Spring/Summer 2005 Vol. 3 No. 1

NETWORKS

Electrical and Computer Engineering

Also inside...

MICHIGAN STATE UNIVERSITY

Smart Microsystems Laboratory

Activities in the Smart Microsystems Laboratory (established in 2004) are focused on three emerging areas in dynamics and control: smart material sensors and actuators, modeling and control of micro-electromechanical systems (MEMS), and networked control systems.

Smart Material Sensors and Actuators

Smart materials (e.g., piezoceramics, magnetostrictives, and electroactive polymers) are characterized by strong couplings of their mechanical properties with applied electric, magnetic, or thermal fields. Such couplings provide built-in mechanisms for sensing and actuation. One of the primary barriers to successful application of smart sensors and actuators is their complicated, highly nonlinear behavior.

Faculty and students in the Smart Microsystems Laboratory are engaged in building models for smart materials that capture nonlinear properties associated with such materials. Such models allow simulation of sensors and actuators that employ these materials in real time sensing and control applications. The modeling efforts require a thorough understanding of the underlying physical process and involve numerical simulation, experimental verification, and model reduction. Efficient control algorithms are then developed based on the models.

Projects currently underway in the laboratory include the modeling and control of ionic polymer-metal composites (IPMCs). Producing large strain output with a low voltage (about 1 Volt), IPMCs are regarded as an important family of electroactive polymers (nicknamed *artificial muscles*). They provide promising solutions to applications where delicate and precise manipulations are needed, e.g., in implantable drug delivery systems and in microassembly of 3D structures. However, without a suitable mathematical model, one cannot answer questions like *how should I apply the voltage so that the robotic micro-fingers can complete the complicated assembly task swiftly, while consuming a minimum amount of energy?*

Below, figure 1 shows an IPMC sample clamped at one end where a voltage is applied across the surfaces. The bending motion of the sample is detected by a laser sensor (red spot).

Figure 1. Experimental setup for investigating IPMCs in the Smart Microsystems Laboratory at MSU.

Continued on page 11

The Chair's Column

An interesting train of thought was introduced recently when a member of our visiting committee used the term "higher education business" to describe the nature of our enterprise. The higher education business is certainly large and a major contributor to our gross domestic product. Although there are many interesting differences between education and other types of businesses, there is one aspect of our "business" that is strikingly out of the ordinary. We do not design our products (students) to grow obsolescent. Indeed, we hope that our students continue to grow intellectually stronger each year, much like the good oak tree that continues to add rings and grow more solid each year. We hope that our students develop a lifelong interest in learning.

As a matter of fact, our accreditation requirements dictate that we have processes in place that ensure that we instill such an interest in students. The question is, how? Several scholarly publications have shed light on the issue. A common theme in the findings of these studies is the need for a curriculum that offers students an opportunity to exercise their talents and to pursue studies in areas that most interest them. We in the department are continually striving to meet this challenge.

We are looking at a strategy that involves evaluating a student's interests and potential at the end of the freshman year. Students with strong interests in research could be encouraged to take additional courses in mathematics, statistics, physics, or chemistry. Such students could be involved in research projects pursued by faculty members and encouraged to consider graduate work as part of their future plans. Likewise, students with an interest in management would be encouraged to take a select set of courses in the business school. Others with an interest in pursuing technical careers in industry would be encouraged to consider taking additional design courses in their junior year. We hope that by allowing students to pursue their passion early on in their program we would instill a lasting love for their chosen field and a desire to grow and thrive professionally.

Our Design Day in December was a spectacular success once again. As in the past, the day-long event attracted a great deal of interest from the campus community as well as industry. Professor Erik Goodman was instrumental in organizing the event and deserves a great deal of credit for bringing out the best in students. (See page five.)

The talents of our faculty continue to be recognized by our peers. Professors Fang Zheng Peng and Edward Rothwell were elected to the rank of Fellow of the Institute of Electrical and Electronics Engineers (IEEE). Most of our professors are Fellows of IEEE and/or other major professional societies, a testament to the excellence of our faculty members and the high regard they enjoy from their peers.

On a sad note, Professor Emeritus Lawrence Giacoletto passed away late last year. He joined MSU in 1961 after spending over 15 years at the RCA Labs and Ford Motor Company. A prolific researcher and inventor, Giacoletto was involved, among numerous other things, in the development of the first color television set. He was also responsible for the development of the well-known hybrid-π model for transistors. Dr. Giacoletto was a caring teacher and a wonderful colleague to have in the department. We will truly miss him. (See page 14.)

On a different note, this will be my last newsletter. I have been informed that I will be serving as the Acting Dean of the College of Engineering, commencing from June 7, 2005. I will be taking over Dean Fouke's responsibilities who will begin her duties as the Provost and Senior Vice President of Academic Affairs at the University of Florida. I'd like to thank Dean Fouke for her help and support in moving the department forward.

I am pleased to inform you that Professor Tim Grotjohn has been appointed as the Acting Chair. We are truly fortunate to have someone as capable as Tim taking over the helm.

It has been a pleasure to serve this department and I hope to watch it continue to grow and prosper in the years to come.

— Satish Udpa, chair and professor

Faculty and Staff Awards and Accomplishments


Fang Z. Peng

Rothwell and Peng Named Fellows of IEEE

Fang Z. Peng, associate professor, and Edward J. Rothwell, professor, have been named fellows of the Institute of Electrical and Electronics Engineers (IEEE). Peng is recognized for his contributions to multilevel power converter topology, control, and applications. Rothwell is recognized for his contributions to the development of radar target identification, discrimination, and detection schemes. Of the IEEE's 400,000 members worldwide, only 0.1 percent receive the prestigious designation of fellow, in recognition of extraordinary accomplishments in their fields.


Edward Rothwell

An MSU faculty member since 2000, Peng conducts research in MSU's Power Electronics and Motor Drives Laboratory. His interests include hybrid electric vehicles and renewable energy interface systems. Prior to joining the MSU faculty, he was on staff at the Oak Ridge National Laboratory.

Rothwell, who earned his PhD in electrical engineering at MSU, has been a faculty member since 1985. Prior to that he was on staff at the MIT Lincoln Laboratory. He attributes much of his success in research to collaborative work with excellent graduate students and with close colleagues K.M. Chen and Dennis Nyquist, who are also IEEE fellows and now retired. Rothwell also received the IEEE Southeast Michigan Section Outstanding Professional Award in April 2005.

ECE Members Honored at Awards Luncheon


Selin Aviyente


Joyce Foley


Timothy Grotjohn

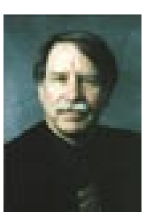
Four ECE faculty and staff members were honored at the College of Engineering's 15th annual awards luncheon. **Selin Aviyente,** assistant professor, received the Withrow Teaching Excellence Award; **Joyce Foley**, administrative assistant, received the Gloria Stragier Award for Dedicated and Creative Service; **Timothy Grotjohn**, professor, received the Withrow Exceptional Service Award; and **Fang Z. Peng,** associate professor, received the Junior Distinguished Scholar Award, which is given to an individual in service to the university as instructor, assistant professor, or associate professor for not more than seven years.

Khalil Receives Best Paper Award

Hassan Khalil, University Distinguished Professor, received the 2005 O. Hugo Schuck Best Paper Award at the June American Control Conference. Khalil had presented his paper, "Output Feedback Sampled-Data Stabilization of Nonlinear Systems," at the 2004 conference.


Hassan Khalil

Erik Goodman Receives Two Honors



Professor Erik D. Goodman was chosen to head the new ACM (Association for Computing Machinery) Special Interest Group for Genetic and Evolutionary Computation (SIGEVO) at its founding on January 1, 2005. He was chair of the predecessor organization, the International Society for Genetic and Evolutionary Computation for three years. He has been developing and using genetic algorithms since 1970 and was the first to try to use them in a large-scale problem in a yearlong computer run from 1970 to 1971. For more information, visit the SIGEVO Web site at http://www.sigevo.org/.

Goodman also received the Outstanding Faculty and Staff Award from the MSU Resource Center for Persons with Disabilities at their 21st Annual Awards and Appreciation Reception in April 2005. Students with disabilities generally nominate the winner of this award, which is given to people who maximize their opportunities for academic or extracurricular achievement.

Undergraduate Program Report

The ECE Department offers two undergraduate degree programs – electrical engineering and computer engineering. The computer engineering BS degree is offered jointly with the Department of Computer Science and Engineering. Both programs are accredited by ABET (Accreditation Board for Engineering and Technology).

Two significant changes in the undergraduate electrical engineering and computer engineering programs were implemented this semester. First, the admission process has been changed. In the past, students were not formally admitted to either major until they reached junior status (defined as 56 credits) with a 2.9 minimum GPA requirement. Now students can be admitted to the major when they complete a set of five core classes (Calculus I and II, Physics I, Chemistry I, and the first computer programming course) and meet the minimum GPA requirement. This allows them to be in their major as early as their freshman or sophomore year and to start taking courses in their major before they are juniors. It also gives them the assurance of admission to EE or CPE earlier in their academic program. This new policy is being tried for a period of three years.

Another important change to the program allows students to earn credits toward their major elective credits with selected educational experiences such as co-op, internship, independent study, and study abroad. In the current job market it is becoming more important for graduating students to have engineering work experiences outside the classroom. In many cases, these non-classroom learning experiences help students to understand possible engineering careers, to understand the broader context of the courses they take, and to interview more effectively when they graduate. Over the next year, the ECE Department will be striving to increase the number and quality of non-classroom learning experiences for ECE students. Ideally, we would like all of our students to have a number of engineering experiences outside the classroom during their time at MSU.

A senior-level course, "Digital Control," has been added to this semester's undergraduate course offerings. This course existed a few years ago but with the retirement of a controls area faculty member, it could no longer be offered. Now, with new faculty in this area, this course brings the number of senior-level courses up to 15. ECE now offers senior-level courses in electromagnetics, electromagnetic compatibility, VLSI design, electronic design automation, circuit design algorithms, digital control, computer-aided manufacturing, communication systems, power systems, digital signal processing and filter design, electronic devices, electro-optics, microelectronic fabrication, and applications of analog circuits, as well as a senior design course. Twelve of these courses include laboratory experience. With these fifteen courses and twelve associated labs, students can specialize in a number of areas during their senior year.

We are always interested in hearing your ideas for improving the learning experiences of our students. Feel free to send an e-mail to Timothy Grotjohn (grotjohn@egr.msu.edu) or drop by the department.

— Timothy Grotjohn, professor and associate chair

Editorial notes:

On June 7, 2005, Satish Udpa, former chair of the department, was appointed as acting dean of the College of Engineering.

Timothy Grotjohn, former associate chair of ECE, was appointed as acting chair of the department.

Hassan Khalil was appointed as associate chair for undergraduate studies of the department on June 13, 2005.

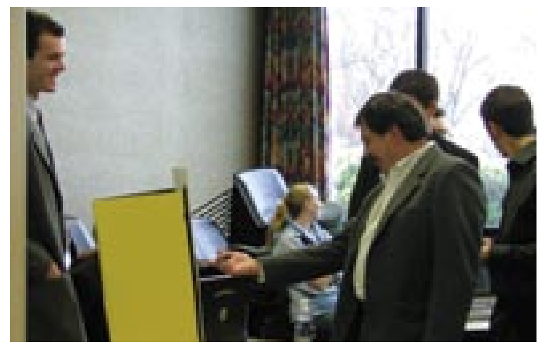
ECE Design Day

ECE Design Day took place December 9, 2004, at MSU's International Center. The event featured competitions among teams of students in the ECE freshman/sophomore design seminar (EGR 291) and among teams of seniors in the capstone design course (ECE 480). Engineers from industry judged the competitions and Prism Venture Partners, sponsor of the event, provided cash prizes to the top three teams. The first-, second-, and third-place winners are pictured below.

Members of the Whirlpool Talking Dryer team (LEFT TO RIGHT: Tony Skarich, James Tucker, and Jonathan Jiskra) show one of the judges, Jim Senneker, how their voice module gives a "voice" to the dryer.

LEFT TO RIGHT: Professor Erik Goodman, Mike Hudson, Karla Hudson. Mike Hudson, director of the MSU Resource Center for Persons with Disabilities, and his wife Karla, who are both visually handicapped, will be testing the usability of the talking dryer.

LEFT TO RIGHT: Stuart Bergstrom, Allan Evans, Nick Davis, Justin Thompson, and Desmond Kursinsky, Texas Instruments – sponsored Low-Power Smart Sensors Team answers questions after their oral presentation.



Professor Elias Strangas, right, looks at data gathered by the Low-Power Smart Sensor system, developed by the TI-sponsored team to assist Professor Stuart Gage, Center for Remote Sensing, in monitoring bird activity. Team member Justin Thompson, far left, looks on.

Erin Groom - Instructional Media Center

Chad Dean, left, and Jon Wiedman, center, demonstrate the robot built by three senior capstone design teams for NASA Goddard Space Flight Center. Mike Comberiate, right, from NASA GSFC, took the robot to Antarctica in January 2005 to test remote operations in a hostile environment.

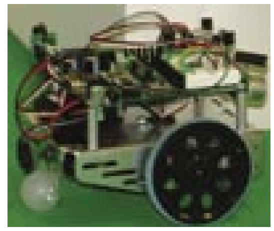
Erin Groom - Instructional Media Center

LEFT TO RIGHT: Jon Wiedman, Faisal Abu-Nimeh, and Chad Dean command their robot through the Internet, using a Web-based graphical user interface developed by their team. The long and variable delays in Internet communication help to test the ability of the control system to work well under such circumstances.

ECE Design Day continued from page 5

ECE Design Day also featured student projects from EGR 291, ECE Freshman/Sophomore Seminar

Brian Wright, right, ECE shop technician, who built the robot maze, helps Pete Semig, left, EGR 291 instructor, carry it into the demonstration room before the competition.



Andrew Baczewski, teaching assistant for EGR 291, sets up the first robot to run the maze. The EGR 291 robot, right, uses Parallax's Boe Bot. It is controlled by a BASIC Stamp 2SX microcontroller and is equipped with a range finder and 2 IR sensors.

Waiting for the robot competitions to begin, Dean Janie Fouke, right, looks over the design day brochure with Pete Semig, center, EGR 291 instructor.

Student Awards & Accomplishments

Shirish S. Karande Honored at University Awards Convocation

Harley J. Seeley - IMC

Shirish S. Karande, graduate teaching assistant, was honored at the university-wide 2005 Awards Convocation, held this sesquicentennial year in conjunction with a Founders' Day Celebration. The February 11 ceremony at the Wharton Center's Great Hall included the installation of Lou Anna K. Simon as the 20th president of Michigan State University.

Karande received an Excellence-in-Teaching Citation for the care and skill he has demonstrated in meeting his classroom responsibilities. He consistently brings novel approaches to teaching while maintaining an extraordinary level of performance. He has introduced new computer-based tools and novel experiments that motivate students to learn the material beyond all expectations. In seven of his courses, students have given him virtually perfect overall ratings. Among his graduate student colleagues, he has authored the most articles in peer-reviewed international publications. His work is being recognized worldwide in some of the most competitive publications venues.

Jacob Kuiper Receives Board of Trustees GPA Scholarship

Jacob Kuiper, a computer engineering major, received the Board of Trustees GPA Scholarship for the highest GPA in the spring 2005 graduating class. As a freshman, Jacob was selected for the prestigious professorial assistantship program and worked with Dr. Rama Mukkamala for over two years. As a direct result of his work, he was published in the Proceedings of the 26th Annual Conference of the IEEE Engineering in Medicine and Biology Society in 2004.

While at Michigan State, he also earned the Distinguished Freshman Scholar award in 2002, and was vice president of the MSU Men's Club Tennis from 2003 to 2005. He maintained this high level of activity while earning a perfect 4.0 GPA. Jacob was recently accepted into our electrical engineering graduate program.

Janelle Shane Wins Prestigious Goldwater Scholarship

Janelle Shane, an electrical engineering student, is the recipient of the prestigious Goldwater Scholarship. While at Michigan State, Janelle has been involved in research activities both here on campus as well as abroad, completing a Research Experience for Undergraduates (REU) last summer in France.

Erin Groom - Instructional Media Center

She has also maintained involvement in the Society of Women Engineers over the past two years as communications chair and as secretary, and earned the outstanding executive board member award in both 2004 and 2005. She has earned the Distinguished Service Award in the Department of Electrical and Computer Engineering and the Alumni Distinguished Scholarship Award.

In her spare time, Janelle has been involved with Habitat for Humanity and as an English tutor for foreign teaching assistants, while maintaining her hobbies in classical piano, French language, and photography. Upon graduation, she aspires to move on to graduate school with an emphasis on research in optics.

David Skalny Receives Board of Trustees GPA Scholarship

David Skalny, a dual degree major in both electrical engineering and computer engineering, received the Board of Trustees GPA Scholarship for the highest GPA in the spring 2005 graduating class.

Jarrod Short - ECE

In a three-year time frame, along with his Engineering degrees, he has also fulfilled the requirements for four years of college-level Japanese language. Additionally, David has completed two terms of cooperative education experience with the U.S. Army TACOM in Warren, Michigan, where he was instrumental in rebuilding a World War II vintage electric tank.

David has received a scholarship from the Boeing Company, as well as Yates Memorial and Walker Memorial scholarships. His academic achievements also earned him the honor of carrying the College of Engineering banner during this year's spring convocation. Following his spring graduation, David will pursue a Juris Doctor degree from Thomas M. Cooley Law School.

Study Abroad

Nine of our ECE undergraduate students are studying in Kaiserslautern, Germany this summer for the Engineering Study Abroad Program.

FRONT ROW, LEFT TO RIGHT: Joe Ciolek, Sasha (German Coordinator), Doug Hines, Nick Tokarz.
BACK ROW, LEFT TO RIGHT: Anthony Recca, Katie Muer, Stanislav Todromovich, David Lenz, Bradley Johnson (MSU Grad Instructor), Andrew Baczewski.

Graduate Program Report

The growth of the department's faculty has created significant new opportunities in graduate studies. Not only have traditional groups expanded, but also new research/graduate studies opportunities have been created. In this newsletter, we'll focus on the new research activities in computer networking and computer architecture, which include wireless data networking, low-power network protocols and algorithms, sensor networks, parallel and high-performance computing, system architecture, and computer systems dependability. The faculty members who recently joined the department with a primary research focus in these fields are Subir Biswas (PhD, University of Cambridge), Nihar Mahapatra (PhD, University of Minnesota), and Peixin Zhong (PhD, Princeton University).

In some cases, a research project involves issues general to a variety of different applications, such as energy related concerns in wireless networks. For example, in one project on embedded sensors, the purpose is to design, characterize, and develop an energy-aware sensor middleware framework that can be used for functional mediation between emerging sensor network protocols and their applications. A sensor network middleware should offer the traditional middleware functions, such as application-network mediation, as well as new functions that can enhance the network services by leveraging special properties of the underlying sensor networks. Aiding sensor energy economy and enabling network adaptation are two such important functions. Constraints in hardware and available energy of the sensor nodes give rise to additional restrictions in terms of the size and processing requirements of middleware software. Our project is aimed at a design solution that can be implemented for a number of emerging sensor network applications.

Energy and power concerns are also important in computer architecture. To achieve power design goals, attention must be paid to minimizing the power consumption at the beginning of system design. On the other hand, system level designers often have little knowledge about the detailed circuit techniques, making it hard to evaluate the performance-power trade-off at high level. To tackle this problem, the development of high level mixed-signal component models and power estimators to be used in system-level design tools is necessary for effective performance-power tradeoffs. In a recent project, an architectural power estimation tool with good accuracy for analog-to-digital conversion was developed, which combined the advantages of both the bottom-up approach and the top-down approach. System-level designers can use the tool without detailed circuit parameters and it can provide topology information that benefits the subsequent detailed design process as well.

Other projects are very application specific. For example, another research project is concerned with the design of a network-centric cyber infrastructure for field acoustic data collection and real-time identification of organisms, specifically birds, which utilize acoustics as a means of communication. This project aims to develop the algorithms, processes, and software for such an application on acoustics based real-time bird species identification. Sensor networks for acoustic monitoring applications need to support heterogeneous sensing granularities, nodal energy efficiency, and provisions for in-network data aggregation and application-driven sensor programming. The ultimate goal of the project is to develop a field deployable acoustic sensor network using off-the-shelf sensor hardware, and to integrate it with species identification software in centralized acoustic servers.

Another application-specific project is being carried out in cooperation with the Department of Civil and Environmental Engineering. The objective of this project is to develop a conceptual as well as experimental framework for vehicle-to-vehicle information networking to enable networked vehicle services (NVS). Example NVS applications include Intelligent Transportation Systems, Local Driving Information Retrieval, Highway Driving Information

Continued on next page

Graduate Program Report

Back-propagation, and Commercial Information Delivery System. The key enabler for NVS applications is a highly mobile wireless ad hoc network that can be used for information retrieval from fixed roadside access points and its selective dissemination among NVS enabled vehicles. Faculty and graduate students are designing NVS-specific wireless access and network layer protocols that can be implemented on top of IEEE-specified Dedicated Short Range Communication (DSRC) radio physical layer. The main challenge of this work is to design and develop broadcast based protocols while maintaining low data delivery latency in networks with nodes moving at 60 to 90 miles per hour.

Performance issues in computer systems are related not only to speed and energy tradeoffs, but also accuracy and error avoidance. Particularly pernicious error types are "soft errors." Soft errors are functional failures resulting from the latching of single-event transients caused by high-energy particle strikes or electrical noise. Traditionally, they have been deemed to be a problem in memory structures, for which effective techniques (such as error correcting codes) are well known. However, due to technology scaling and reduced supply voltages, they are expected to increase by several orders of magnitude in logic circuits. Existing circuit and architectural approaches to addressing soft errors in logic circuits have appreciable area/cost, performance, and/or energy overheads or are limited to particular types of circuits (combinational or sequential). One project related to this involves a systematic error masking technique that uses the same circuitry to cope with soft errors in combinational and sequential circuits. The method is performed without additional delay and within the clock cycle time in an area- and energy-efficient manner, which makes this technique attractive for commodity as well as reliability-critical applications.

Activities in computer engineering have also led to significant graduate course development. Current offerings in computer engineering include the following, several of which are co-listed with the Department of Computer Science and Engineering.

ECE 807 - Computer System Performance and Measurement
ECE 808 - Modeling and Discrete Simulation
ECE 809 - Algorithms and Hardware Implementation
ECE 813 - Advanced VLSI Design
ECE 814 - Embedded Wireless RF Transceivers
ECE 816 - Cryptography and Network Security
ECE 820 - Advanced Computer Architecture
ECE 802-602 - Evolutionary Computing
ECE 802-606 - Low Power Analog and Mixed Signal VLSI Syst.
ECE 802-606 - Multimedia Networking
ECE 802-609 - Mobile Networks: Protocols and Systems
ECE 802-610 - Mixed Signal Prototyping and Testing

The expanding research area of computer engineering is important to the education of the department's graduate students for several reasons. First and foremost, it provides the thesis opportunities that are so critical to the training of students for their later work in industry, government laboratories, and academia. Secondly, the involvement of faculty and graduate students in new areas of externally funded research leads to a vigorous faculty/student team interaction. And thirdly, the involvement of the faculty in new areas of research results in new graduate classes that enrich the graduate program curriculum.

— Don Reinhard, associate chair and graduate program coord.

ECE FACTS and FIGURES

Faculty	40
Emeritus Faculty	17
Support Staff	13
Temp. Research & Teaching Staff	12
Undergraduate Students (Fr-Sr) (EE = 407, CPE = 301)	708
Graduate Students (MS = 54, PhD = 109)	163
Research Expenditures in 03-04 =	~$8.8M

Research News Report

Our department's research volume (in terms of external funding, publication production, and PhD students) has been on the increase for the past several years. This past quarter was no exception. Research production is going strong throughout the department and, significantly, no single research group is responsible for more than 10 percent of the total research base. Hence, the research base is diverse as well as robust. Many of our faculty members have, in aggregate across the several projects in which they are concurrently participating, external research programs that are competitive with the best in the nation.

The scope of current and ongoing large research projects is also very encouraging. One goal of the department is to increase the number and size of large extramural awards within the department since they lead to both enhanced visibility and stability. Several of the larger single projects are highlighted in this column. Many of these projects are interdisciplinary in nature and hence of particular interest to the College of Engineering and Michigan State University.

Professors Dean Aslam, Andrew Mason, and **Percy Pierre** are funded by the Wireless Integrated Microsystems (WIMS) Center. This engineering research center is funded by the National Science Foundation as well as various industrial partners and the State of Michigan. The WIMS Center represents a partnership between Michigan State University, the University of Michigan, and Michigan Tech. Professor Aslam is serving as an associate director as well as running active research projects within WIMS. At MSU, the WIMS faculty members are leading efforts in diamond-based micro-electromechanical (MEMs) devices, diamond packaging, and design of a universal interface for WIMS devices. Aslam has also introduced new courses at MSU in concert with the WIMS center as well as developed a K-12 outreach program. In addition, **Drew Kim** of the College of Engineering's Diversity Programs Office, is leading a very active outreach program in connection with WIMS activities. During reviews of the center conducted by the NSF, the educational and outreach activities of the WIMS center have received special commendation from NSF. Recently, the WIMS center was recommended for continuation beyond the initial five-year grant period. WIMS funding at MSU is typically more than $400K per year. If the full ten-year ERC funding is exercised, the total WIMS investment in MSU research, education, and outreach will exceed $4M.

Professor Jes Asmussen is leading a team of researchers from ECE in collaborations with Fraunhofer USA. Faculty participants from ECE include **Professors Tim Grotjohn, Donnie Reinhard, Ning Xi, Tim Hogan, Leo Kempel,** and **Karim Oweiss**. The Fraunhofer Center for Coatings and Laser Applications (CCL) is headquartered on the MSU East Lansing campus in the Engineering Research Complex. The Coatings Division is managed by Dr. Thomas Schuelke, an adjunct associate professor in ECE, while the Laser Applications Division is managed by Mr. Eric Stiles and is located in Plymouth, Michigan. Fraunhofer/CCL bridges the gap between basic research results and practical manufacturing processes. Fraunhofer at MSU has numerous research contracts with various industries, collaborations with other Fraunhofer institutes and centers in Germany and the United States, and is funding several projects on campus. An example of Fraunhofer/MSU collaboration involves the development of diamond foils for use in the National Superconducting Cyclotron Laboratory (NSCL) at MSU. These foils are used to strip electrons from a beam of particles for use in high energy research. The diamond foils developed by Fraunhofer for the NSCL will last longer than conventional foils and hence result in more "uptime" for the facility. Over a five-year period, Fraunhofer's investment in MSU research will exceed $8M.

Professors Satish and **Lalita Udpa** manage a research program involving the nondestructive inspection of Bjork-Shiley heart valves. These were some of the original heart valves that gave new hope to many individuals requiring heart valve replacement. Unfortunately, some of these valves have been found to develop cracks after years of use and therefore require replacement. Since it is generally not good practice to replace a valve that is not expected to fail in the near term (due to the risks of heart surgery), a method for noninvasively inspecting the implanted valve is needed. The ECE department is collaborating with colleagues in the College of Veterinary Medicine, who are conducting animal studies as part of this effort. To date, the ECE department at MSU has been awarded over $3.6M, and we have achieved significant success. This research project is responsible for additional funding to ECE's partner, the College of Veterinary Medicine.

Professor Ning Xi was recently awarded a project by the Office of Naval Research (ONR) involving the development of nano-sensors using carbon nanotubes that are assembled using an atomic force microscope (AFM). This project will result in exceptionally sensitive sensors with a myriad of applications — in defense, homeland security, and civilian domains. When all the options are exercised, the project will have expended $1.12M over three years.

— Leo Kempel, associate professor and research program coord.

Smart Microsystems continued from page 1

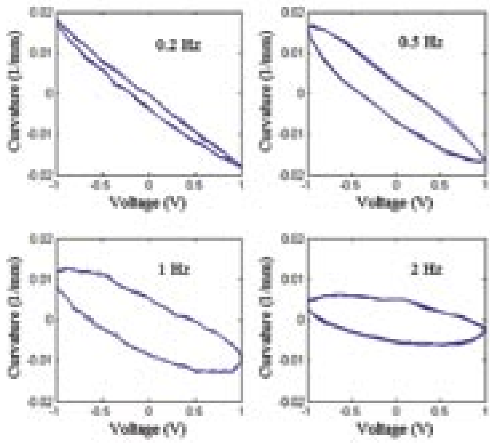


Figure 2. Nonlinear behaviors of an IPMC sample under excitations of different frequencies, demonstrating coupling of hysteresis with dynamics.

In addition to modeling and control of smart materials, novel applications of smart sensors and actuators in active sensing and micromanipulation are also being actively pursued in the lab.

Modeling and Control of MEMS

The past two decades have witnessed significant progress in the arena of MEMS fabrication. Modeling and control techniques are essential for the design of microsystems with high degrees of functionality and complexity and for their reliable operation.

Forces downscale differently with the linear dimension l of a micro-device/system. For instance, gravity scales as l^3, friction scales as l^2, while surface tension scales as l. A direct consequence is that dominant players in microsystems are different from those in macrosystems. For instance, friction could be much more important than gravity in some applications. Macroscopic models could also break down at microscales due to qualitative changes of physical processes, or due to coupling of multiple energy domains within a tiny volume. All these factors call for a careful reevaluation of factors when it comes to modeling of microsystems.

As an example, researchers of the Smart Microsystems Laboratory collaborate with their counterparts in the MEMS Sensors and Actuators Laboratory at the University of Maryland in characterizing and modeling friction in silicon-based microball bearings. Such bearings are expected to provide a low-friction and robust alternative to existing sliding-based contact bearings or sophisticated air bearings in micromachines. This study is expected to provide valuable information for improving bearing design and for controlling micromachines (e.g., micromotors, microgenerators) that employ such bearings.

Swarm Intelligence and Networked Control Systems

With the advent of pervasive sensing, computation, and communication, we are witnessing an increasing convergence of control and communication paradigms. Examples of networked control systems include MEMS sensor and actuator networks, robotic swarms, and automated highway systems, to name just a few. The large scale of such systems necessitates the use of a distributed/decentralized approach to control and communication.

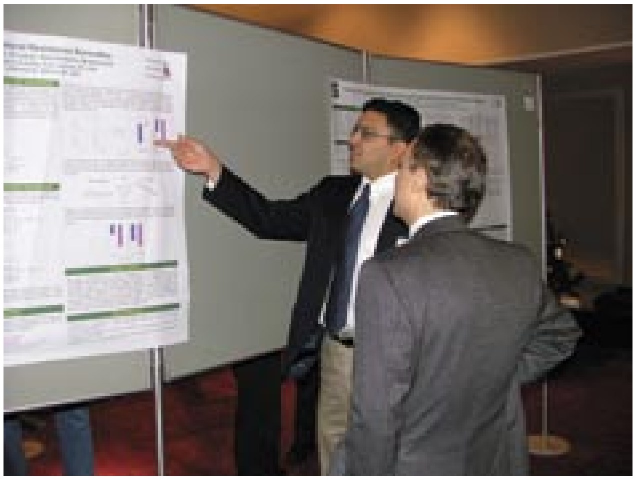
Inspired largely by the behavior of bacteria and social insects, research is currently underway in the Smart Microsystems Laboratory to explore control methods for achieving global goals by regulating simple local interactions. One of the approaches based on the theory of Markov random fields has been applied successfully to the control of autonomous swarms. The problem of joint quantization and control is also being investigated in this context in an attempt to understand the tradeoff between the communication consumption and the system performance.

— Xiaobo Tan, assistant professor

ECE students, left to right, Anthony Cerri, Zheng Chen, Jason Malinak, and Christopher Ziel, are testing a two degree-of-freedom robotic arm made of IPMCs.

Xiaobo Tan, far right, explains artificial muscles and their applications in biomimetic robots and biomedical devices, to visitors during the Science, Engineering and Technology (S.E.T.) Day.

Research in The Physiologic Signal Processing and Modeling Laboratory



Rama Mukkamala, left, explains his research to a visitor during the Pfizer/MSU poster presentation on November 30, 2004.

The Physiologic Signal Processing and Modeling Laboratory (PSPML) was established within the Department of Electrical and Computer Engineering in 2002 and will be supported by the American Heart Association and the National Institutes of Health this summer. The principal aim of the PSPML is to innovate technological solutions to overcome the limitations of current patient monitoring systems, i.e., devices that permit the real-time assessment of critical physiologic parameters so as to guide therapy. To a large extent, conventional patient monitoring systems simply measure and display physiologic signals without attempting to interpret them. As a result, these systems are limited in that they require a high level of invasiveness, necessitate an operator, and/or provide nonspecific clinical information. Solutions that overcome these limitations are especially imperative at present due to the growth in the aging population together with the acute shortage of clinical staff. Indeed, the increasing clinical need for new patient monitoring solutions is demonstrated by the ten percent average annual growth rate of the world patient monitoring equipment industry beginning in 2000 when the market totaled over $7 billion (www.frost.com).

In the PSPML, our general approach to advancing the state-of-the-art of patient monitoring systems is to reveal significant "hidden" information in physiologic signals obtained from available biosensors by employing signal processing and estimation theory with physiologic knowledge. In this way, the patient monitoring systems may become noninvasive or minimally invasive, provide automated physiologic assessment, and/or indicate specific clinical parameters that significantly contribute to therapeutic decision making. To this end, we have formed multidisciplinary research collaborations with life scientists in the Departments of Pharmacology and Toxicology and Small Animal Clinical Sciences at MSU as well as the Department of Physiology at the Wayne State University School of Medicine. With these collaborators, we are currently focused on the development and experimental validation of physiologic-based signal processing techniques for specifically monitoring hemodynamic and neural cardiovascular regulatory function.

Continuous Hemodynamic Monitoring by Pressure Waveform Analysis

Much of the current hemodynamic monitoring systems provide continuous, automatic measurement and display of blood pressures. Invasive fluid-filled catheter systems are utilized in millions of critically ill patients each year to monitor pressures in the radial artery, right heart, and pulmonary artery. Moreover, commercial systems have recently been introduced to measure peripheral arterial blood pressure noninvasively via tonometry and photoplethysmography and right ventricular pressure chronically via implanted devices. The main limitation of these systems is that the measured blood pressures are multi-factorial and therefore not sufficiently specific to guide therapy. For example, hypotension or low blood pressure may be caused by the inability of the heart to fill or contract or the inability of the circulation to return blood to the heart. To distinguish among these possibilities, the cardiac output (total blood flow rate), left heart filling pressure (too unsafe to measure by direct catheterization), and cardiac function indices (e.g., ejection fraction) must also be monitored. While methods are available to measure each of these important hemodynamic parameters, these methods are limited in that they require an operator and either a high level of invasiveness or expensive capital equipment. Thus, the methods may be utilized only intermittently in staffed clinical settings such as critical care units and emergency rooms. In the PSPML, we are analyzing the physiologically related blood pressure waveforms so as to estimate the cardiac output, left atrial pressure, and/or cardiac function indices. In this way, these critical hemodynamic parameters may be automatically monitored, for the first time, in 1) critical care units so as to provide a complete, continuous hemodynamic monitoring solution; 2) home health care systems so as to reduce hospital admissions and health care costs; 3) implanted systems so as to provide optimized therapy on a daily or even continual basis; and 4) combat so as to permit remote triage of casualties.

Probing Neural Cardiovascular Regulation via Multi-Signal Analysis

Neural cardiovascular regulation aims to maintain blood pressures by multiple fast-feedback control mechanisms so as to protect blood flow to the brain, heart, and other vital organs. This regulatory process is often disturbed in disease (e.g., diabetes mellitus, Parkinson's disease, and congestive heart failure). The most commonly employed method for monitoring neural cardiovascular regulation in the clinic is to observe the blood pressure fall in response to upright body tilting. However, this blood pressure response is the collective result of many distinct physiologic mechanisms acting together and is therefore not specific to any particular neural cardiovascular regulatory mechanism. While spectral analysis of subtle, beat-to-beat fluctuations in heart rate has been shown to provide more specific information, a single cardiovascular signal is not informative enough to be able to distinguish between each distinct neural cardiovascular regulatory mechanism. In the PSPML, we are analyzing and modeling the dynamic relationship between the beat-to-beat fluctuations in multiple cardio-respiratory signals so as to permit, for the first time, non-invasive monitoring of the 1) neural control of the peripheral circulation and 2) selective functioning of the two cardiac autonomic nervous branches. These techniques may ultimately be utilized to guide more specific therapies and serve as the basis for risk stratification in patients suffering from various disease processes.

The above research activities and others are well under way in the recently formed PSPML. Our hope is that the fruits of this research ultimately reach clinical practice so as to meet the increasing demands on today's and tomorrow's patient monitoring systems.

— Ramakrishna Mukkamala, assistant professor

Retirement

Percy Pierre Retires - Actively

Percy Pierre began his career at Michigan State University in 1990 as the vice president of research and graduate studies and professor of electrical engineering. During his five years as vice president, he provided leadership that substantially increased the federal research and education dollars coming to the university. He was the lead administrator for the facilities grant for the Food Safety/Toxicology Center, the largest federal facilities grant ever received by MSU up to that time. He enhanced the university's national reputation through his service on national commissions and boards, including the Commission on the Future of the National Science Foundation, the Defense Science Board, and the Board of Overseers of the Fermi National Accelerator Laboratory. On the home front, he implemented the reestablishment of the Graduate School and created the Office of Intellectual Property and the position of University Integrity Officer.

Since 1996, Pierre has held a full-time position in the Department of Electrical and Computer Engineering, teaching undergraduate and graduate courses in the area of signals and stochastic processes. During that time, he has worked with research specialist Barbara O'Kelly to increase the number of under-represented minorities in engineering graduate programs while maintaining a high rate of retention and graduation. They have secured grants to support their programs and students, including the Alfred P. Sloan engineering program. Their initiatives have fostered a 36 percent increase in the enrollment of African American and Hispanic doctoral students in the College of Engineering.

Pierre earned his BS (1961) and MS (1963) degrees at the University of Notre Dame. He received his doctorate from The Johns Hopkins University in 1967, becoming the nation's first African American electrical engineering PhD. After a post-doctoral appointment at the University of Michigan, he accepted a position with the Rand Corporation in 1968. "I felt good about having made it," Pierre said, "but I felt that there was something wrong with being the only one." That impulse evolved into a drive to open the doors to engineering careers for minorities that has spanned more than 30 years. He held leadership positions at two historically Black universities (Dean of Engineering at Howard University and President of Prairie View A&M University) in addition to serving as a part-time program officer for the Sloan Foundation and as Assistant Secretary of the Army for Research, Development, and Acquisition.

Retirement continued from previous page

On May 4, 2004 he was honored as one of the founders of the National Action Council for Minorities in Engineering Inc. (NACME) at a lavish 30th anniversary gala in New York City. Over its 30 years, NACME has provided more than $100 million to nearly 18,000 black, American Indian, and Hispanic students at 160 colleges and universities. "Percy Pierre is a distinguished educator and public servant," said NACME president and CEO John Brooks Slaughter. He helped lay the foundation for what eventually became NACME and continues to serve as an inspiration to minority students and the engineering community."

Although he is officially retired, Pierre has a half-time appointment in the department to actively supervise the programs he directs, mentor the students participating in them, and guide the institutions on whose boards he serves. He and his wife plan to enjoy their home in New Orleans, visit their daughters on the east coast, and travel around the world.

In Memoriam

L. J. Giacoletto (1916-2004)

Lawrence J. Giacoletto, Professor Emeritus of electrical engineering at Michigan State University and inventor, died of a heart attack on October 4, 2004 at his home in Okemos, Michigan. He was the creator of the hybrid-π transistor model and the inventor of the transistorized automotive ignition system. He was a participant in the original development of an all-electronic compatible color television system.

Born on November 14, 1916, in Clinton, Indiana, Lawrence Giacoletto received his BS degree in electrical engineering in 1938 from Rose-Hulman Institute of Technology and his MS degree in physics from the State University of Iowa in 1939. He then began his PhD in electrical engineering at the University of Michigan, but had to postpone his studies to serve in World War II, and subsequently received his PhD in 1952.

From 1941 to 1945, he was stationed at the Army Signal Corps Laboratories in Fort Monmouth, New Jersey. Here he was responsible for research and development work on navigational systems, communications and meteorological direction finders, and related equipment. In August 1945, he was sent to postwar Japan to do technical intelligence on Japanese electronic equipment. He subsequently retired from the army as a lieutenant colonel in 1946. That spring, he joined the Electron Tube Research Group as a research engineer at the RCA Laboratories in Princeton, New Jersey. Initially, his project was to develop improved high-frequency electron tubes for black-and-white TV applications. Later, when RCA Laboratories became involved in a crash program to develop an all-electronic color television system, he was asked to fabricate an electron tube for high-speed dot-sequential sampling. His contribution and others led to the successful development of the RCA color television system, which was compatible with the existing black-and-white transmission system.

When Bell Laboratories announced the invention of the transistor in June of 1945, essentially all members of the Electron Tube Research Group became involved with work related to the transistor. Giacoletto's first contribution was a comparison of the junction transistor with the electron tube.

In mid-1951, a Bell Laboratories grown-junction transistor was obtained for evaluation. Measurements were first made using an electron-tube test set. These measurements quickly established that there was a large capacitance associated with the base terminal. More detailed measurements indicated that there was a base-terminal series resistance which, together with the base capacitance, seriously limited the medium-frequency performance. This discovery led to fabrication of alloy-junction transistors with improved higher frequency performance, which in turn provided devices for a wide array of transistorized apparatuses including the first-ever transistorized TV receiver. Specially designed test equipment was used to further define the alloy-junction transistor. Detailed measurements led to the development of a hybrid-π equivalent circuit for junction transistors and to the development of a noise factor for evaluating performance. As color TV was being developed commercially, a significant problem with the drift of the local oscillator frequency became apparent. A semiconductor diode with improved UHF properties was developed for automatic frequency control of the TV local oscillator. This diode, now known as a varactor, proved to be highly successful.

In 1953, General Motors engineers were visiting the RCA Laboratories to assess the potential of plasma research for possible replacement of the contact points in automobile ignition systems. Giacoletto recognized that the junction transistor would be a possible replacement. A bench experiment quickly established satisfactory operation. Unfortunately, the operation lasted only a few minutes, at which point the transistor exhibited a short circuit between collector and emitter with valid diode action still present between base and emitter or collector. This was probably the first observation of second breakdown phenomena, which were to plague transistor operation in its early days. In 1961, transistor designers succeeded in increasing the breakdown voltage to the point where transistorized ignition systems rapidly became standard in all automobiles.

In 1956, after 10 years at RCA Laboratories, Giacoletto left to become manager of the electronics department at Ford Motor Co. Scientific Laboratory. His group was primarily responsible for exploring electronic applications to automobiles, especially as related to electric propulsion. He was one of the original promoters of the hybrid electric car. Besides automotive applications, the electronics department developed an intracardiac pressure pickup, a blood flow meter, and a hand dynamometer. They even prototyped a scaled-down energy efficient home using semiconductor solar cells.

In 1961, Giacoletto moved to Michigan State University as professor of electrical engineering. His experiences in industry made him the consummate teacher of design. To bring new and innovative ideas to the classroom, as well as to keep abreast of current research, he spent summers at several research labs including IBM, Bell Labs, and Hughes Aircraft. He retired in 1987.

Professor Giacoletto founded the CoRes (Cooperative Research) Institute in 1961. Here he continued not only his research on automotive electronics but explored ideas to improve products such as salt water converters, furnace humidifiers, surgical knives, and transformers. He had a lifelong interest in motors and power conversion. Inspired by the unipolar motor first proposed by Faraday in 1831, he invented the homopolar alternator in 1985. His passion for research was never-ending, especially his drive to understand how things worked.

The author of more than 70 technical publications and 22 patents, Giacoletto was a coauthor of the *RCA Laboratories Transistor I* (1956) book, author of the *Differential Amplifiers* (1970) book, and editor of the *Electronics Designers' Handbook* (1977), as well as a contributor of seven chapters. His last publication was at age 83. Besides being a fellow of the IEEE, he was also a fellow of the American Association for the Advancement of Science. He served as the chairman of the Monmouth-Princeton and Southeastern Michigan sections of the IEEE. He was a member of the IEEE board of directors and served as chairman of the IEEE Field Awards Committee. He was a member of the American Physical Society and Sigma Xi. For his achievements, he has been listed in several compilations of *American Men of Science* and *Who's Who in America*.

Professor Giacoletto is survived by his wife of 63 years, Maxine; his daughter Carol, vice president of Bank One in Lansing, Michigan; brother John, retired vice president of Collins Radio Company of Canada; and many nieces, nephews, and grandnieces and grandnephews.

— by Gregory M. Wierzba, associate professor

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