and Bansri Patel
Faculty Supervisors: Dr. Wenbing Zhao, Dr. Nigamanth Sridhar, Dr. Chansu Yu, Dr. Pong Chu, Dr. Yongjian Fu, and Dr. Ye Zhu, Electrical and Computer Engineering

In this project, students worked with several pieces of embedded devices used to control a research blimp, an open-source electronics prototyping platform (called Arduino) for the implementation of blimp control logic, and the Apple iOS platform for graphical user interface design and implementation on an iPhone touch.

TITANIUM NANO-TEXTURE AND OSTEOBLASTIC UMR 106.01 CELL ATTACHMENT

Undergraduate Student Involved: Colin Welter
Faculty Supervisors: Dr. Surendra Tewari and Dr. Joanne Belovich, Chemical and Biomedical Engineering (*co-supervisor:* Dr. Ronald Midura, Biomedical Engineering, Cleveland Clinic)

Titanium alloy implants are commonly used by the orthopaedic surgeons to treat hip-bone fractures. It is believed that the immediate healing time and also the useful life of an implant is determined by the efficiency and quality of its osteoinegration into the surrounding bone (formation of new bones and its adherence to the transplant). Since the formation of new bones is carried out by osteoblast cells (bone forming), which are about 10-15 μm in size and whose cytoskeleton is made up of a complex three-dimensional network of about 10-20 nm diameter microfilaments, an implant surface texture that mimics their own cytoskeletal morphology is preferred by them for their attachment and growth. Polished, anodized, and NaOH treated titanium surfaces with three distinct nanotopography were examined for cell attachment. The NaOH treated surface showed distinct advantage over the polished or anodized surface.

DETECTING GAME BOTS WITH ENCRYPTED GAME TRAFFIC

Undergraduate Student Involved: Matthew Itomlenskis*
Faculty Supervisor: Dr. Ye Zhu, Electrical and Computer Engineering (co-supervisor: Dr. Huirong Fu, Dept. of Computer Science and Engineering, Oakland University)

This project involved an approach to detect cheating with game bots in Massively Multiplayer Online Role playing Games (MMORPGs). Cheating with game bots which can auto-play online games without human involvement is a big threat to the industry of MMORPGs. The proposed approach can detect game bots by analysis of encrypted game traffic. In this project, hidden Markov models (HMMs), known for the power in temporal pattern recognition, were trained to model game bots' and human players' gaming behaviors. A detection decision was made by testing a game trace of interest against trained HMMs. The proposed detection approach was evaluated with game traces collected from the Internet. The results showed that the proposed detection could detect game bots accurately with only a small number of training traces.

*Dept. of Computer and Information Science, CSU

Graduate students Yuanchao Lu and Seetharamayya Vyaghri also participated

Ohio Aerospace Institute Industry Day at the Fenn College of Engineering

On March 24, 2011, the Fenn College in association with the Ohio Aerospace Institute (OAI) organized the OAI Industry Day. Thirty five visitors from twenty companies – members of OAI as well as other industrial networks, such as MAGNET, WIRE-Net, and EWI – participated in the event which was held in the ballroom of Fenn Tower and in Stilwell Hall, home of the Fenn College.

The agenda included a morning session with faculty research presentations, a lunch session with a keynote speech, an early-afternoon laboratory tour session, and a late-afternoon poster session. Visitors had the chance to learn from our faculty about the cutting edge research being performed at Fenn College, enjoy the keynote speech by Dr. Julian Earls (former director of NASA-Glenn Research Center), tour numerous research laboratories, and learn about the high-quality of our graduate and undergraduate students' research at a poster session which displayed more than thirty five posters.

At the event, OAI recognized a number of Fenn College of Engineering individuals who made the event a big success, including Interim Associate Dean of Operations, Dr. George Chatzimavroudis and the Dean of Engineering office staff members Patricia Donovan, Joanne Hundt, Gregg Schoof, and Ram Rayala.

The Ohio Aerospace Institute (OAI) is a non-profit corporation incorporated in Ohio in 1989 to grow Ohio's aerospace economy through research and technology development, education and training, and collaboration and innovative solutions. With offices in Cleveland and Dayton, Ohio, OAI works closely with Ohio's aerospace industry, federal laboratories, universities, the state government and regional economic development agencies. OAI's membership includes over 80 preeminent Ohio aerospace and aviation companies, the ten Ohio universities with doctoral research programs related to aerospace, and NASA Glenn Research Center. OAI is a statewide organization with an exclusive aerospace and aviation focus. OAI represents Ohio to the national aerospace community, to include the American Institute of Aeronautics and Astronautics, Aerospace Industry Association, and Aerospace States Association.

WWW.OAI.ORG

OAI Ohio Aerospace Institute

OAI Industry Day Highlights

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1. Dr. Bahman Ghorashi, Dean, Fenn College of Engineering welcomes the industrial visitors.
2. Faculty and visitors break for discussion.
3. Dr. Majid Rashidi, Professor and Chair, Department of Engineering Technology speaks about his research in harnessing the energy of wind.
4. Dr. Surendra Tewari, Professor, Department of Chemical and Biomedical Engineering presents his research in aerospace and biomedical materials.
5. OAI's President and CEO, Dr. Michael Heil (center), and OAI's Vice President of Technology and Innovation Partnerships, Donald Majcher, recognize Fenn College's Patricia Donovan for organizing the event.
6. Dr. Julian Earls, Executive-in-Residence, CSU's Nance College of Business and former Director of the NASA Glenn Research Center, presents his keynote speech.
7. Donald Majcher presents his introductory remarks.
8. Dr. Norbert Delatte, Professor and Chair, Department of Civil and Environmental Engineering speaks about his research in failure analysis and concrete technology.
9. Dr. Orhan Talu, Professor, Department of Chemical and Biomedical Engineering speaks about his research in gas-solid interfaces in nanoporous materials.
10. Dr. Nigamanth Sridhar, Associate Professor, Department of Electrical and Computer Engineering presents his research in dependable systems and networks.
11. Dr. Michael Heil (right) with Dr. George Chatzimavroudis, Interim Associate Dean of Operations, Fenn College of Engineering.
12. Dr. Dan Simon, Professor, Department of Electrical and Computer Engineering presents his research in evolutionary optimization.
13. Dr. Mounir Ibrahim, Professor, Department of Mechanical Engineering speaks about his research in power conversion systems.

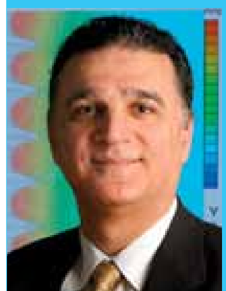
PHOTOS BY JAMES MAJOR

Endowed Faculty

Fenn College is very proud to have an Endowed Distinguished Professor and an Endowed Chair within its family.

MAJID RASHIDI, PH.D., P.E.

Professor and Chair, Department of Engineering Technology
The Betty L. Gordon Endowed Distinguished Professor



Dr. Majid Rashidi, an alumnus of Case Western Reserve University, received his Ph.D. in the field of Mechanical & Aerospace Engineering in 1986, MS in 1983, and BSME in 1981 from CWRU. Following his graduation in 1986, Dr. Rashidi worked at NASA for the Institute of Computational Mechanic in Propulsion (ICOMP). In the Fall of 1987, he started a tenure-track position in the Mechanical Engineering Department at Cleveland State University, was promoted to the rank of Associate Professor in 1993, and to the rank of Professor in 2008.

The teaching and research areas of Dr. Rashidi are: renewable energy devices, machine system and machine components design, design for manufacturing (DFM), vibrations of machinery, dynamics of gear trains, design/analysis of rotating machinery, and fluid-solid interactions in machinery. Dr. Rashidi has 24 years of machine design experience related to the real-world engineering problem solving for industry. The results of his industrially sponsored research work at CSU have helped several Ohio's industrial companies to keep their competitive edge relative to that of the off-shore industries. His research work has also resulted in several publications in referred technical journals as well as 5 patents in print, with 2 additional patents pending in the area of wind power harnessing systems. Dr. Rashidi's latest patent has been reduced to a fully functional wind harnessing system installed on the rooftop of the Plant Service Building at Cleveland State University. The system is designed to harness wind energy in typical urban settings where the wind speed is not fast enough to operate typical conventional wind towers.

Dr. Rashidi received $1.1 million from the US Department of Energy, and additional $400 thousands from the State of Ohio for his research efforts in the area of design of innovative wind harnessing systems. Additionally, his research in this field attracted the attention of Mrs. Betty L. Gordon who initially provided $52,000 to the Fenn College of Engineering to support Dr. Rashidi's research in the area of Renewable Energy, specifically his new wind tower system. In 2009, Mrs. Gordon committed a $1.0 Million gift to create the Betty L. Gordon Alternative Energy Research Endowment and the Betty L. Gordon Endowed Distinguished Professorship in the Fenn College of Engineering at CSU. In 2009, and by the action of a faculty committee of the Fenn College, Dr. Rashidi was named as the "Betty L. Gordon Distinguished Professor".

Dr. Rashidi's Endowed Distinguished Professor title was celebrated during the unveiling ceremony of the CSU's Experimental Wind Tower in June 2009; this ceremony was arranged by the Office of University Advancement at CSU and attended by the University officials and invited guests from the Greater Cleveland Community. As the result of this endowment, in 2010, Dr. Rashidi established a financially self-sustaining Center for Advancements in Renewable Energy (CARE) at Fenn College of Engineering. The research activities of the center includes: a) innovative designs for large turbines blades, b) power-train of the large turbines (megawatt level), and c) distributed wind power system (Kilowatt level). In addition to research activities, the center (CARE) is involved with educational outreach that is in line with the educational mission of CSU.

DR. JERZY T. SAWICKI, PH.D, P.E., ASME FELLOW

The Donald E. Bently and Agnes Muszynska Endowed Chair in Rotating Machinery
Associate Vice President for Research, Cleveland State University
Professor, Department of Mechanical Engineering

Dr. Sawicki, the Donald E. Bently and Agnes Muszynska Endowed Chair in Rotating Machinery is the Associate Vice President for Research at CSU and the director of the Center for Rotating Machinery Dynamics and Control (RoMaDyC).

Dr. Sawicki is an internationally recognized expert in dynamics, control and tribology of rotating machinery. He received his Ph.D. in Mechanical and Aerospace Engineering from Case Western Reserve University in 1992. He has published one book, co-edited several conference proceedings, and authored over 200 peer-reviewed journal papers and conference articles in the areas of rotating machinery dynamics, tribology, control, and structural health monitoring. He has presented many invited lectures nationally and internationally. His research has been funded by federal and state agencies, state and out-of-state corporations, including GE Corporate R&D Center, GE Aircraft Engines, Allied Signal, Federal-Mogul Corp., Philips Medical Systems, Bendix, NASA, and the Ohio Board of Regents. He has provided consulting services to the manufacturing and power generation industry and the federal government. He has been serving on several editorial boards for scientific journals and has been representing the U.S. in the ISO/TC 108/SC 2/WG 7 international committee. Dr. Sawicki has received multiple honors and awards, including a Fellow of the American Society of Mechanical Engineers (ASME), the Ohio Outstanding Engineering Educator Award from the Ohio Society of Professional Engineers, the University Distinguished Faculty Award for Research at Cleveland State University, Best Paper (SPIE, IFToMM) awards, and recognitions from industry and NASA.

The center RoMaDyC has been established in 2004 and is dedicated to enhance productivity and competitiveness of its partners in industry. In association with industry, RoMaDyC focuses on problem solving and research to provide cutting-edge technical innovations to solve complex problems in engineering systems involving rotating machinery. RoMaDyC serves as an intellectual resource for the industry with the aim of continuous improvement and long-term development. The center's activities directly support improvements in design, manufacturing, diagnostics, structural health monitoring, advanced control and performance of vital rotating mechanical systems and components, including but not limited to bearings, seals, rotors, gears, turbines, compressors, and generators. In addition to research and development, RoMaDyC maintains an active educational mission to both educate and provide information to the community regarding rotating machinery.

The Donald E. Bently and Agnes Muszynska Endowed Chair in Rotating Machinery, the very first Endowed Chair in Fenn College of Engineering, was established in 2004 by $1 million gift of Donald E. Bently and Agnes Muszynska, globally recognized authorities on rotor dynamics and vibration monitoring and diagnostics. The established Chair pays lasting tribute to their remarkable joint research accomplishments in the dynamics and diagnostics of rotating machinery.

New Faculty

The Fenn College community is very pleased to welcome two new faculty who will join the college in August 2011. Dr. Chandra Kothapalli will join the Department of Chemical and Biomedical Engineering as a tenure-track Assistant Professor and Dr. Jacqueline Jenkins will join the Department of Civil and Environmental Engineering as a tenure-track Assistant Professor.

CHANDRA KOTHAPALLI, PH.D.

Dr. Kothapalli earned a Bachelor's degree in Chemical Engineering from Andhra University in India, and Master's degrees in Chemical Engineering and Materials Sciences from Mississippi State University and University of Connecticut, respectively. He received his PhD in Bioengineering from Clemson University in May 2008, where he identified and optimized biomolecular cues comprising extracellular matrix components and growth factors, for regenerating elastin in aortic aneurismal blood vessels.

During his Postdoctoral Fellowship in the Biological Engineering Department at the Massachusetts Institute of Technology, he developed microfluidic assays to evaluate neurite responses to growth factor gradients in vitro, and investigated axonal targeting of projection neurons (e.g., corticospinal motor neurons) in three dimensional cultures. At MIT, Dr. Kothapalli also identified the role of microenvironment (matrix composition, stiffness, porosity, growth factors) on embryonic stem cell differentiation into various neural and glial lineages, for wide-ranging applications in cell transplantation therapies. His current postdoctoral work on glioblastoma cell migration and proliferation in 3D milieu is funded by the "Emergent Behaviors of Integrated Cellular Systems" grant by NSF at CUNY. So far, his research has resulted in one patent filing, 22 peer-reviewed publications and proceedings, and more than 30 conference and seminar presentations. Among his numerous honors, he is a member of Sigma XI, and was the Presidential Scholar at the Medical University of South Carolina.

Dr. Kothapalli has accepted a faculty appointment in the Department of Chemical and Biomedical Engineering and will assume the position of Assistant Professor. At Cleveland State University, Dr. Kothapalli plans to build a research program at the interface of engineering and medicine, with strong clinical applications in regenerating diseased or injured tissues and organs. Using state of the art bioengineering approaches, he would like to integrate his background and expertise in stem cells, tissue engineering, biomaterials and nanotechnology for developing long-lasting solutions for vascular and neural clinical conditions. Specifically, he is interested in formulating strategies which will encourage stem cell differentiation into multiple lineages on demand, and enhance their survival, functionality and integration into the host tissue post-implantation. If his research approach proves successful, Dr. Kothapalli anticipates significant improvement in the quality of life for those suffering with fatal neurodegenerative or cardiovascular conditions.

His other interests include developing highly-specialized microfluidic platforms to understandmolecular mechanisms and signaling pathways involved in heterotypic cellular interactions under chemogradients. These microfluidic devices will allow for precise control of the cellular and non-cellular microenvironment at physiologically relevant length- and time- scales. Given the interdisciplinary nature of this research, Dr. Kothapalli anticipates significant collaborations with researchers at Cleveland State University and Cleveland Clinic. He is also excited at the possibility of teaching and mentoring undergraduate and graduate students in chemical and biomedical engineering principles.

JACQUELINE JENKINS, PH.D.

Dr. Jenkins holds a B.A.Sc. degree in Civil Engineering from the University of Waterloo and M.E. and Ph.D. degrees from Texas A&M University. Specializing in transportation, Dr. Jenkins' research is focused on examining the characteristics of users as they relate to the design, operation and maintenance of transportation facilities and systems. The overarching goal is to improve how the needs, capabilities and limitations of drivers, cyclists and pedestrians are considered, thus improving the safety and efficiency of such systems.

A major challenge of this work is observing users in the field. Although collecting information about the characteristics of traffic flow and the movement of individual vehicles has benefited from the use of advanced technologies, such as laser scanners and radar, collecting personal information about individual users still requires direct contact. A driving simulator offers the safety benefits of a controlled environment to test participants under a variety of specific test conditions, capture detailed information about participants' control of the simulated vehicle, as well as provide the opportunity to interview participants. For these reasons, Dr. Jenkins turned to the use of driving simulation as a tool for conducting traffic and transportation studies.

Dr. Jenkins' dissertation examined integrating driving simulator and traffic simulation software to improve the ability to generate calibrated traffic flows in driving simulation environments and improve vehicle behavior in traffic simulations. An integration was facilitated using High Level Architecture, developed by the Department of Defense and then applied to study the impact of longer impeding vehicles on the passing behavior of drivers on two lane rural roads.

Dr. Jenkins has also conducted driving simulation studies to examine the extent and effect of cellular telephone conversations on drivers' vehicle control and drivers' understanding of various protected and permitted left turn indications. The results have been compared to observations taken in the field to determine the external validity of such experiments. To examine the internal validity of driving simulator experiments, Dr. Jenkins has supervised research in the area of adaptation, defined as the process through which participants learn to interact with the simulator vehicle and simulated environment. The results of this work support the notion that driving tasks practiced during a training scenario can predispose the driver's performance during subsequent experimental scenarios, thus highlighting the importance of designing complementary training scenarios and providing participants adequate opportunity to adapt.

At CSU, Dr. Jenkins will collaborate with the University Transportation Center, industry, government, and professional organizations, along with faculty and students to study work zone safety and efficiency. Both field studies and driving simulation studies will be valuable in this endeavor and will contribute to the evaluation of driver behavior and the development of practical solutions, sensitive to the prevailing political, social and economic environments.

Journal Editorial Achievements

College faculty have been very active not only publishing their research findings but also serving as editors, associate editors, and editorial board members in numerous prestigious journals, including:

DR. JOANNE BELOVICH, Professor of the Department of Chemical and Biomedical Engineering, is a Member of the Editorial Board of the *Journal of Biological Chemistry* (www.jbc.org)

DR. PAUL BOSELA, Professor of the Department of Civil and Environmental Engineering, is a Member of the Publications Committee and Editorial Review Board of the *ASCE Journal of Performance of Constructed Facilities* (ascelibrary.org/cfo)

DR. NORBERT DELATTE, Professor and Chair of the Department of Civil and Environmental Engineering, is the Chief Editor of the *ASCE Journal of Professional Issues in Engineering Education and Practice* (ascelibrary.org/epo) and a Member of Editorial Review Board of the *ASCE Journal of Performance of Constructed Facilities* (ascelibrary.org/cfo)

DR. RAMA GORLA, Professor of the Department of Mechanical Engineering, is the Editor-in-Chief of the *International Journal of Fluid Mechanics Research* (dl.begellhouse.com/journals) and an Associate Editor/Member of the Editorial Board of the *International Journal of Applied Mechanics and Engineering* (www.ijame.uz.zgora.pl); the *Journal of Magnetohydrodynamics, Plasma, and Space Research* (www.novapublishers.com/catalog); the *Journal of Pure and Applied Physics* (jpaph.com); the *International Journal of Turbo and Jet Engines* (www.degruyter.de); the *Journal of Mechanics of Continua and Mechanical Sciences* (www.journalimcms.com); and the *International Journal of Microscale and Nanoscale Thermal and Fluid Transport Phenomena* (www.novapublishers.com/catalog)

DR. YUNG-TSE HUNG, Professor of the Department of Civil and Environmental Engineering, is the Editor of the *International Journal of Environment and Waste Management* (www.inderscience.com/ijewm), the Editor of the *International Journal of Environmental Engineering* (www.inderscience.com/ijee), and the Editor-in-Chief of the *International Journal of Environmental Engineering Science* (www.serialspublications.com/journals.asp)

DR. PAUL LIN, Associate Dean of Academic Affairs and Professor of the Department of Mechanical Engineering, is the Editor-in-Chief for the *International Journal of Intelligent Systems in Engineering* (ijise.yolasite.com)

DR. DAN SIMON, Professor of the Department of Electrical and Computer Engineering, is an Associate Editor of *Aerospace Science and Technology* (www.elsevier.com) and a Member of the Editorial Board of the *International Journal of Intelligent Systems in Engineering* (ijise.yolasite.com)

DR. ORHAN TALU, Professor of the Department of Chemical and Biomedical Engineering, is the Regional Editor of *Adsorption, the Journal of the International Adsorption Society* (www.springer.com/chemistry/journal/10450)

DR. MARK TUMEO, Professor of the Department of Civil and Environmental Engineering, is a Corresponding Editor for the *ASCE Journal of Professional Issues in Engineering Education and Practice* (ascelibrary.org/epo)

DR. YE ZHU, Assistant Professor of the Department of Electrical and Computer Engineering, is an Associate Editor of the *International Journal of Computers and Applications* (www.actapress.com) and an Editorial Member of the *International Journal of Advanced Networking and Applications* (www.ijana.in/) and Communications (www.actapress.com)

Information in this section is provided by the faculty listed above.

BOOK DISPLAY AREA

With the help of our faculty and staff, an impressive display of books authored by Fenn College faculty has been created and received stellar reviews by the CSU community and our visitors.

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