IOWA STATE UNIVERSITY
Department of Electrical and Computer Engineering

AUGUST 2010

Research Highlights

Creating Solutions to Global Grand Challenges

www.ece.iastate.edu

Department Overview

Fast Facts

- **Established:** 1909
- **Alumni:** More than 11,000
- **Research Centers & Institutes:** 11
- **Endowed Professorships & Chairs:** 9

New Facilities & Equipment (2008-10)

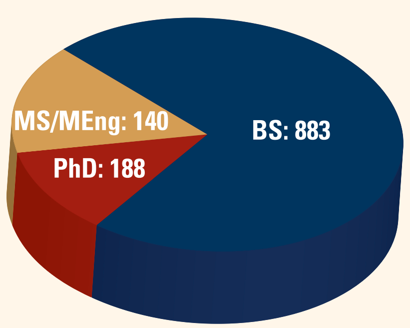
- Sun Microsystems supercomputer acquired
- Real-time power grid simulator acquired
- Raith e-line lithography system acquired
- 9 new research laboratories established

Honors (2008-10)

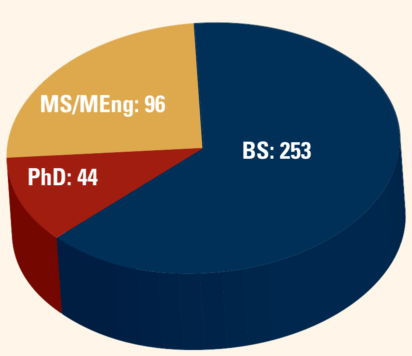
- **New IEEE Fellows:** 2
- **Best Paper Awards:** 9
- **Patents Awarded:** 15
- **Journal Editorships:** 24
- **Conference Keynote Speakers:** 13

Students

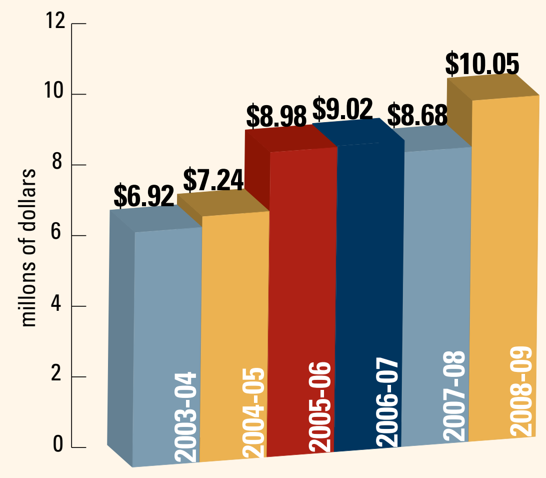
Enrollment (Fall 2009)



Degrees Awarded (2008-10)



Research Expenditures



Funded Research Proposals

- **FY08:** $7.2 million
- **FY09:** $16.5 million

Private Funding (2008-10)

- **Organization Gifts:** $2.3 million
- **Individual Gifts:** $1.1 million
- **Scholarships Awarded:** Nearly $250,000 annually

Faculty/Staff Details

- 51 faculty (not including courtesy or adjunct faculty)
- 12 NSF CAREER Award winners
- 8 IEEE Fellows (out of 14 full professors)
- 1 ACM Distinguished Engineer
- 20 staff

Full-time Equivalent (FTE) Faculty Data (2008-10)

- **Faculty FTE:** 43.6
- **PhD degrees awarded per FTE:** 1.01
- **MS/MEng degrees awarded per FTE:** 2.22

Iowa State University
Department of Electrical and Computer Engineering

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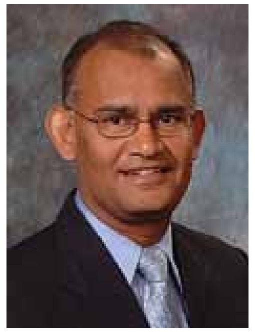

Letter from the Chair

It is my pleasure to present you with our 2010 *Research Highlights* biennial report. We are pleased to include highlights of faculty winning National Science Foundation CAREER awards, new research laboratories under development in our department, and research accomplishments of faculty in the areas of ultrasound technology, energy infrastructure, compressed sensing, VLSI, and computer processor design and performance.

By the time you receive this publication, I will be in the process of stepping down as chair of the Department of Electrical and Computer Engineering (ECpE), and a new department chair will be on his way to Iowa State. When I became the department's chair in 2003, we created a new strategic plan, and in 2004, we began implementing it. Our report this year illustrates how our department has grown under this plan, which called for strengthening our undergraduate education and PhD program, and concentrating our research in five strategic areas: bioengineering, cyber infrastructure, distributed sensing and decision making, energy infrastructure, and small-scale technologies.

This plan has served the department well and has helped us focus our faculty recruiting efforts to identify and hire candidates in areas key to the department's current and future growth, and it has helped the department and faculty expand our research programs. In fact, the department's research expenditures have nearly doubled in the past five years since this plan has been in place. The production of PhD students also has improved.

It is with great satisfaction in knowing the department is on a path to continue to hold true to our reputation for providing a quality education to students and excelling in innovative research activities that I am ready to move on to a new chapter in my career. I will be returning to my position as a professor in the department and will continue my research in computing and networking systems, as well as my work teaching and mentoring students.

The new department chair, **David Jiles**, is no stranger to Iowa State. He was an Anson Marston Distinguished Professor of Engineering in Iowa State's materials science and engineering and ECpE departments through 2005. He has led a distinguished career and we welcome him back to Iowa State to be the next leader of the ECpE department and we wish him success.

Best regards,

Arun K. Somani
Anson Marston Distinguished Professor
Jerry R. Junkins Endowed Chair
ECpE Department Chair

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features

GRADUATE STUDENT PHOTO BY PATRICK HERTEEN

JILES PHOTO COURTESY OF DAVID JILES

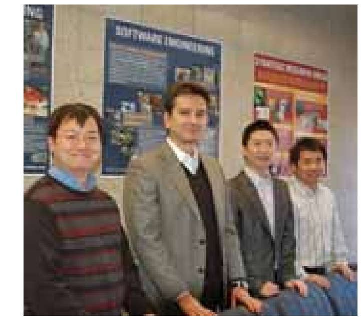
Four ECpE Professors Receive New NSF CAREER Awards

Four Iowa State University electrical and computer engineering assistant professors received prestigious National Science Foundation CAREER Awards in 2009 and 2010:

Dionysios Aliprantis will research methods to decrease the weight and size of motors and generators, as well as improve their efficiency and cost-effectiveness. His project is called "Sculpting Electric Machines for Unidirectional Motion."

Liang Dong's research focuses on developing a state-of-the-art, universal photonic circuit platform that will advance smart sensor applications in fields such as photonic computing, optical communication, environmental monitoring, biochemical defense, and lab-on-a-chip technology. His project is titled, "Programmable, Reconfigurable, and Tunable Photonic Integrated Circuit Platform through the Fusion of Photonic Crystals and Nano-Electro-Mechanical Systems."

Jaeyoun Kim plans to create an ultra-wide field-of-view imaging system inspired by biological systems. His project is called "Bio-inspired MEMS Imaging Platform with Ultrawide, Dynamically Tunable Field-of-View for Biomedical and Assistive Applications."



From left to right: Jaeyoun Kim, Dionysios Aliprantis, Lei Ying, and Liang Dong

Lei Ying is establishing a new approach for building wireless networks for mission-critical applications, including wireless mesh networks that are used for emergency response and public safety, wireless sensor networks used for medical technologies and unmanned surveillance of U.S. borders, vehicular networks that use accident warning technology, and in cellular networks for users who use many forms of real-time streaming media. His project is titled, "Meeting Deadlines: Theories and Algorithms to Support Delay Constrained Communication in Wireless Networks."

In addition, **Timothy Bigelow** was newly hired in fall 2008 and brought with him an NSF CAREER award. ■

More Online

To learn more about the NSF CAREER projects of Dionysios Aliprantis, Liang Dong, Jaeyoun Kim, and Lei Ying, visit *www.tinyurl.com/ECpENSF2010* and *www.tinyurl.com/ECpENSF2009*.

Bioengineering Introduced as New Core Research Area

The ECpE department established bioengineering as a new core area of research and graduate study in 2009. The new area will bring together faculty conducting research in bio-optics, bio-electromechanical systems, biomedical imaging, bio-signal processing, bioinformatics, and other areas of bioengineering under one umbrella, helping them to identify common goals and challenges.

For graduate students, this new core area will allow them to take courses in three broad areas: bio-signal processing, bioinformatics, and bio-microsystems.

More information about the bioengineering core research group is online at *www.ece.iastate.edu/research/bioengineering*. ■

ECpE Welcomes New Palmer Department Chair

David Jiles has been appointed the Palmer Department Chair in Electrical and Computer Engineering. He will begin this fall.

Jiles is currently the director of the Wolfson Centre for Magnetics and professor of magnetics at Cardiff University in the United Kingdom. He formerly was an Anson Marston Distinguished Professor of Engineering at Iowa State—a rank he will resume—and held a joint appointment with the ECpE and materials science and engineering departments. He has maintained his ties with the college as a collaborating professor and with the U.S. Department of Energy's Ames Laboratory as a research associate since he went to Cardiff in 2005.

Jiles is the first Palmer Department Chair recipient. The endowed chair was created in March 2010 through additional earnings from an endowed faculty position established by Iowa State alumni Barbara R. and **James R. Palmer** (BSEE '44) in 1986. ■

David Jiles

More Online

For more information on David Jiles and his appointment as chair, visit *news.engineering.iastate.edu/?p=1818*.

Srinivas Aluru

Rana Biswas

Vikram Dalal

Three Faculty Named IEEE, APS Fellows

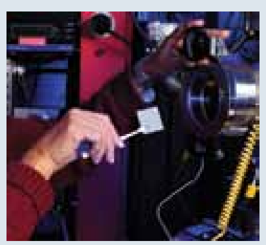
Three ECpE faculty were named fellows of their fields' major professional organizations:

Srinivas Aluru, the Ross Martin Mehl and Marylyne Munas Mehl Professor of Computer Engineering, was named a fellow of the Institute of Electrical and Electronics Engineers (IEEE) for his extraordinary contributions to the field of computational biology. Aluru's work to sequence the maize genome recently was featured in *Science* magazine, and he was named a 2007 finalist for the Computerworld Honors Program's 21st Century Achievement Award.

Rana Biswas, an adjunct professor of electrical and computer engineering and physicist at the U.S. Department of Energy's Ames Laboratory, was named a fellow of the American Physical Society for his theoretical contributions to the dynamics of semiconductors, solar materials, and photonic crystals.

Vikram Dalal, the Thomas M. Whitney Professor of Electrical and Computer Engineering, was named a fellow of IEEE for his contributions to thin-film solar photovoltaic energy conversion materials and devices. Dalal has authored or coauthored more than 140 refereed publications in scholarly journals and conference proceedings. He also holds 11 U.S. patents. ■

Professor Receives $1.69 Million Solar Energy Research Grant



Vikram Dalal is working to boost thin-film solar cell efficiency.

In 2009, **Vikram Dalal**, the Thomas M. Whitney Professor of Electrical and Computer Engineering and director of the university's Microelectronics Research Center, received a three-year, $1.69 million grant from the Iowa Power Fund, a state program to support energy innovation and independence, to improve thin-film solar cell technology.

Through this research project, Dalal hopes to boost thin-film solar cell efficiency to about 10 percent, rather than the current 7 percent.

The project has three primary goals:

- Study, characterize, and optimize new silicon alloys that can be used in photovoltaic cells that convert sunlight directly into electricity.
- Develop new solar cell structures that optimize the performance of the new materials.
- Study how semiconductors based on organic molecules can be used in solar applications.

The project also includes work in the maturing field of thin-film silicon-based photovoltaic technology. And it includes work in the emerging field of organic semiconductors.

"Looking 20 years out it's very clear that organic semiconductors will be a major player in photovoltaic technology," Dalal says. "The technology is in its infancy. And if we don't nurture a technology in its infancy, how do we grow a mature technology? I'm hoping Iowa State can become a leader in this field and help make a smooth transition from our current technology."

This project supports the work of Dalal and six other Iowa State University faculty members plus eight graduate students, including ECpE faculty members: **Rana Biswas**, **Sumit Chaudhary**, **Jaeyoun Kim**, and **Ruth Shinar**. The researchers also are collaborating with chemistry professor Malika Jeffries-El, PowerFilm of Ames, and Micron Technology of Boise, Idaho, and have support from the Iowa Energy Center.

Dalal hopes the research at Iowa State can contribute to the continued growth of solar energy, making it a major energy option for the future.

"Our whole objective is to achieve greater solar efficiency without sacrificing cost," he says. "We want to do this better and cheaper. Only then can solar penetrate the large-scale utility market." ■

—Excerpt from article by Mike Krapfl

DALAL RESEARCH PHOTO BY BOB ELBERT

IT-Adventures Program Brings Students to ECpE Fields, Careers

Iowa State University hosted the third annual IT-Olympics on campus last spring. The competition, which is the culmination event for a yearlong IT-Adventures program, attracted nearly 500 students from more than 45 Iowa high schools who competed in three areas: robotics, cyber defense, and video game design programming.

Doug Jacobson, university professor and director of the Information Assurance Center, began the IT-Adventures program in 2007-08. The program is dedicated to increasing interest in and awareness of information technology (IT) and related careers among high school students using fun, inquiry-based learning activities in three content areas. It encourages high schools throughout Iowa to establish local IT-Clubs and arranges for local IT professionals to mentor the students and their teachers by helping them when they experience technical problems in their labs, experiments, or project challenges. Iowa State provides the IT-Clubs with the tools they need to get started and continue their clubs at no cost to the students or schools. Corporate sponsorships, foundations, and donations from individuals provide financial support for the program.

Jacobson developed the program to respond to a national downward trend of students who elect to study an IT-related curriculum in college and graduates who enter the workforce as IT professionals. As a result of the program, he hopes to increase the number of high school students who are interested in IT careers and increase the number of undergraduates who enroll to study IT-related fields at community colleges and four-year universities.

So far, the program is working. Of the students who have participated in IT-Adventures and its predecessor programs in the past five years, nearly 80 students have enrolled at Iowa State in an IT-related area. More than 30 of those students enrolled in electrical, computer, or software engineering. ■

Students participate in the robotics, *above*, and cyber defense, *below*, competitions.

See videos about IT-Olympics and the IT-Adventures program online at *www.youtube.com/ECpEdepartmentISU*.

Iowa State Named a Sun Microsystems Center of Excellence

Because of the ECpE department's new supercomputer, nicknamed "Cystorm," Iowa State University is now designated as a Sun Microsystems Center of Excellence for Engineering Informatics and Systems Biology.

The computer, a Sun Microsystems machine, was acquired in 2009. It boasts a peak performance of 28.16 trillion calculations per second—five times faster than CyBlue, an IBM Blue Gene/L supercomputer that has been on campus since 2006.

Srinivas Aluru, the Ross Martin Mehl and Marylyne Munas Mehl Professor of Computer Engineering, and other Iowa State researchers purchased the computer with a $719,000 National Science Foundation grant; $400,000 from Iowa State colleges, departments, and researchers; and a $200,000 equipment donation from Sun Microsystems.

The computer will assist materials science, power systems, and systems biology researchers on campus. ■

—Excerpt from article by Mike Krapfl

SUPERCOMPUTER PHOTO BY BOB ELBERT

ECpE Offers New Master of Engineering Degrees

In Fall 2009, the ECpE department began offering two new degrees: a Master of Engineering in electrical engineering and Master of Engineering in computer engineering.

The new degree programs allow students to earn a coursework-only degree through Engineering Distance Education at Iowa State University and are targeted toward students who do not wish to pursue research-based careers. The programs answer a call from industry to allow professionals more flexibility to earn master's degrees.

Additional details on the new degree programs are online at *www.ece.iastate.edu/students/graduate-students*.

Targeting Cancer

An electrical engineering professor invents a new ultrasound therapy system to replace surgical treatments for eliminating cancer cells.

BY **DANA McCULLOUGH**

In the year 2050, the American Cancer Society estimates that 27 million people worldwide will be diagnosed with cancer and 17.5 million worldwide will die from the disease. In fact, 1 in 2 American men and 1 in 3 American women will develop some form of cancer in their lifetime. And cancer is currently the second leading cause of death for people in the United States.

The numbers sure are scary, and so are the chemotherapy, radiation therapy, and surgical treatments patients must undergo to cure their disease, but Assistant Professor **Timothy Bigelow** has worked for the past couple years on a funded National Science Foundation CAREER project to change that. Bigelow is developing a much less frightening and less expensive way for cancer patients to be treated for the ubiquitous and life-changing disease: a new, innovative ultrasound therapy system that would replace surgical treatments.

"Rather than going in for surgery, the tumor would be hit by high-powered sound waves and as a result, the tumor would be disintegrated," Bigelow says.

"Rather than going in for surgery, the tumor would be hit by high-powered sound waves and as a result, the tumor would be disintegrated."

Revolutionizing treatment

During the past year, Bigelow and his graduate and undergraduate students have invented an innovative prototype for his ultrasound therapy system. The system uses four small ultrasound sources and focuses the sound waves from those sources to a very sharp point that targets and destroys the cancer cells. Electrical and computer engineering students in the department's senior design course are creating the circuitry to drive the ultrasound source.

"The goal is to excite small bubbles in the tissue and once those bubbles get excited they can collapse violently and create jets of fluid that impact the cells," Bigelow says. "As they impact the cells, they can shred the cancer cells and rip them apart."

Once the cancerous tissue is killed, cell remains would be reabsorbed or excreted from the body. After undergoing ultrasound therapy, it is likely patients also would undergo other forms of cancer treatment such as radiation or chemotherapy, to help reduce the likelihood of cancer returning, just as they would do if they had surgery to remove a cancerous tumor.

Bigelow's system is different from other ultrasound therapies in two ways. First, Bigelow's system uses mechanical shredding to eliminate cancer cells, while most others use heat to accomplish the same task. Those thermal methods require the use of MRI machines, rather than less expensive, traditional ultrasound machines, to monitor the effectiveness of the therapies. Second, other therapies similar to Bigelow's that use sound waves require one large ultrasound frequency source and operate under the assumption that lower frequencies are always better. In contrast, Bigelow's therapy system uses four frequency sources that can operate at higher frequencies. His research indicates that frequency may not be as critical as previously thought, allowing for higher frequency ultrasound sources to work.

"We have found that increasing the frequency could provide better spatial control of the

Timothy Bigelow stands in the Biomedical Engineering Laboratory where he researches ultrasound technology.

Medicine Man

Assistant Professor **Timothy Bigelow** knew since he was an undergraduate student that he wanted to do research that had a significant impact on people's lives. His lofty research ambitions sparked his involvement in three other biomedical research projects currently underway:

Ultrasonic imaging for detecting breast cancer: Bigelow is a consultant on a $4.7 million National Institutes of Health research project, led by the University of Illinois at Urbana-Champaign's William D. O'Brien, Jr., and the University of Wisconsin, Madison's Timothy J. Hall. The goal of this project is to use ultrasonic imaging to perform biopsies of potentially cancerous lumps. This means patients would no longer need to undergo a painful biopsy procedure in order to find out if a lump is benign or malignant, making more people more likely to have the procedure done, and receive treatment earlier.

Determining risk of premature delivery for babies: For this project, Bigelow is collaborating with a nurse from the University of Illinois, Chicago, to assess the likelihood of babies being delivered prematurely by looking at echocardiograms from ultrasounds. Bigelow's collaborator sends him data from ultrasounds and Bigelow uses signal processing techniques to determine premature delivery risks.

Noninvasively killing infections on implantable medical devices: When a medical device such as a pacemaker or heart valve is surgically inserted into a patient, there is always a risk of infection. Currently, the only way to treat an infection is to do another surgery and replace the implant with a new device. Bigelow is working on a project to use ultrasound technology to kill the infections that form on those medical devices, thus eliminating the need for patients to have additional major surgeries and dramatically improving their quality of care.

More Online

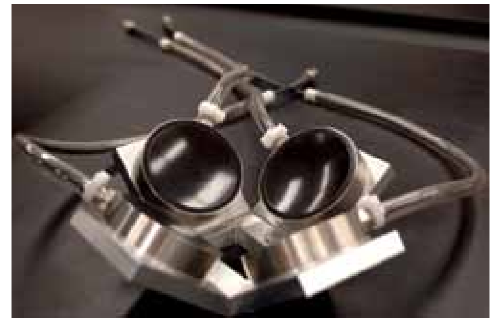
See a video of Timothy Bigelow discussing his ultrasound therapy research online at *www.tinyurl.com/bigelowresearch.*

tissue damage in a clinical setting," Bigelow says. "With four frequency sources, it also will be more reliable than one large source. If one out of four sources dies, you can replace it for less money than if you have one big source. The two main advantages of our system is that it is less expensive and it is easier to monitor than other ablation therapies."

Maximizing effectiveness

Bigelow says the next step in his research is to find the optimal settings for the therapy system—such as determining appropriate pulsing sequences—to maximize the destruction of cancerous tissue, while minimizing risk to the patient. After that, he will test the therapy in guinea pigs.

Determining the optimal ultrasound parameters for destroying the targeted tissue to ensure all the cancerous tissue is killed during the therapy procedure is a major hurdle in Bigelow's research. For example, when



This prototype for Bigelow's ultrasound therapy system uses four identical transducers, each of which focuses the energy in the same location. The square "hole" in the bottom middle will accommodate an ultrasound imaging transducer to monitor the therapy.

a doctor performs surgery to remove a tumor, the doctor cuts around the tumor to a sufficient depth to make sure he gets the whole tumor out. With ultrasound therapy, researchers and doctors need to be able to accurately determine the correct margin around the tumor that they need to treat to ensure all cancer cells are eliminated.

"Because the mechanism responsible for the tissue destruction tends to be chaotic, controlling the size of the lesion will require a careful selection and understanding of the relevant ultrasound parameters," Bigelow says. "We've got to target the tumor like a scalpel would."

Bigelow is currently working this year to find those optimal ultrasound parameters so he can begin testing his ultrasound therapy system through animal experiments soon.

Impacting patient care

The results of Bigelow's research could greatly impact health care and quality of life for cancer patients. By removing tumors with ultrasound therapy rather than with deeply invasive surgery, patients will spend less time in the hospital. In fact, Bigelow's therapy system could even be an outpatient procedure and require only a couple days recovery time at home. And because the effectiveness of Bigelow's therapy can be monitored using traditional ultrasound machines, rather than more expensive MRIs, it could reduce the cost of cancer treatments to patients.

Bigelow hopes doctors can begin using his new ultrasound therapy system within about the next decade or so. ■

More Online

To see videos about the NETSCORE-21 project visit *www.youtube.com/NETSCORE21*. For more information about the NETSCORE-21 project, go to *www.ece.iastate.edu/research/research-projects/netscore-21.*

Building America's Energy & Transportation Infrastructure Road Map

An interdisciplinary research team develops a first-of-its-kind tool to optimize planning for 21st-century energy *and* transportation infrastructure in the United States.

BY **DANA McCULLOUGH**

For years coal, petroleum, natural gas, nuclear power, and hydropower have been critical sources of energy in the United States. More recently, solar, wind, geothermal, and clean coal technologies have been introduced into America's energy infrastructure. At the same time, the transportation industry is moving from producing petroleum-guzzling vehicles and diesel-powered trains to manufacturing flex-fuel vehicles, plug-in hybrid-electric vehicles, and electric trains.

As electric power and biofuels are becoming increasingly prevalent in the transportation industry and renewable energy technologies are improving, a group of Iowa State University researchers began asking two questions: How are America's energy and transportation infrastructures—two systems that have operated separately for nearly 100 years—going to intersect in the future? What are the best ways to evolve today's infrastructure to a more sustainable, resilient, and cost-effective system?

The answers aren't easy, but **James McCalley**, the Harpole Professor in Electrical

Key Players

The NETSCORE-21 interdisciplinary team combines researchers from electrical, computer, industrial, mechanical, and transportation engineering. Each researcher plays an integral role in the project:

James McCalley
Professor, Electrical Engineering

Dionysios Aliprantis
Assistant Professor,
Electrical Engineering

Arun K. Somani
Distinguished Professor,
Computer Engineering

Lizhi Wang
Assistant Professor,
Industrial Engineering

Robert C. Brown
Distinguished Professor,
Mechanical Engineering

Nadia Gritzka
Assistant Professor,
Transportation Engineering

Graduate students: **Jinxu Ding**, **Josh Gifford**, **Lizbeth Gonzalez**, **Eduardo Ibáñez**, **Diego Mejia**, **Katerina Rentziou**, **Di Wu**, and **Ying Zhou**

Engineering, and his interdisciplinary team of six faculty and eight graduate students are developing a tool that can give engineers, researchers, energy planners, transportation planners, and policymakers answers to those questions. The $2 million project—the 21st Century National Energy and Transportation Infrastructure Balancing Sustainability, Costs, and Resiliency project, NETSCORE-21 for short—is funded by the National Science Foundation.

"We are already making decisions and legislating lots of things without the ability to test those decisions very well," McCalley says. "With the tool we're developing, we hope it will be useful to guide policy at the national level. There could be directions that are surprising and contrary to what many people have thought for a long time. Our tool gives you the basis to discuss and test in an objective way whether certain energy and transportation policy decisions are wise or not."

Model milestones

Even though individual energy and transportation sectors have had their own off-the-shelf planning tools, none of those tools optimize both energy *and* transportation in their models, nor do they tell policymakers which policies among many are better than others. That is where McCalley's NETSCORE-21 research team comes in.

McCalley's research team recently reached a milestone in their research by completing the first version of their first-of-its-kind software tool, NETPLAN. The software identifies areas where the United States should invest in its energy and transportation infrastructure over the next 40 years. The NETSCORE-21 team's tool is unique because it is the first software modeling tool that accounts for optimizing both energy and transportation infrastructure, as well as optimizes results based on multiple objectives: sustainability, reliability, and cost-effectiveness.

"NETPLAN identifies trajectories we should be going in with respect to investment. The objective is to identify the good solutions. There's no single best solution, and so we need to separate the good from the bad," McCalley says.

The software tool, which uses computational tools such as linear, nonlinear, and integer programming; genetic algorithms; multi-objective optimization; and high-performance computing, considers all forms of energy to find the best solutions.

"We are truly pushing the envelope in terms of high-performance computing and computational algorithms," says **Dionysios Aliprantis**, assistant professor and a co-principal investigator on the NETSCORE-21 project.

McCalley adds that the software has no preference or bias towards any energy source, such as nuclear power or renewables.

"All options are on the table," McCalley says. "We just want to find good solutions. Good means low-cost, good means low environmental impact, and good means resilient."

To McCalley and his research team, a resilient infrastructure means that if a catastrophic, unforeseen disaster such as a hurricane like Katrina or a major earthquake in St. Louis happens, the prices of electricity, natural gas, and petroleum in America would still remain stable.

If one combination of energy resources is desirable due to its resiliency, it doesn't necessarily mean it also is the lowest cost or most environmentally friendly option. That is one of the major challenges of the multi-faceted optimization model McCalley's team is putting together.

"This is a complicated problem to solve," Aliprantis says. "For example, a more environmentally friendly system is typically more expensive than a fossil-fuel based one. Therefore, the tool we are developing is one policymakers will be able to use to analyze the unavoidable trade-offs that long-term investment planning decisions involve."

A few sources of energy are already beginning to emerge as important players for America's energy investment strategy.

"It's been difficult to find a way to exclude wind from new solutions, not simply because it is renewable, but because it also has other positive attributes, including relatively low-cost, no emissions, and a distributed nature," McCalley says. "Solar is still at such a high cost. And geothermal is very attractive and could be a big player in the future because you can deploy it anywhere. Nuclear power also is attractive, in spite of the waste issue. And although hydropower is also a big renewable, and we will certainly retain what we have, there aren't many gigawatts left to develop for future growth."

Driving strategic changes

Even after McCalley and his team finish developing their energy and transportation infrastructure modeling tool, they realize that changes won't happen overnight.

"These kinds of infrastructure changes are changes that take place over years and require a lot of discussion, interaction, and negotiating," McCalley says. "All of those processes are affected by political and socioeconomic issues, but we hope our tool can stabilize the decision making process because what we do in 2030 depends on what we do today and in 2015. There's an intricate and complicated interdependency in terms of what you do at different times."

For example, much of the infrastructure—roads, railways, power plants, and transmission lines—that exist now, will be retiring because they have reached their lifetime limit. The NETSCORE-21 team's plans account for that retiring infrastructure, as well as for new renewable technologies and cleaner fossil fuels, to supply the energy needs of the American people and the transportation industry through the year 2050, while being sensitive to the environmental impacts it has. Strategic planning to account for retiring infrastructure and new technologies is necessary to avoid making billion- or trillion-dollar mistakes on energy policy today.

"To build an energy and transportation infrastructure is an ongoing evolutionary thing that will never be done, never be complete," McCalley says. "So, think of our application not as a single point in time application that we run today, get answers, and are done. You need to run it today and see the best plan, and then continue to rerun it again every year as new information becomes available, so that we are continuously updating a 40-year-ahead national plan in a strategic fashion." ■

Symposium News

In November 2009, Iowa State University and the NETSCORE-21 research project team hosted the "National Energy and Transportation: Investment Strategies through 2050" symposium. The symposium brought together experts and educators in energy and transportation to discuss national modeling for electric energy and fuel systems, and national modeling for transportation systems.

"The ultimate objectives of this symposium stem from the desire to guide and inform the ongoing heavy public discourse on how the nation should focus investments in terms of what kinds of technologies, how much of each, and when and where the investments should be made," **James McCalley** says.

Tom Allers, senior vice president of energy resource development for Alliant Energy, served as the symposium's keynote speaker.







Advancing Compressed Sensing

Two ECpE researchers challenge conventional wisdom in signal processing to advance imaging technologies used in nondestructive evaluation and the heath care industry.

BY **DANA McCULLOUGH**

Conventional wisdom in the signal processing research area tells us that to sense or gather data—such as music for an MP3 file or photographic data in a digital camera to create JPEG images—you need to do it at a rate of at least twice its highest frequency to get the best, most accurate results. But in the past few years, innovative researchers have developed a new area of signal processing called compressed sensing and begun challenging conventional wisdom, asking: Why do we need to collect such large amounts of data if we're only going to compress it later? Why not collect and compress the data you need at the same time, rather than in two separate steps? And how can we speed up data collection and reconstruction without negatively impacting quality?

Associate Professor **Aleksandar Dogandzic** and Assistant Professor **Namrata Vaswani** have developed solutions to some of these issues that could help address two major challenges engineers will face by the year 2050: protecting people from potential disasters caused by errors in man-made machinery and modernizing health care technologies. Dogandzic and his graduate student **Kun Qiu** are working to change the way data is collected and used for nondestructive evaluation applications. Vaswani and her graduate students **Chenlu Qiu** and **Wei Lu** are looking at a different compressed sensing problem: modifying compressed sensing and using their new approach to enable doctors to use magnetic resonance imaging (MRI) technology for real-time applications such as image-guided surgery.

Changing the way we collect data

Sparsity is a key aspect of all compressed sensing research, including Dogandzic's current research project. Dogandzic says sparsity is currently used for audio, image, and video compression of files into MP3s, MPEGs, and JPEGs, but the current data collection approaches are wasteful because they collect a large amount of data only to reduce it later by compressing it.

"Compressive sampling provides a methodology to do data collection and compression simultaneously," Dogandzic says. "It has caused excitement in the field partly because sparsity is already omnipresent and heavily utilized to store data. Why not use it to change the way we collect data?"

In the past year, Dogandzic has used funding from a National Science Foundation (NSF) CAREER award and initiated one of the first research projects in the world that focuses on developing automatic and fast reconstruction methods for compressed sensing and introducing the methodology for nondestructive evaluation applications. The goal? To create new methods of recovering signals from compressive samples (aka collecting data) and demonstrate that these new methods can reduce inspection time, save storage space, and improve estimation accuracy compared to traditional methods. The result? Dogandzic achieved two key milestones by developing two new automatic compression methods using probabilistic frameworks: an expansion-compression variance-component based method (ExCoV for short) and an automatic hard thresholding (AHT) method.

> "The methods we are developing are automatic and do not require tuning or prior knowledge, yet they maintain top-tier reconstruction performance compared with the existing methods."

Both the ExCoV and AHT methods automatically reconstruct sparse signals from compressive samples. The ExCoV method works best in challenging cases, where the number of measurements is small. The AHT method is more efficient than ExCoV and is more suitable for large-scale applications. These data reconstruction methods can be applied to X-ray data, particularly CT scans, to reduce inspection time, save storage space, and improve estimation accuracy. For example, Dogandzic and his research team plan to apply CT scans using their new compressed sensing reconstruction method in nondestructive evaluation inspections of airplane engines. The CT scan can find defects such as cracks or corrosion so the defective parts can be replaced before they cause a plane crash or other disaster. Other applications could include using CT technology to find defects in equipment in nuclear power plants or submarines before the defects cause problems.

Reconstructing Images

Original cardiac sequence

Compressed sensing reconstructed sequence

Modified compressed sensing reconstructed sequence

Assistant Professor **Namrata Vaswani**'s compressed sensing research looks at how to modify compressed sensing when prior knowledge of the signal support is available and how to use this approach to design recursive algorithms for real-time reconstruction of a sequence of signals or images using fewer measurements than what is needed for static compressed sensing.

The most compelling application for Vaswani's approach involves making magnetic resonance imaging (MRI) technology usable for real-time applications such as image-guided surgery. Her solutions also can provide a low complexity solution for offline dynamic MRI reconstruction using few measurements. Reducing the number of measurements for MRI directly translates into reduced scan times, which is critical for real-time applications in the medical industry.

The above pictures show an image of the heart that was obtained through three methods: an original sequence, a reconstruction sequence using traditional compressed sensing methods (simple CS), and a reconstruction sequence using Vaswani's modified compressed sensing methods (modified-CS). Notice that the modified-CS image achieves an almost exact reconstruction of the original, while the error in the simple-CS image is visibly much larger. Both reconstructions were obtained using only 19 percent measurements for all frames, except the first, which needed more measurements. This means that to achieve a good quality image reconstruction, modified-CS has an MRI scanning time per frame that is five times faster than existing technology, and has a scanning time that is two times faster than simple-CS.

Key compressed sensing reconstruction innovations

Dogandzic says the key innovation of both methods is that the main approach uses a probabilistic model for capturing signal sparsity that automatically recovers the appropriate data.

"The most important feature of the AHT method is that it recovers sparse signals automatically without requiring any additional knowledge about signal sparsity or measurement noise level, which is required by most other compressed sensing reconstruction methods," Dogandzic adds. "The AHT method also does not require any matrix inversion manipulation and, therefore, is a very fast method that is readily applicable to large-scale applications."

While past compressed sensing reconstruction methods required tuning or prior knowledge about the sparsity of the signal or level of noise measurement causing them to sometimes be less than accurate, Dogandzic's two new methods do not.

"The methods we are developing are automatic and do not require tuning or prior knowledge, yet they maintain top-tier reconstruction performance compared with the existing methods," Dogandzic says.

In the next couple of years, Dogandzic and his team will continue to enhance their new methods, conduct simulations to compare their approaches with existing reconstruction methods, and then apply their new methods to X-ray data and analyze the results.

Making real-time MRI possible

Vaswani's research also deals with sparse signals, but rather than developing algorithms for sparse reconstruction without prior knowledge as Dogandzic's research involves, Vaswani's research focuses on sparse reconstruction with partial knowledge of sparsity pattern—using as much prior knowledge as is available. Her biggest recent achievement in this area has been providing the first solution of its kind to solve a compressed sensing problem that will make real-time imaging possible for use with MRI technology.

IMAGES PROVIDED BY NAMRATA VASWANI AND WEI LU

"We have shown, both theoretically and via experiments, that with much fewer numbers of measurements than those needed for simple compressed sensing, our modified compressed sensing and Kalman-filtered compressed sensing algorithms can significantly outperform simple compressed sensing," Vaswani says. "This translates into reduced scan times for MRI, which in turn, means faster imaging, making real-time imaging possible."

Most existing algorithms for the dynamic MRI problem Vaswani is working on are offline and batch solutions with very high complexity. They use compressed sensing to jointly reconstruct an entire time sequence in one attempt.

"Our research is the first to develop and analyze recursive algorithms for online reconstruction of signal sequences," says Vaswani, whose research is funded by an NSF grant.

"We have shown that with much fewer numbers of measurements than those needed for simple compressed sensing, our modified compressed sensing and Kalman-filtered compressed sensing algorithms can outperform simple compressed sensing."

She also explains that her new algorithms have the same complexity as simple compressed sensing, but have two key differences: They achieve exact reconstruction using much fewer noise-free measurements than those needed by simple compressed sensing and they achieve a smaller reconstruction error than simple compressed sensing when using noisy measurements. Vaswani's algorithms are recursive (i.e., they use the past reconstruction and the current measurements' vector to obtain the current reconstruction) and she has theoretically shown that they are stable over time and experimentally demonstrated this for real MRI sequences. This is an important discovery because without stability, the error of a recursive algorithm could keep increasing and eventually explode.

Vaswani's advances can enable data to be acquired faster and MRI reconstruction to be completed faster than previous methods. These faster data acquisition and image reconstruction times can allow doctors to use MRI—which currently is not usable for real-time applications because of its slow image acquisition—to perform MRI-guided surgeries and other procedures requiring real-time imaging, such as endovascular therapies and biopsies, among others. Also, because MRI technology does not use ionizing radiation, it could replace some X-ray procedures, which pose a radiation risk to patients and are limited by their ability to visualize soft tissue.

Vaswani and her research team are already working with radiologists on experiments to implement her research discoveries in technology to treat and diagnose patients. They also are considering expanding this research to uses for single-pixel video imaging in the future.

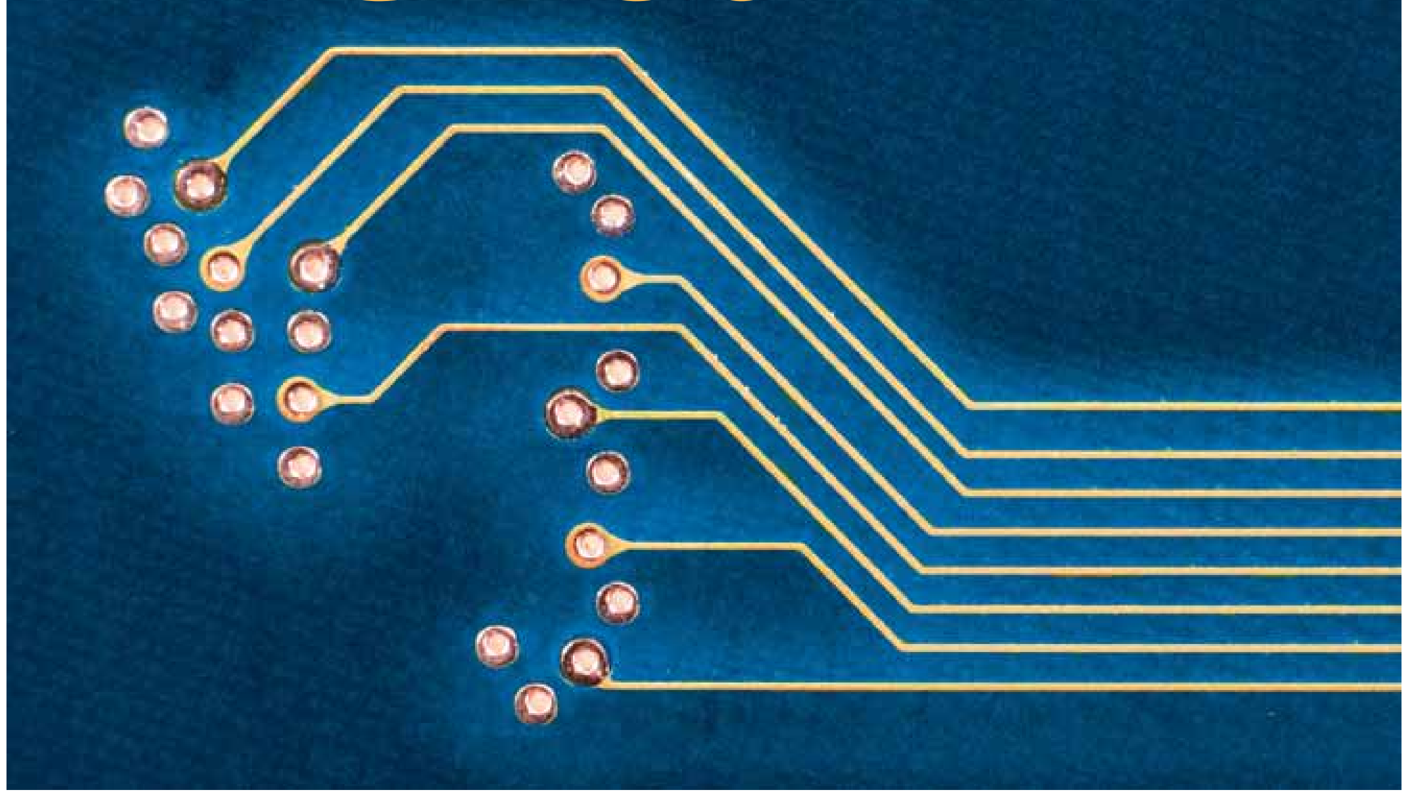
Final impact

While their approaches may be different, both Vaswani's and Dogandzic's compressed sensing research is helping to speed up data acquisition and processing times, and deliver improved imaging technologies that can impact society and the tools society uses. Vaswani's research can help modernize health care technology, and Dogandzic's research can help create nondestructive testing tools to prevent disasters caused by previously undetectable safety defects in machines we use every day. ■

More Online

For more details on Namrata Vaswani's and Aleksandar Dogandzic's research, visit *www.ece.iastate.edu/~namrata* and *home.eng.iastate.edu/~ald.*

Success Circuit



Two new assistant professors experience early success, advancements in VLSI research.

BY **DANA McCULLOUGH**

Although they come from two different backgrounds—one just received his PhD from the University of Washington in 2008 and the other came to Iowa State after working for eight years at Texas Instruments in Dallas—both **Nathan Neihart** and **Ayman Fayed**, who came to Iowa State during the 2008-09 academic year, are building on their past research and career achievements to achieve early success as assistant professors in the ECpE department's VLSI research group.

Advancing cognitive radio research

Prior to coming to Iowa State, Neihart focused his research on fully integrated multiple-input, multiple-output (MIMO) transmitters, which he says will be instrumental in realizing the high data rates being required by consumers and next-generation wireless standards. While in the past, researchers had focused primarily on the receiver, Neihart took a different approach and focused on the transmitter. As a result, Neihart demonstrated the first all complementary metal-oxide semiconductor (CMOS), fully integrated, four-antenna transmitter implementing spatial-multiplexing. From there, he helped develop a new inductor layout scheme that reduced parasitic coupling by a factor of 1,000.

"Up until this point, MIMO radios have only implemented phased-array type communication, wherein each path transmits the same data," Neihart says. "If the parasitic coupling becomes too large, then the spatial multiplexing scheme begins to fail, resulting in the failure of the communication link. The new inductor layout scheme we created greatly reduces the complexity and the sensitivity to parasitic coupling."

Since coming to Iowa State, Neihart has been highly involved with setting up and improving laboratories in the department's Analog and Mixed-Signal VLSI Design Center. He also has reached a milestone important to all young faculty members: receiving his first National Science Foundation (NSF) grant.

Neihart's new NSF Broadening Participation Research Initiation Grant in Engineering supports his current research on designing circuits for cognitive radios, a new type of reconfigurable radio that is not confined to operate in a small fixed band of frequencies as traditional wireless systems were required to do, thus allowing it to choose its operating frequency and bandwidth as long as those frequencies are not already being used by another system.

Neihart took an interest in this area because of its key problem: an apparent spectrum shortage and today's increasing reliance on and development of new wireless communication devices that can operate in the 1 to 10 GHz frequency range.

"Recent measurements have shown that even though nearly 100 percent of the 1 to 10 GHz band is licensed, approximately only 18 percent is being used at any given time," Neihart explains. "Therefore, if we could build radios that could find unused frequencies and borrow them on a temporary basis, such as the length of data transmission, then the apparent spectrum shortage would disappear."

The biggest challenge Neihart is trying to overcome in his research is designing circuits and radio sub-blocks capable of operating over an ultra-wide bandwidth (such as bandwidths up to 10 GHz). Stringent performance requirements for today's radios are also a challenge.

"We are trying to address these issues by looking outside the field of radio frequency circuit design for inspiration," Neihart says. "We have found that by using nonstandard circuits and new configurations of traditional circuits, we are potentially capable of achieving wide band operation, as well as good performance in terms of linearity, power consumption, and noise."

The impact of Neihart's research on industry and society could be significant. For example, by allowing radios to self-govern, overall network congestion could be reduced and overall data rates and network reliability could be increased. The research also has applications in emergency response and for military communication. In particular, cognitive radios could provide emergency first-responders with a way to establish reliable communication and overall efficiency and safety when they respond to large disasters. In military communication, cognitive radios could improve communication security, coordination, and safety of military personnel because the radios can operate at any frequency and it is unknown beforehand which frequency the systems will operate on.

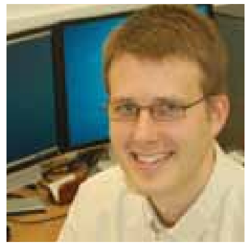
> "The new inductor layout scheme we created greatly reduces the complexity and the sensitivity to parasitic coupling."

Efficient power management design

Like Neihart, Fayed also has been highly involved with setting up and improving laboratories in the department's Analog and Mixed-Signal VLSI Design Center since coming to Iowa State. And for Fayed, his past experience as an analog and mixed-signal designer at Texas Instruments already has proven valuable in academia. In his first year at Iowa State, Fayed initiated collaborations with several semiconductor companies, including Texas Instruments, who are interested in power management.

"Securing access to the most advanced silicon fabrication technologies from Texas Instruments to support my power management research was certainly a great accomplishment for me this year," Fayed says. "This will enable us to continue to conduct state-of-the-art research at Iowa State."

In his first year, Fayed also has started a research project to discover ways to



Nathan Neihart

Ayman Fayed

Beyond the Lab

Faculty in the ECpE department do more than research—they also educate students and find ways to continually improve students' educational experience. Assistant professors **Nathan Neihart** and **Ayman Fayed** both are leading initiatives to improve the quality of education Iowa State electrical and computer engineering students receive.

Since coming to Iowa State in 2008, Neihart has created an internship program for students at Skyworks Solutions, a semiconductor company with an office in nearby Cedar Rapids, Iowa.

"Every fall a representative from Skyworks comes and talks to the students in EE 414/514: Microwave Engineering, and then one or more internship opportunities are made available to those students beginning the following spring and continuing through the summer semester," Neihart says.

This program started in Fall 2009 and so far three students—two undergraduates and one graduate student—were given internships and one undergraduate student was offered a full-time position.

Fayed, who came to Iowa State in 2009, is tying in his research with his teaching to better prepare students who want to work in industry by developing a new graduate course in power management for VLSI systems.

"I focus on basic circuit- and system-level concepts of linear/switching power converters in this course," Fayed says. "Universities rarely address this area, despite its crucial importance to the semiconductor industry, which is causing a serious shortage of engineers graduating with any knowledge of this subject."

overcome a fundamental hurdle of expanding functional capabilities of portable electronic devices—battery life. This research project is motivated by Fayed's industry experience.

"We are in an age where portable electronic devices are relied upon in almost every aspect of human life, and expanding functional capabilities of these devices is no longer a luxury, but a necessity," he says.

Specifically, Fayed's research focuses on the design of system and circuit solutions for power regulation, delivery, and distribution in VLSI systems targeting portable and battery-operated devices.

"The process of battery charging is one of the major challenges facing battery-operated devices that are remotely deployed or where access to traditional power sources is scarce or impractical," Fayed says. "The ability to harvest energy from the device's environment can greatly enhance the system's run time or reduce the number of batteries needed to sustain it for its intended operation time."

Fayed's main research goal is to implement a comprehensive multi-input power management system that can convert, regulate, and deliver power from harvested solar, mechanical, thermal, and wireless energy sources to the device and its battery, in addition to using other non-harvested power sources such as AC outlets, vehicular batteries, and fuel cells.

Energy harvested from each source generally is intermittent, highly variable, and very small to make a noticeable difference in battery life; however, several sources often are available simultaneously and their collective power can be significant, Fayed explains.

"The key challenge is discovering how to automatically add the energy from all the individual sources instead of the traditional approach of simply using the one source that can deliver maximum energy. When you work with so many power sources at the same time, it becomes like building a multi-source power distribution grid on the microscale."

Fayed's research could impact industry and society by reducing an electronic device's dependence on batteries for operation and opening the door to many applications such as battery-free biomedical implants and self-powered wireless sensor grids.

Additionally, researchers and engineers could incorporate more functionality into battery-operated devices without degrading the battery's life, something crucial for many portable navigation and communication devices for consumers and the military.

A bright future

With the early successes of these two VLSI assistant professors, it is clear they have positioned themselves for long-term career success and already have learned a lot from their early research experiences.

"I have learned that perseverance is important," Neihart says. "You cannot give up the first time something doesn't work. As Thomas Edison said, 'When I have eliminated the ways that will not work, I will find the way that will work.'"

Neihart's and Fayed's research perseverance will serve them well as they begin making the innovations of tomorrow in their research labs today. ■

More Online

For more information on Nathan Neihart's and Ayman Fayed's research, visit their websites at *home.engineering.iastate.edu/~neihart* and *home.eng.iastate.edu/~aafayed.*

Mastering the Clock

A team of ECpE researchers overcomes traditional clock speed design limitations to invent and patent a new method for improving computer processor design and performance.

BY **DANA McCULLOUGH**

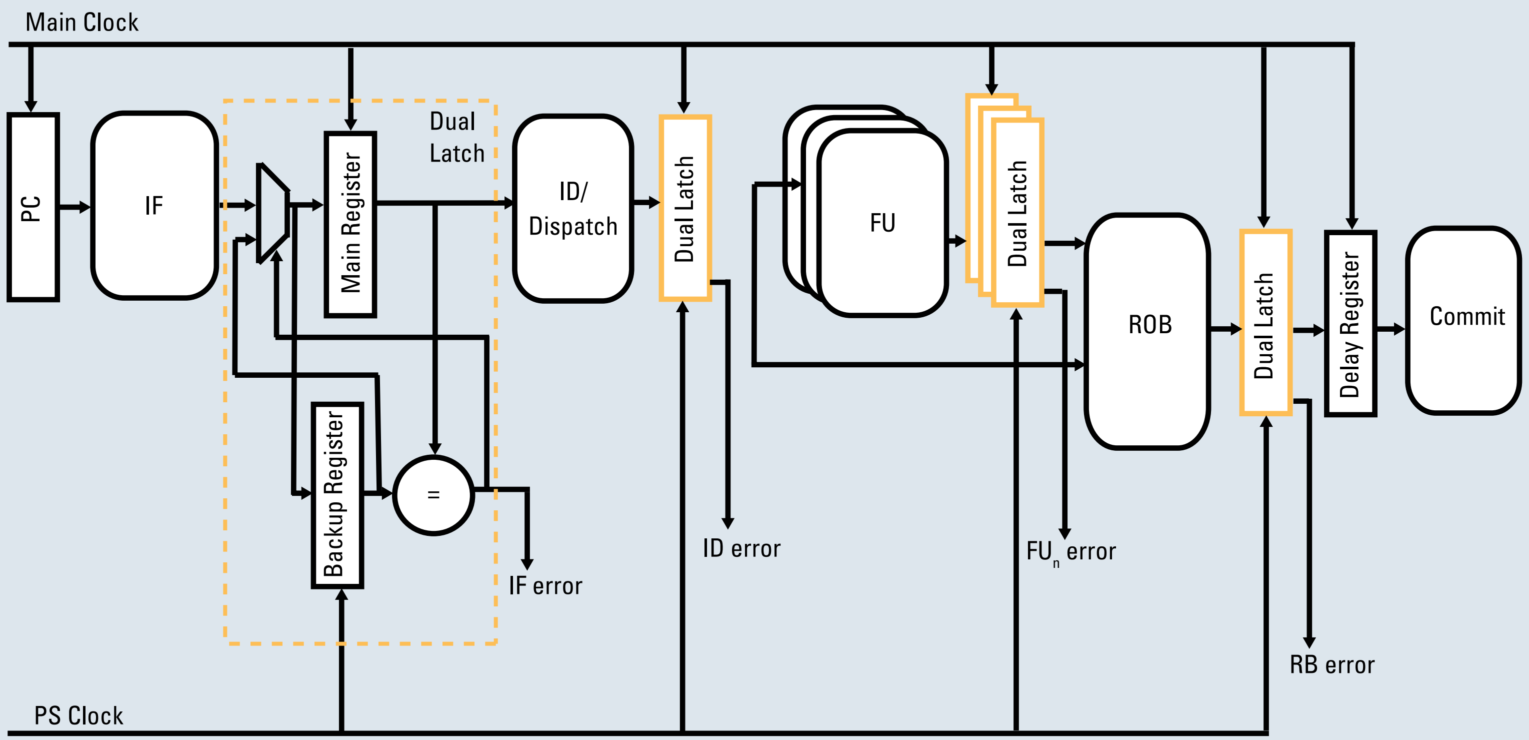
SOMANI PHOTO BY BOB ELBERT

Major concerns for designing modern computer processors involve minimizing power consumption, reducing overheating, and increasing speed and reliability. When **Arun K. Somani**, an Anson Marston Distinguished Professor of Engineering and the Jerry R. Junkins Endowed Chair, thought about those concerns, he started thinking about how he could get better performance from processors using already-known technologies. In particular, Somani began contemplating clock speed in computers, which largely determines how quickly processors run applications, and its limitations.

"Clock speed is traditionally limited by worst-case delay. The clock must be slow enough to give the circuit the maximum time it will need to execute correctly, but this delay cannot be determined precisely because of certain environmental and physical factors," Somani says.

The first factor is variable delays induced in computer chips during the manufacturing process, the second factor is temperature and voltage variations that affect delay through the circuit during operation, and the third factor is that traditional design assumes a worst-case delay scenario to ensure chip reliability, but it is not known how often those worst-case—or near worst-case—delay scenarios occur during operation.

Arun K. Somani



This diagram shows the concept of overclocking in a simple pipeline processor, which easily can be extended to more complex processors. The method outlined in the diagram employs dual latches to detect an error in the execution due to data-dependent delay or any other time-dependent failure. When a timing error is detected, a recovery process is initiated.

New method to run faster

Somani and his graduate students **Michael Bezdek**, **Vishwanathan Subramaniam**, and **Prem Kumar Ramesh** have invented a new method using fault tolerance and dynamic control theory that overcomes the traditional worst-case delay assumption, allowing modern superscalar processors to run more reliably at faster speeds, while reducing power consumption and heat generation. The research was funded by a National Science Foundation grant as well as funds from the Jerry R. Junkins Endowed Chair. The new method—called Superscalar Performance Improvement Through Tolerating Timing Errors, or SPRIT^{3}E for short—performs both error detection and correction, an advancement over the previous state-of-the-art, which could perform only error avoidance.

"Our new method addresses limitations imposed when engineers design computer chips using worst-case design methods," Somani says. "Our method modifies processor design to allow clock frequency of a superscalar processor to be dynamically tuned to its optimal value beyond the worst-case limit, while still performing reliable and correct execution at all times, thus improving performance."

Somani also explains that the new method is unique because it uses a data dependent execution time rather than a worst-case execution time. In addition, because the frequency is dynamically modified as the processor is running, Somani's method automatically accounts for variations in temperature, voltage, and other environmental conditions, as well as variations in chip fabrication. In essence, Somani and his research team can monitor the error rate during run time and then dynamically adjust the clock frequency based on a set of tolerable error rates that do not affect the computer's performance.

In fact, simulation results show that Somani's method improved computer performance by up to 57 percent.

> "What we think is that you can take an older generation technology for which everything is well understood and now speed it up using our method."

More Online

For more information on Arun K. Somani's SPRIT^{3}E method, visit *ecpe.ece.iastate.edu/dcnl* or *www.tinyurl.com/SPRIT3E*.

Time for industry impact

Somani's new method, which was awarded a U.S. patent in March, allows researchers and engineers to design processors using low-cost technology and simple design.

"You can use cheaper technology and simple design tools that initially operate at a slower speed, and then the processor dynamically overclocks itself to achieve improved performance, while still being reliable," Somani says.

Specifically, the computer industry could apply Somani's method to current technology that exists without having to make a huge investment in newer technology.

"Every time you change technology and go to the next technology node, it requires a large investment. What we think is that you can take an older generation technology for which everything is well understood and now speed it up using our method," Somani says. "The same technology node's technology capability can be increased further, and you don't have to change industry investment in your foundries." ■

Solving the Heat Generation Issue

While Arun K. Somani's research focuses mainly on increasing computing speed, several faculty in the ECpE department are concentrating on solving the heat generation problem caused when systems operate at high speeds.

Mitigating hotspots

Phillip Jones, an assistant professor, recently published a paper on "Hotspot Mitigation Using Dynamic Partial Reconfiguration for Improved Performance." The goal of Jones' research is to explore the use of system feedback to increase performance.

"It has been shown in many areas that adding knowledge to a system often opens up opportunities for taking more optimal actions. In this case, having the system monitor its own thermal behavior and then using this thermal information to dynamically adjust its circuit layout at run-time can more evenly distribute heat," Jones says.

Jones is approaching this research problem by looking to use the advanced abilities of reconfigurable hardware to detect when a portion of a chip is too hot, and then move the functionality of that area of the chip to a cooler portion of the chip. So far, Jones has used hardware to measure partial reconfiguration overhead times and a free simulation tool to collect simulated temperature and thermal time constant data. He next plans to use a high-precision, high-speed thermal camera with the hardware to collect data and verify simulation results, as well as calibrate ring oscillator-based temperature sensors deployed in the reconfigurable hardware fabric.

Memory and temperature

According to **Zhao Zhang**, an associate professor, with the increasing demand on memory performance from multi-core processors, the memory subsystem has become a new thermal concern, in addition to the processor and hard disk drive. With funds from a National Science Foundation grant, Zhang built the first dynamic DRAM thermal model for multi-core computers.

"The model tracks the change in memory temperature by observing traffic on memory bus, deriving power consumption at memory devices, and predicting temperature in small time windows," Zhang says. "We have also built software modules that implement memory thermal management into operating systems, so that the system can run at a high performance without memory overheating."

As Zhang continues his research, he plans to improve the accuracy of the memory thermal model by addressing a newly found weakness of the model that ignored the thermal interaction between the processor and memory modules.

For more information on Jones and Zhang and their research, visit *www.ece.iastate.edu/~phjones* and *home.eng.iastate.edu/~zzhang/index.htm*.

KORAY CELIK PHOTO BY PATRICK HERTEEN

The Ultimate GPS-free Navigation System

A graduate student uses a personal experience as motivation to create novel algorithms to allow autonomous micro aerial vehicles to fly in GPS-denied environments.

BY **DANA McCULLOUGH**

What do you get when a doctoral student marries personal experience with a medical condition and a passion for airplanes and engineering? A novel research project resulting in the creation of one of the world's smallest fully self-contained, collective-pitch autonomous helicopters equipped with advanced on-board image processing and the capability to fly and navigate both indoors and outdoors.

"A short-term medical condition, vestibular neuritis (VN), involving the inertial measurement mechanisms of the human head resulting in severe vertigo inspired me to research how human vision can be computerized at a high-level," says **Koray Celik**, a computer engineering PhD student. "I wanted to create the ultimate vision-guided autonomous flying robot. I was the person with a broken vestibular system, but operational eyes, where as a micro aerial vehicle (MAV) was a machine with perfect VN, but no vision."

And so began Celik's doctoral research.

Vision meets reality

First, Celik designed a lightweight multi-functional optical sensor for unmanned aircraft guidance and navigation for Rockwell Collins, an international avionics company headquartered in Cedar Rapids, Iowa. After experiencing success on this project, Celik built an unmanned helicopter around the guidance and navigation technology he had developed.

The helicopter, which Celik dubbed *Saint Vertigo*, is 20 inches in length and weighs about 2 pounds. It carries a flight computer, navigation computer, and monocular vision digital video camera, among other electronics. It flies up to 45 miles per hour and is capable of facial recognition and other high-level tasks. But what really sets it apart from other MAVs is that all image processing and simultaneous localization and mapping (SLAM) computations are performed on-board the copter.

"It's a very versatile research platform," Celik says. "It's the smallest, 100 percent self-contained UAV with autonomous flight and vision SLAM capability."

Celik and other Iowa State researchers developed the two novel algorithms for monocular vision-based depth perception and bearing sensing (a visual compass of sorts) with 3-D SLAM technology that the helicopter uses. The new algorithms replicate the functions of a laser rangefinder in the copter's navigation systems and replace it with a monocular camera, allowing the helicopter to navigate autonomously inside a building.

"The machine we developed demonstrates that absolute range measurement is possible with a monocular camera. The world's first vision-guided indoor autonomous helicopter flight was performed in Iowa State University's Howe Hall with our machine," Celik says.

Because Celik's helicopter uses monocular vision to navigate, the system does not emit any signals from the aircraft, as do other MAV technologies that use a laser rangefinder for navigation. The copter also can command multiple other swarming agents, such as robots like bugs, rovers, and other MAVs that fly in the air. Because you can have central control over these agents with Celik's helicopter, the military or other organizations could use fewer of them or pair them with robots of lesser intelligence, reducing the cost to use these devices.

"There are no signals emitted from the aircraft that can be detected and used as a homing signal to take it down. And because fewer aircraft can perform the same mission, it is cost effective," Celik says.

How it works

The technology Celik and other Iowa State researchers—including Celik's major professor **Arun K. Somani**, Assistant Professor **Soon-Jo Chung** (now at the University of Illinois at Urbana-Champaign), and undergraduate student **Matthew Clausman**—created, allows the helicopter's video camera to look for what Celik calls high energy points—areas of extreme contrast—and then register those hundreds of points on the on-board computers.

After the points are identified, the helicopter's computer runs an algorithm that cross-references these points to determine what it is seeing—a door, a floor, a wall, or a line between any of those items. The on-board computer then processes the images, builds a map with the points and lines, and measures distances based on how the points and lines move when the helicopter moves.

"In essence, the MAV is capable of flying through an unknown building while generating its floor plan in real-time," Celik says.

Visualizing the future

So far, Celik's research has been published in four IEEE and American Institute of Aeronautics and Astronautics journals. Celik says it also has sparked proposals and attracted interest from the avionics industry, the U.S. Army, and U.S. Air Force.

In the future, Celik plans to pursue other related research, including ways to adapt his MAV system to be an indoor-outdoor machine, as well as use aspects of the system in wearable devices, such as a firefighter's helmet, and add further complexity in the mapping system to handle odd-shape rooms and stairs in addition to hallways.

"The foreseeable future of intelligence, surveillance, and reconnaissance missions will involve GPS-denied environments," Celik says. "An MAV with vision based on online SLAM capabilities can pave the way for an ultimate GPS-free navigation tool for both urban outdoors and architectural indoors." ■

In Detail

Koray Celik's micro aerial vehicle (MAV) achieves localization in GPS-denied environments such as in a concrete building. The MAV's system dynamically generates a map and performs localization via particle filtering. The filter has three steps:

Prediction: It evaluates its surroundings and based on its own system dynamics, it generates a partial map of the area using statistical prediction.

Measurement: The MAV's video camera detects landmarks and room features, and measures the range and bearing to each landmark to enhance the prediction.

Update: To improve accuracy, the filter continuously corrects any errors in the map in order to localize itself.

A This area is comprised of the fuselage, which powers the vehicle's power plant, transmission, main batteries, actuators, gyroscope, and the tail rotor.

B This part of the helicopter contains the collective pitch rotor head mechanics.

C The autopilot compartment, which contains the inertial measurement unit, all communication systems, and all sensors, is located here.

D This area carries the navigation computer, which is attached to a digital video camera at the helicopter's front.

More Online

See a video on Koray Celik's research project online at *www.youtube.com/ECpEdepartmentISU* (under ECpE Research).

PHOTO COURTESY OF THE ISU FOUNDATION

Facilitating Success

Discover new research laboratories housed in the department's ECpE Building Addition and Coover Hall.

BY **DANA McCULLOUGH**

Since the department opened its new building, the ECpE Building Addition, in 2008, many faculty in the department have been working hard to move laboratories from Coover Hall and other buildings on campus to the space in the new building dedicated for research labs. In the past couple of years, faculty also have established new laboratories and upgraded existing laboratories, such as labs in the department's Analog and Mixed-Signal VLSI Design Center.

New research laboratories in the department include the:

- Alternate Energy Grid Infrastructure and Systems Laboratory
- Biomedical Engineering Laboratory
- Digital Forensics Laboratory
- Micro/Nanoscale Systems Laboratory
- Plasmonics and Microphotonics (Biophotonics) Laboratory
- Power Infrastructure Cyber Security Laboratory
- Reconfigurable Computing Laboratory
- Scalable Software Engineering Research Laboratory
- Software Defined Radio Laboratory

Each of the labs provide state-of-the-art equipment for faculty to use in their research activities. Recently, the department acquired a Sun Microsystems supercomputer, a real-time power grid simulator, and an atomic force microscope to aid faculty in their research pursuits.

The following provides a peek into a few of the department's new and revamped labs. >

More Online

Detailed information on all ECpE research laboratories is featured online at *www.ece.iastate.edu/research/labs.*

> Developmental Robotics Laboratory

www.ece.iastate.edu/~alexs/lab

Assistant Professor **Alexander Stoytchev** established the Developmental Robotics Laboratory in 2008 to create autonomous robots that are more intelligent, adaptable, and useful than the robots of today, which can only function in very limited domains and situations. Researchers at the lab approach this problem from the point of view of developmental robotics, a new field that blends the boundaries between robotics, artificial intelligence, developmental psychology, developmental neuroscience, and philosophy.

The researchers' basic hypothesis is that truly intelligent robot behavior cannot be achieved in the absence of a prolonged interaction with a physical or a social environment. In other words, robots must undergo a developmental period similar to that of humans and animals.

"We are interested in discovering the fundamental processes and principles that drive human cognitive development and applying them on robots," Stoytchev says. "Generally speaking, modeling the developmental trajectory for almost any intelligent task that a 2-year-old child can perform on a robot is a potential research topic for us."

The lab's main piece of equipment is its upper-torso humanoid robot. Two Barrett Whole Arm Manipulators (WAMs) make up the robot's arms. Each WAM has seven degrees of freedom, allowing it to rotate like a human arm. In addition, each arm is equipped with a three-finger Barrett Hand. The hands also have seven degrees of freedom. Fingers one and three can rotate 180-degrees as well as bend. This allows the robot to grasp items with its two opposable thumbs, which compensate for it having only three fingers.

Research in the lab is funded with internal department funds.

The robot uses a pencil to learn how to write with its three-finger Barrett Hand. It also can pick up and manipulate containers and other objects to learn about them like a human infant does.

The Analog and Mixed-Signal VLSI Design Center occupies three rooms in the ECpE Building Addition. This photo shows an overview of two of the adjoined rooms.

> Analog and Mixed-Signal VLSI Design Center

vlsi.ece.iastate.edu

The Analog and Mixed-Signal VLSI Design Center at Iowa State University recently upgraded its facilities when it moved into the new ECpE Building Addition in 2008. The center, which was established in 1988, encompasses the research efforts of nine faculty members. The center's faculty bring extensive academic experience, broad industrial experience, and continued professional interactions into a center that relies heavily on industrial direction, interaction, and support.

The faculty members associated with the VLSI Design Center focus on research with applications in areas such as biomedical engineering and consumer electronics. Specific research focus areas include digital VLSI, gigabit rate silicon integrate circuits, high-speed and high-resolution data converters, high-speed communication circuits, high-stability voltage references, integrated fiber-optics circuits, low-voltage electronics, magnetic devices and circuits, mixed-signal circuits, and RFIC technology.

Current laboratories within the VLSI Design Center are located in three new rooms in the ECpE Building Addition. The labs house state-of-the-art equipment such as a bit rate error tester, a network analyzer, digital oscilloscopes, probe stations, a semiconductor characterization system, a vector signal generator, a real-time spectrum analyzer, and an anechoic chamber, among other equipment.

In addition to the center's new physical space, the VLSI Design Center also revamped its website at *vlsi.ece.iastate.edu* in late 2009. The website includes several photographs of key equipment the center houses.

Professor **Robert J. Weber** is the director of the VLSI Design Center. Other ECpE faculty who are involved in the center's research activities include **Morris Chang**, **Degang Chen**, **Chris Chu**, **Ayman Fayed**, **Randall L. Geiger**, **Nathan Neihart**, **Gary Tuttle**, and **Akhilesh Tyagi**.

> Bioengineering Laboratories

www.ece.iastate.edu/research/bioengineering

Since 2008, three bioengineering laboratories have been established in a four-room bioengineering suite:

The **Biomedical Engineering Laboratory**, operated by Assistant Professor **Timothy Bigelow**, supports research to improve medical ultrasound with two major research thrusts: to improve the diagnostic effectiveness of medical ultrasound to diagnose cancer, and to improve the therapeutic effectiveness of medical ultrasound to treat cancer with an noninvasive alternative to surgery. Research in the lab is supported by the National Science Foundation (NSF) and National Institutes of Health.

The **Micro/Nano Systems Laboratory**, operated by assistant professors **Santosh Pandey** and **Liang Dong**, focuses on bioengineering research on the micro- and nano-levels. Pandey's research studies behavior and physiological changes in live microorganisms and biological cells in special electronic and microfluidic devices. His main goal is to unravel complex interrelationships between a microorganism's behavioral changes and biological makeup for applications in developing new instruments to probe signals in live cells and cultures, and in the biosensors area for detecting and tracking nanoscale molecules and particles.

Dong's research covers four main areas: nano-opto-electromechanical systems for realizing reconfigurable nanophotonics, lab-on-a-chip systems for studying single cells and microorganisms, nanoscale light sources for high resolution cellular bioimaging, and bioinspiration and biomimetics for novel sensors and actuators. Current research projects in this lab are funded by the NSF, the College of Engineering, and internal departmental funds.

The **Plasmonics and Microphotonics (Biophotonics) Laboratory**, created by Assistant Professor **Jaeyoun Kim**, focuses on using optical technologies on the micro- and nano-scales. Current research covers two main topics: utilizing surface plasmon-polaritons to enhance the interaction between material and optical waves for creating more efficient photovoltaic devices and more sensitive biosensors, and using microfabrication technology to miniaturize existing or new optical systems for implementing dynamically tunable, miniaturized optical sensors for in medical applications. This lab is supported by the Iowa Office of Energy Independence.

BIOENGINEERING LABORATORY PHOTOS (FAR LEFT, CENTER RIGHT, RIGHT) BY BOB ELBERT

BELOW, FAR LEFT: This area in the bioengineering suite houses the chemical safety hood.

BELOW, CENTER LEFT: The Biomedical Engineering Laboratory has a computer-controlled positioning system (*pictured*) and ultrasound machine.

BELOW, CENTER RIGHT: Bioengineering researchers primarily use three microscopes, including a new atomic force microscope (*not pictured*).

BELOW, RIGHT: ECpE researchers use the SMART table mainly for nanotechnology research.

> Alternate Energy Grid Infrastructure and Systems Laboratory

The Alternate Energy Grid Infrastructure and Systems Laboratory was established in 2007 by Assistant Professor **Dionysios Aliprantis** and Professor **Venkataramana Ajjarapu**. The lab's name and acronym—AEGIS—were chosen because of its meaning in ancient Greek—"violent windstorm." The acronym signifies that the faculty in the lab perform research on wind energy, among other topics. In particular, faculty associated with the lab focus on novel power electronics systems and controls as they relate to alternate energy technologies such as wind and solar power, and plug-in electric vehicles.

"The main purpose of the lab is to aid the Iowa State University Electric Power and Energy Systems group's research on the integration of large quantities of renewable energy sources in the electric power grid in an optimal manner, providing experimental validation and advanced simulation capabilities," Aliprantis says.

Current research in the AEGIS lab involves projects on wind power transmission, wind turbine power electronics and controls, plug-in electric vehicles, rotating electric machinery design, advanced metering infrastructure, distributed generation sources, and the smart grid concept. The lab has efforts addressing distributed solar energy sources as well.

The AEGIS lab is equipped with a real-time digital simulator, a state-of-the-art computing platform capable of simulating power systems in real-time and with high fidelity. It also has several dynamometers, which provide the capability to test and validate a range of electric motors and power electronics systems.

The laboratory's research is funded by the U.S. Office of Naval Research, National Science Foundation, and internal funding. Projects in the research laboratory also are sponsored by Iowa State's Electric Power Research Center and the Power Systems Engineering Research Center. ■

ECpE Research Laboratories

The following is a complete list of laboratories in the ECpE department.

- Alternate Energy Grid Infrastructure and Systems Laboratory
- Biomedical Engineering Laboratory
- Dependable Computing and Networking Laboratory
- Developmental Robotics Laboratory
- Digital Forensics Laboratory
- Discrete Event Systems Laboratory
- Distributed Sensing and Decision Making Research and Teaching Laboratory
- High-Speed Communications Carver Laboratory
- High-Speed Systems Engineering Laboratory
- iCUBE Sensors Application Laboratory
- Internet-Scale Event and Attack Generation Environment
- Micro/Nano Systems Laboratory
- Plasmonics and Microphotonics (Biophotonics) Laboratory
- Power Infrastructure Cyber Security Laboratory
- Reconfigurable Computing Laboratory
- RF/Microwave Circuits and Systems Laboratory
- Rockwell Automated/Allen Bradley Power Electronics and Drive Systems Laboratory
- Scalable Software Engineering Research Laboratory
- Software Defined Radio Laboratory

PhD Student Production

Forty-four PhD students have graduated from the ECpE department in the last two years. They have been hired as faculty at major universities, as well as for various positions in industry and at national laboratories.

NAME	DISSERTATION TITLE	MAJOR PROFESSOR
Acharya, Naresh	Security, Protection, and Control of Power Systems with Large-Scale Wind Power Penetration	C. Liu
Al-Kofahi, Osameh Mahmoud	Network Coding-based Survivability Techniques for Multi-hop Wireless Networks	A. Kamal
Al-Mefleh, Haithem A.	Design and Analysis of MAC Protocols for Wireless Networks	M. Chang
Cao, Haibo	Intraocular Pressure (IOP) Passive Sensor Modeling, Design, Fabrication, and Measurement	R. Weber
De, Tathagata	Systems Approach Based Solution to Fundamental Limitations in Unraveling Spatial and Temporal Regimes in Nano-Interrogation and Nano-Positioning	M. Salapaka
Erbas, Cihan	Validation of Remotely-Sensed Soil Moisture Observations for Bare Soil at 1.4 GHz: A Quantitative Approach Through Radiative Transfer Models to Characterize Abrupt Transitions Caused by a Ponding Event in an Agricultural Field, Modifications to the Radiative Transfer Models, and a Mobile Ground-based System	B. Hornbuckle
Evans, Nathaniel	Information Technology Social Engineering: An Academic Definition and Study of Social Engineering—Analyzing the Human Firewall	D. Jacobson
Fraiwan, Mohammad Amin	Overlay Networks Monitoring	M. Govindarasu
Gathala, Sudha Anil Kumar	System Level Energy Management in Networked Real-Time Embedded Systems	M. Govindarasu
Ghosh, Debju	Structurally Integrated Luminescence Based Oxygen Sensors With Organic LED/ Oxygen Sensitive Dye and PECVD Grown Thin Film Photodetectors	V. Dalal
Gutierrez, Guillermo	Information Requirements for Strategic Decision Making: Energy Market	G. Sheble/A. Somani
Hamad, Ashraf M. I.	All Optical Multicasting in Wavelength Routing Mesh Networks with Power Considerations: Design and Operation	A. Kamal
Huang, Jing	Directed Control of Discrete Event Systems	R. Kumar
Jackson, Benjamin	Parallel Methods for Short Read Assembly	S. Aluru
Jaju, Vishwas	Device Quality Low Temperature Gate Oxide Growth Using Electron Cyclotron Resonance Plasma Oxidation of Silicon	V. Dalal
Jin, Licheng	Reachability and Model Prediction Based System Protection Schemes for Power Systems	R. Kumar
Katyal, Vipul	Low Power, High Speed, and High Accuracy Design Methodologies for Pipeline Analog-to-Digital Converters	R. Geiger/D. Chen
Khaitan, Siddhartha Kumar	On-Line Cascading Event Tracking and Avoidance Decision Support Tool	J. McCalley
Li, Hongyan	Dynamic Performance of Restructured Wholesale Power Markets with Learning Generation Companies: An Agent-Based Test Bed Study	L. Tesfatsion/ J. McCalley
Li, Yuan	Decision Making Under Uncertainty in Power System Using Benders Decomposition	J. McCalley
Lin, Jiang	Thermal Modeling and Management of DRAM Memory Systems	Z. Zhang
Luse, Andrew	Exploring Utilization of Visualization for Computer and Network Security	D. Jacobson/ A. Townsend
Madhavan, Atul	Alternative Designs for Nanocrystalline Silicon Solar Cells	V. Dalal
Mitra, Saayan	I/O Automata-based Formal Approach to Web Services Choreography	R. Kumar
Qleibo, Haider W	Message Integrity Model for Wireless Sensor Networks	D. Jacobson
Ray, Souvik	Design and Analysis of Anonymous Communications for Emerging Applications	Z. Zhang
Salazar Isaza, Harold	Economic Analysis of Transmission Enhancement Through Merchant Projects	C. Liu
Saripalli, Satyalakshmi K.	Transport Properties in Nanocrystalline Silicon and Silicon Germanium	V. Dalal
Stanek, Edward Jason	Computation of Evolutionary Change	S. Kothari
Stieler, Daniel	Characterization of Defect Cavities and Channel-Drop Filters in the Three Dimensional Woodpile Photonic Crystal	G. Tuttle
Subramanian, Viswanathan	Timing Speculation and Adaptive Reliable Overclocking Techniques for Aggressive Computer Systems	A. Somani
Viswanathan, Natarajan	Placement Techniques for the Physical Synthesis of Nanometer-Scale Integrated Circuits	C. Chu
Wanner, Shannon	Phase Array System Design	R. Weber
Wen, Qin	Fault-tolerant Supervisory Control of Discrete-Event Systems	R. Kumar
Xia, Tian	Network Modeling Systems in Biology	J. Dickerson/X. Gu
Xing, Hanqing	Fully Digital-Compatible Built-in Self-test Solutions to Linearity Testing of Embedded Mixed-Signal Functions	D. Chen
Xu, Bojian	A Study of Time-Decayed Aggregate Computation on Data Streams	S. Tirthapura
Yang, Guanqun	Energy-efficient Coverage with Wireless Sensors	D. Qiao
Yang, Yang	Modeling Discharge and Surface Processes in Capacitively Coupled Reactors	M. Kushner
Yu, Zhen	Practical Security Scheme Design for Resource-Constrained Wireless Networks	Y. Guan
Zhan, Sanyi	Analysis and Design of Metal-Surface Mounted Radio Frequency Identification (RFID) Transponders	R. Weber/J. Song
Zhang, Linfeng	Effective Techniques for Detecting and Attributing Cyber Criminals	Y. Guan
Zhou, Jiangfeng	Study of Left-Handed Materials	G. Tuttle/C. Soukoulis
Zhou, Wei	Protocol Design and Optimization for QoS Provisioning in Wireless Mesh Networks	D. Qiao

*Faculty Directory

BIOENGINEERING

Srinivas Aluru
Mehl Professor in Computer Engineering
PhD, Computer Science, Iowa State University (1994)
- IEEE Fellow

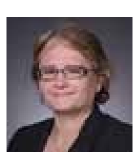
Research interests: High-performance computing, bioinformatics and systems biology, combinatorial scientific computing, applied algorithms

Selected publications:
- Schnable, P. S., D. Ware, ... , S. Aluru, R. A. Martienssen, S. W. Clifton, W. R. McCombie, R. A. Wing, and R. K. Wilson. "The B73 Maize Genome: Complexity, Diversity, and Dynamics." *Science* 326, no. 5956, (2009): 1112–1115.
- Jackson, B., P. S. Schnable, and S. Aluru. "Consensus Genetic Maps as Median Orders from Inconsistent Sources." *ACM/IEEE Trans. Computational Biology and Bioinformatics* 5, no. 2, (2008): 161–171.

Timothy Bigelow
Assistant Professor
PhD, Electrical Engineering, University of Illinois at Urbana-Champaign (2004)

Research interests: Ultrasound systems to treat cancer and infections, physical properties of tissue using backscattered ultrasound signals, bioeffects for ultrasound safety and therapy

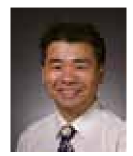
Selected publications:
- Bigelow, T. A., T. Northagen, T. M. Hill, and F. C. Sailer. "The Destruction of Escherichia Coli Biofilms Using High-intensity Focused Ultrasound." *Ultrasound in Medicine and Biology* 35, no. 6, (2009): 1026–1031.
- Bigelow, T. A. "Ultrasound Attenuation Estimation Using Backscattered Echoes from Multiple Sources." *Journal of the Acoustical Society of America* 124, no. 2, (2008): 1367–1373.



Julie A. Dickerson
Associate Professor
PhD, Electrical Engineering, University of Southern California (1993)

Research interests: Systems biology, bioinformatics, pattern recognition, data visualization, real-time sensor networks

Selected publications:
- Mao, L., J. Van Hemert, S. Dash, and J. Dickerson. "Arabidopsis Gene Co-expression Network and Its Functional Modules." *BMC Bioinformatics* 10, (2009): 346.
- Grimplet, J., G. R. Cramer, J. A. Dickerson, K. Mathiason, J. Van Hemert, and A. Y. Fennell. "VitisNet: 'Omics' Integration through Grapevine Molecular Networks." *PLoS ONE* 4, no. 12, (2009): e8365.



Liang Dong
Assistant Professor
PhD, Electronics Science and Technology, Tsinghua University, China (2004)

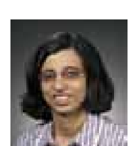
Research interests: MEMS, lab on a chip, microfluidics, biomimetics and bioinspiration, biosensors, nanophotonics, cell/tissue engineering, solar cells

Selected publications:
- Yang, H. and L. Dong. "Selective Nanofiber Deposition Using a Microfluidic Confinement Approach." *Langmuir* 26, no. 3, (2010): 1539–1543, http://pubs.acs.org/doi/abs/10.1021/la903988w.
- Dong, L. and H. Jiang. "Selective Formation and Removal of Liquid Microlenses at Predetermined Locations Within Microfluidics Through Pneumatic Control." *ASME/IEEE Journal of Microelectromechanical Systems* 17, no. 2, (2008): 381–392.

Santosh Pandey
Assistant Professor
PhD, Electrical Engineering, Lehigh University (2006)

Research interests: Microfluidics, bioelectronics, bioMEMS, behavioral neuroscience

Selected publications:
- Pandey, Santosh, Michelle Daryanani, Baozhen Chen, and Chengwu Tao. "Novel Neuromorphic CMOS Device Array for Biochemical Charge Sensing." In *Proc. IEEE Engineering in Medicine and Biology Society*, Vancouver, British Columbia, Canada, August 20-24, 2008.
- Chen, Baozhen, Chengwu Tao, and Santosh Pandey. "Fabrication and Characterization of a Novel Dual-Gate Charge-Sensing Device Architecture for Single Cell Studies." In *Proc. Materials Research Society Spring Meeting*, San Francisco, CA, March 24-28, 2008.



Namrata Vaswani
Assistant Professor
PhD, Electrical and Computer Engineering, University of Maryland (2004)

Research interests: Statistical and sequential signal processing, recursive sparse reconstruction and compressive sensing, medical imaging

Selected publications:
- Vaswani, Namrata, Yogesh Rathi, Anthony Yezzi, and Allen Tannenbaum. "Deform PF-MT: Particle Filter with Mode Tracker for Tracking Non-Affine Contour Deformations." *IEEE Trans. Image Processing* 19, no. 4, (April 2010): 841–857.
- Vaswani, Namrata. "Particle Filtering for Large Dimensional State Spaces with Multimodal Observation Likelihoods." *IEEE Trans. Signal Processing* 56, no. 10, (October 2008): 4583–4597.

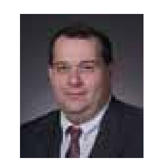
*Position titles reflect the faculty or staff member's status as of August 16, 2010.

CYBER INFRASTRUCTURE

Morris Chang
Associate Professor
PhD, Computer Engineering, North Carolina State University (1993)

Research interests: Embedded systems, power-aware computer systems, performance in Java virtual machines, wireless network protocols

Selected publications:
- Abichar, Z. and J. M. Chang. "A Medium Access Control Scheme for Wireless LANs with Constant-Time Contention." *IEEE Trans. Mobile Computing*, 2010, (forthcoming).
- Hasan, Yusuf, W. M. Chen, J. M. Chang, and B. M. Gharaibeh. "Upper Bounds for Dynamic Memory Allocation." *IEEE Trans. Computers* 59, no. 4, (April 2010): 468–477.



Thomas Daniels
Senior Lecturer
PhD, Computer Science, Purdue University (2002)

Research interests: Information assurance and security, network attribution, scalable laboratory systems for education, education of first-year computer engineers

Selected publications:
- Wang, W. and T. E. Daniels. "A Graph-based Approach Towards Network Forensic Analysis." *ACM Trans. Information System Security* 12, no. 1, (October 2008): Article no. 4.
- Al-Kofahim, M., S. Chang, and T. E. Daniels. "SCWIM: An Integrity Model for SOA Networks." In *Proc. IEEE International Conference on Web Services*, Beijing, China, September 23-26, 2008.

James A. Davis
Associate Professor
Vice Provost for Information Technology and Chief Information Officer (2004-present)
PhD, Computer Science, Iowa State University (1984)

Research interests: Enterprise information security strategies, risk management, computer security education

Manimaran Govindarasu
Associate Professor
PhD, Computer Science and Engineering, Indian Institute of Technology, Madras (1998)

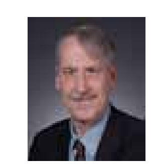
Research interests: Real-time systems, computer network security, critical infrastructure systems

Selected publications:
- Ten, C. W., G. Manimaran, and C. C. Liu. "Cybersecurity for Critical Infrastructures: Attack and Defense Modeling." *IEEE Trans. Systems, Man, and Cybernetics—Part A* 40, no. 4, (July 2010): 1–13.
- Pudar, S., G. Manimaran, and C. C. Liu. "A Practical Method and Tool for Integrated Modeling of Security Attacks and Countermeasures." *Computers and Security* 28, no. 8, (November 2009): 754–771.

Yong Guan
Associate Professor
PhD, Computer Science, Texas A&M University (2002)

Research interests: Digital forensics, wireless and sensor network security, privacy-enhancing technologies for the Internet

Selected publications:
- Peng, Y., L. Zhang, M. Chang, and Y. Guan. "An Effective Method for Combating Malicious Scripts Clickbots." In *Proc. 14th European Symposium on Research in Computer Security*, Saint Malo, France, September 21-23, 2009: 523–538.
- Yu, Z., Y. Wei, B. Ramkumar, and Y. Guan. "An Efficient Signature Scheme for Securing XOR Network Coding Against Pollution Attacks." In *Proc. 28th IEEE International Conference on Computer Communications*, Rio de Janeiro, Brazil, April 19-25, 2009: 1409–1417.

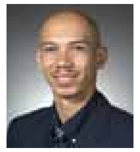


Doug Jacobson
University Professor
PhD, Computer Engineering, Iowa State University (1985)

Research interests: Information assurance, large-scale cyber attack simulation

Selected publications:
- Rursch, Julie, Andy Luse, and Doug Jacobson. "IT-Adventures: A Program to Spark IT Interest in High School Students Using Inquiry-Based Learning with Robotics, Game Design, and Cyber Defense." *IEEE Trans. Education* 53, no. 1, (2009): 71–79.

- Rursch, J. and D. W. Jacobson. "Using Cyber Defense Competitions to Build Bridges Between Community Colleges and Four-Year Institutions: A Footbridge for Students into an IT Program." In *Proc. Frontiers in Education*, San Antonio, TX, October 18-21, 2009: W1A1–W1A6.



Phillip Jones
Assistant Professor
PhD, Computer Engineering, Washington University (2008)

Research interests: Adaptive computing systems, reconfigurable hardware, embedded systems, specialized hardware for application acceleration, fault-tolerant systems

Selected publications:
- Gupte, Adwait and Phillip Jones. "An Evaluation of a Slice Fault Aware Tool Chain." In *Proc. Design, Automation, and Test in Europe*, Dresden, Germany, March 8-12, 2010: 1803–1808.
- Gupte, Adwait and Phillip H. Jones. "Hotspot Mitigation Using Dynamic Partial Reconfiguration for Improved Performance." In *Proc. IEEE International Conference on Reconfigurable Computing and FPGAs*, Cancun, Mexico, December 9-11, 2009: 89–94.

Ahmed Kamal
Professor
PhD, Electrical Engineering, University of Toronto, Canada (1986)

Research interests: High-performance networks, optical networks, wireless and wireless sensor networks, performance evaluation

Selected publications:
- Kamal, A. E. "1+N Network Protection for Mesh Networks: Network Coding-Based Protection Using p-Cycles." *IEEE/ACM Trans. Networking* 18, no. 1, (February 2010): 67–80.
- Al-Kofahi, O. M. and A. E. Kamal. "Network Coding-Based Protection of Many-to-One Wireless Flows." Special issue, *IEEE Journal on Selected Areas in Communications* 27, no. 5, (June 2009): 797–813.

Suraj C. Kothari
Professor
PhD, Mathematics, Purdue University (1977)

Research interests: Software engineering and its applications to high-performance computing, computational science, and bioinformatics

Selected publications:
- Kothari, Suraj C. "Scalable Program Comprehension for Analyzing Complex Defects." In *Proc. 16th IEEE International Conference on Program Comprehension*, Amsterdam, The Netherlands, June 10-13, 2008: 3–4.
- Stanek, Jason, Kang Gui, and Suraj C. Kothari. "Method of Comparing Graph Differencing Algorithms for Software Differencing." In *Proc. IEEE International Conference on Electro/Information Technology*, Ames, IA, May 18-20, 2008: 482–487.

Tien Nguyen
Assistant Professor
PhD, Computer Science, University of Wisconsin (2005)

Research interests: Software engineering, software maintenance and evolution, version control, mining software repositories, information retrieval, Web engineering

Selected publications:
- Nguyen, Tung T., Hoan A. Nguyen, Nam H. Pham, Jafar M. Al-Kofahi, and Tien N. Nguyen. "Recurring Bug Fixes in Object-Oriented Programs." In *Proc. ACM/IEEE International Conference on Software Engineering*, Cape Town, South Africa, May 2-8, 2010: 315–324.
- Nguyen, Tung T., Hoan A. Nguyen, Nam H. Pham, Jafar M. Al-Kofahi, and Tien N. Nguyen. "Graph-based Mining of Multiple Object Usage Patterns." In *Proc. ACM SIGSOFT Symposium on the Foundations of Software Engineering*, Amsterdam, The Netherlands, August 24-28, 2009: 383–392.

Diane Rover
Professor
PhD, Computer Engineering, Iowa State University (1989)

Research interests: Embedded systems, reconfigurable hardware, integrated program development and performance environments for parallel and distributed systems, visualization, performance monitoring and evaluation, engineering education

Selected publications:
- Cao, Z., R. Mercado, and D. T. Rover. "System-Level Memory Modeling for Bus-Based Memory Architecture Exploration." In *Proc. IEEE International Conference on Electro/Information Technology*, Windsor, Ontario, Canada, June 7-9, 2009: 239–244.
- Rover, D. T., R. Mercado, Z. Zhang, M. Shelley, and D. Helvick. "Reflections on Teaching and Learning in an Advanced Undergraduate Course in Embedded Systems." *IEEE Trans. Education* 51, no. 3, (August 2008): 400–412.

Arun K. Somani
Anson Marston Distinguished Professor
Jerry R. Junkins Endowed Chair
Department Chair
PhD, Electrical Engineering, McGill University, Montreal, Canada (1985)
- IEEE Fellow
- ACM Distinguished Engineer

ARUN K. SOMANI PHOTO COURTESY OF CRAIG CARROLL PHOTOGRAPHY

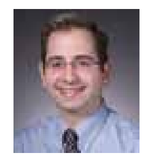
Research interests: Optical fiber networking, computer system architecture, dependable computing and networking systems, critical infrastructure monitoring

Selected publications:
- Avirneni, N. D. P., V. Subramanian, and A. K. Somani. "Low Overhead Soft Error Mitigation Techniques for High-Performance and Aggressive Systems." In *Proc. of Dependable Computing and Communications Symposium at the International Conference on Dependable Systems and Networks*, Estoril, Lisbon, Portugal, June 29-July 2, 2009: 185–194.
- Balasubramanian, S. and A. K. Somani. "Dynamic Survivable Network Design for Path Level Traffic Grooming in WDM Optical Networks." *Journal of Networking* 7, no. 8, (August 2008): 759–782.

Akhilesh Tyagi
Associate Professor
PhD, Computer Science, University of Washington (1988)

Research interests: Embedded systems, trusted computing base, private circuit synthesis

Selected publications:
- Baumgarten, Alex, Akhilesh Tyagi, and Joseph Zambreno. "Preventing IC Piracy Using Reconfigurable Logic Barriers." *IEEE Design and Test of Computers* 27, no. 1 (February 2010): 66–75.
- Keung, K. and Akhilesh Tyagi. "State Space Reconfigurability: An Implementation Architecture for Self Modifying Finite Automata." *Journal of Low Power Electronics* 6, no. 1, (April 2010): 18–31.



Joseph Zambreno
Assistant Professor
PhD, Computer Engineering, Northwestern University (2006)

Research interests: Reconfigurable computing, computer security, compilers, computer architecture

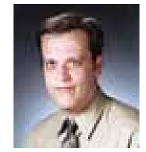
Select publications:
- Baumgarten, Alex, Akhilesh Tyagi, and Joseph Zambreno. "Preventing IC Piracy Using Reconfigurable Logic Barriers." *IEEE Design and Test of Computers* 27, no. 1 (February 2010): 66–75.
- Pande, A. and J. Zambreno. "A Reconfigurable Architecture for Secure Multimedia Delivery." In *Proc. International Conference on VLSI Design*, Bangalore, India, January 3-4, 2010: 258–263.

Zhao Zhang
Associate Professor
PhD, Computer Science, College of William and Mary (2002)

Research interests: Computer architecture, parallel and distributed computing, hardware support for security

Selected publications:
- Lin, Jiang, Qingda Lu, Xiaoning Ding, Zhao Zhang, Xiaodong Zhang, and P. Sadayappan. "Enabling Software Multicore Cache Management with Lightweight Hardware Support." In *Proc. Supercomputing*, Portland, OR, November 14-20, 2009.
- Zheng, Hongzhong, Jiang Lin, Zhao Zhang, and Zhichun Zhu. "Decoupled DIMM: Building High-Bandwidth Memory System from Low-Speed DRAM Devices." In *Proc. 36th International Symposium on Computer Architecture*, Austin, TX, June 20-24, 2009: 255–266.

DISTRIBUTED SENSING AND DECISION MAKING



Aleksandar Dogandzic
Associate Professor
PhD, Electrical Engineering and Computer Science, University of Illinois at Chicago (2001)

Research interests: Statistical signal processing theory and applications

Selected publications:
- Qiu, K. and A. Dogandzic. "Variance-component Based Sparse Signal Reconstruction and Model Selection." *IEEE Trans. Signal Processing* 58, (June 2010): 2935–2952.
- Dogandzic, A. and K. Qiu. "Decentralized Random-field Estimation for Sensor Networks Using Quantized Spatially Correlated Data and Fusion-center Feedback." *IEEE Trans. Signal Processing* 56, no. 12 (December 2008): 6069–6085.

Nicola Elia
Associate Professor
PhD, Electrical Engineering, Massachusetts Institute of Technology (1996)

Research interests: Networked control systems, feedback communication systems, control with limited information

Selected publications:
- Jin, L., R. Kumar, and N. Elia. "Model Predictive Control-based Real-time Power Systems Protection Schemes." *IEEE Trans. Power Systems*, 2010, (forthcoming).
- Wang, J. and N. Elia. "Consensus Over Networks with Dynamic Channels." Special issue, *International Journal of Systems Control and Communications* 2, (2010): 275–297.

Sang W. Kim
Associate Professor
PhD, Electrical Engineering, University of Michigan (1987)

Research interests: Cooperative communications, code division multiple access, MIMO, channel and network coding, cross-layer design, wireless security

Selected publications:
- Kim, Sang W. "Randomized Parity Forwarding in Large-scale Cooperative Broadcast Network." *IEEE Trans. Communications* 58, no. 3, (March 2010): 860–868.
- Kim, Sang W. "Substream-based Soft Handoff in CDMA Cellular Networks." *IEEE Trans. Communications* 57, no. 9, (September 2009): 2576–2579.

Ratnesh Kumar
Professor
PhD, Electrical and Computer Engineering, University of Texas at Austin (1991)
- IEEE Fellow

Research interests: Control, diagnosis, and verification of event-driven, real-time, and hybrid systems, and their applications in software, embedded, and power systems

Selected publications:
- Kumar, R. and S. Takai. "Inference-based Ambiguity Management in Decentralized Decision-Making: Decentralized Control of Discrete Event Systems." *IEEE Trans. Automatic Control* 52, no. 10, (2007): 1783–1794.
- Zhou, C. and R. Kumar. "Bisimilarity Control of Partially Observed Deterministic Discrete Event Systems." *IEEE Trans. Automatic Control* 52, no. 9, (September 2007): 1642–1653.

Daji Qiao
Associate Professor
PhD, Electrical Engineering, University of Michigan (2004)

Research interests: Algorithm innovation and implementation for wireless local area networks, modeling and analysis of sensor networks, pervasive computing applications

Selected publications:
- Yang, Guanqun and Daji Qiao. "Barrier Information Coverage with Wireless Sensors." In *Proc. IEEE Conference on Computer Communications*, Rio de Janeiro, Brazil, April 19-25, 2009: 918–926.
- Chen, Xi, Prateek Gangwal, and Daji Qiao. "Practical Rate Adaptation in Mobile Environments." In *Proc. IEEE International Conference on Pervasive Computing*, Galveston, TX, March 9-13, 2009: 204–213.

Aditya Ramamoorthy
Assistant Professor
PhD, Electrical Engineering, University of California, Los Angeles (2005)

Research interests: Network information theory, error control coding and signal processing with applications to nanotechnology and data storage

Selected publications:
- Ramamoorthy, Aditya. "Minimum Cost Distributed Source Coding Over a Network." *IEEE Trans. Information Theory*, 2010, (forthcoming).
- Kumar, Naveen, Pranav Agarwal, Aditya Ramamoorthy, and Murti V. Salapaka. "Maximum Likelihood Sequence Detector for Dynamic Mode High Density Probe Storage." *IEEE Trans. Communications* 58, no. 6, (June 2010).

Alexander Stoytchev
Assistant Professor
PhD, Computer Science, Georgia Institute of Technology (2007)

Research interests: Developmental robotics, autonomous robotics, machine learning, computational perception

Selected publications:
- Stoytchev, A. "Some Basic Principles of Developmental Robotics." *IEEE Trans. Autonomous Mental Development* 1, no. 2, (2009): 122–130.
- Sinapov, J., M. Wiemer, and A. Stoytchev. "Interactive Learning of the Acoustic Properties of Household Objects." In *Proc. IEEE International Conference on Robotics and Automation*, Kobe, Japan, May 12-17, 2009: 2518–2524.

Srikanta Tirthapura
Associate Professor
PhD, Computer Science, Brown University (2002)

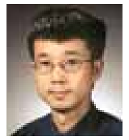
Research interests: Mining massive data sets, parallel and distributed computing

Selected publications:
- Cormode, Graham, Srikanta Tirthapura, and Bojian Xu. "Time-decaying Sketches for Robust Aggregation of Sensor Data." *SIAM Journal on Computing* 39, no. 4, (2009): 1309–1339.
- Xu, Bojian, Srikanta Tirthapura, and Costas Busch. "Sketching Asynchronous Data Streams Over Sliding Windows." *Distributed Computing* 20, no. 5, (2008): 359–374.

Umesh Vaidya
Litton Industries Assistant Professor
PhD, Mechanical Engineering, University of California, Santa Barbara (2004)

Research interests: Control of complex dynamical systems with applications to power system and fluid flow problems, control of network control systems

Selected publications:
- Vaidya, U., P.G. Mehta, and U. Shanbhag. "Nonlinear Stabilization via Control Lyapunov Measure." *IEEE Trans. Automatic Control*, 2010, (forthcoming).
- Vaidya, U. and P. G. Mehta. "Lyapunov Measure for Almost Everywhere Stability." *IEEE Trans. Automatic Control* 53, no. 1, (2008): 307–323.



Zhengdao Wang
Associate Professor
PhD, Electrical Engineering, University of Minnesota (2002)

Research interests: Wireless communication, signal processing, information theory

Selected publications:
- Wang, Z., S. Zhou, and J. Wu. "Transmitter Optimization and Performance Gain for Multiple-input Single-output Systems with Finite-rate Direction Feedback." *IEEE Trans. Wireless Communications* 8, no. 5, (May 2009): 2253–2258.
- Ke, H. Yin, W. Gong, and Z. Wang. "Finite-resolution Digital Receiver Design for Impulse Radio Ultra-wideband Communication." *IEEE Trans. Wireless Communications* 7, no. 12, (December 2008): 5108–5117.

Lei Ying
Litton Industries Assistant Professor
PhD, Electrical Engineering, University of Illinois at Urbana-Champaign (2007)

Research interests: Wireless communication networks, wireless sensor networks, distributed algorithms, peer-to-peer networks

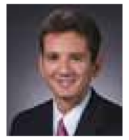
Selected publications:
- Liu, S., L. Ying, and R. Srikant. "Scheduling in Multichannel Wireless Networks with Flow-Level Dynamics." In *Proc. ACM SIGMETRICS 2010*, New York, NY, June 14-18, 2010.
- Bodas, S., S. Shakkottai, L. Ying, and R. Srikant. "Scheduling in Multichannel Wireless Networks: Rate Function Optimality in the Small-Buffer Regime." In *Proc. ACM SIGMETRICS/Performance*, Seattle, WA, June 15-19, 2009: 121–132.

ENERGY INFRASTRUCTURE

Venkataramana Ajjarapu
David C. Nicholas Professor of Electrical Engineering
PhD, Electrical Engineering, University of Waterloo (1986)
- IEEE Fellow

Research interests: Power system security, voltage stability, wind and solar energy integration, real-time control of power and power electronics systems

Selected publications:
- Yang, Sheng and V. Ajjarapu. "A Speed-Adaptive Reduced Order Observer for Sensorless Vector Control of Doubly-Fed Induction Generator-based Variable Speed Wind Turbines." *IEEE Trans. Energy Conversion*, 2010, (forthcoming).
- Konopinski, R. J., P. Vijayan, and V. Ajjarapu. "Extended Reactive Capability of DFIG Wind Parks for Enhanced System Performance." *IEEE Trans. Power Systems* 24, no. 3, (2009): 1346–1355.



Dionysios Aliprantis
Litton Industries Assistant Professor
PhD, Electrical Engineering, Purdue University (2003)

Research interests: Electric machines, power system dynamics and simulation, power electronics and controls, wind and solar photovoltaic energy, smart grid applications

Selected publications:
- McCalley, J., E. Ibáñez, K. Gkritza, D. Aliprantis, L. Wang, and A. Somani. "National Long-term Investment Planning for Energy and Transportation Systems." In *Proc. IEEE Power Energy Society General Meeting*, Minneapolis, MN, July 25-29, 2010.
- Aliprantis, D. C., O. Wasynczuk, and C. D. Rodríguez Valdez. "A Voltage-behind-reactance Synchronous Machine Model with Saturation and Arbitrary Rotor Network Representation." *IEEE Trans. Energy Conversion* 23, no. 2, (June 2008): 499–508.

Sumit Chaudhary
Assistant Professor
PhD, Electrical Engineering, University of California, Riverside (2006)

Research interests: Organic semiconductors, solar cells, nano-optoelectronics

Selected publications:
- Vengasandra, S. and S. Chaudhary. "Nano-mechano-electrical Characterization Applications in Fuel Cells and Organic Photovoltaics." *Materials Today* 13, (2010): 1–5.
- Chaudhary, S., A. M. Muller, W. Huang, R. O. Al-Kaysi, C. J. Bardeen, C. S. Ozkan, M. Ozkan. "Effects of Solvent and Annealing on Photophysical Properties of Polythiophene Photovoltaic Cells." *Advanced Science Letters* 2, no. 1, (2009): 14–20.

Vikram Dalal
Whitney Professor in Electrical and Computer Engineering
Associate Department Chair
PhD, Electrical Engineering, Princeton University (1969)
- IEEE Fellow

Research interests: Photovoltaic solar energy conversion devices, plasma processing, semiconducting materials and devices, sensor devices

Selected publications:

- Curtin, Benjamin, Rana Biswas, and Vikram Dalal. "Photonic Crystal Based Back Reflectors for Light Management and Enhanced Absorption in Amorphous Silicon Solar Cells." *Applied Physics Letters* 95, (2009): 231102.
- Dalal, Vikram, Atul Madhavan, S. Saripalli, Nayan Chakravarty, and Max Noack. "Device Physics of Nanocrystalline Silicon Solar Cells." In *Proc. IEEE 34th Photovoltaic Specialists Conference*, Philadelphia, PA, June 7-12, 2009: 1667–1671.

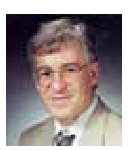
James McCalley
Harpole Professor in Electrical Engineering
PhD, Electrical Engineering, Georgia Institute of Technology (1992)
- IEEE Fellow

Research interests: Energy control centers, security assessment, power system dynamics, asset management, bulk energy production and transportation, energy system planning, wind energy

Selected publications:

- Liu, H., L. Jin, J. McCalley, R. Kumar, V. Ajjarapu, and N. Elia. "Planning Reconfigurable Reactive Control for Voltage Stability Limited Power Systems." *IEEE Trans. Power Systems* 24, no. 2, (May 2009): 1029–1038.
- Khaitan, S., J. McCalley, and Q. Chen. "Multifrontal Solver for Online Power System Time Domain Simulation." *IEEE Trans. Power Systems* 23, no. 4, (November 2008): 1727–1739.

SMALL-SCALE TECHNOLOGIES



John R. Bowler
Professor
PhD, Physics, University of Surrey, UK (1984)

Research interests: Analysis of electromagnetic fields, applications to nondestructive evaluation, computational methods in electromagnetics

Selected publications:

- Lu, Yi, N. Bowler, J. R. Bowler, Y. Huang. "Edge Effects in Four Point Direct Current Potential Drop Measurements." *Journal of Physics D-Applied Physics* 42, no. 13 (2009): 135004.
- Bowler, J. R. and T. P. Theodoulidis. "Boundary Element Calculation of Eddy Currents in Cylindrical Structures Containing Cracks." *IEEE Trans. Magnetics* 45, no. 3, (2009): 1012–1015.

Nicola Bowler
Associate Professor
PhD, Physics, University of Surrey, UK (1994)

Research interests: Electromagnetic properties of composite materials, electromagnetic nondestructive evaluation of dielectrics and metals

Selected publications:

- Zhang, C., N. Bowler, and C. C. H. Lo. "Magnetic Characterization of Surface-Hardened Steel." *Journal of Magnetism and Magnetic Materials* 321, (2009): 3878–3887.
- Liu, J. and N. Bowler. "Comment on: Finite-Element Modeling Method for the Study of Dielectric Relaxation at High Frequencies of Heterostructures Made of Multilayered Particle." *Journal of Applied Physics* 104, (2008): 096105.

Degang Chen
Professor
PhD, Electrical and Computer Engineering, University of California, Santa Barbara (1992)

Research interests: Analog and mixed-signal VLSI design and testing

Selected publications:

- Xing, Hanqing, Hanjun Jiang, Degang Chen, and Randall Geiger. "High-resolution ADC Linearity Testing Using a Fully Digital-Compatible BIST Strategy." *IEEE Trans. Instrumentation and Measurement* 58, no. 8, (August 2009): 2697–2705.
- He, Jun, Sanyi Zhan, Degang Chen, and Randall Geiger. "Analyses of Static and Dynamic Offset Voltage in Dynamic Comparators." *IEEE Trans. Circuits and Systems I: Fundamental Theory and Applications* 56, no. 5, (May 2009): 911–919.

Chris Chong-Nuen Chu
Associate Professor
PhD, Computer Science, University of Texas at Austin (1999)

Research interests: Interconnect optimization, placement, and routing of VLSI circuits

Selected publications:

- Zhang, Yanheng and Chris Chu. "CROP: Fast and Effective Congestion Refinement of Placement." In *Proc. IEEE/ACM International Conference on Computer-Aided Design*, San Jose, CA, November 2-9, 2009: 344–350.
- Yan, Jackey Z. and Chris Chu. "DeFer: Deferred Decision Making Enabled Fixed-Outline Floorplanner." In *Proc. IEEE/ACM Design Automation Conference*, Anaheim, CA, June 2008: 161–166.

Ayman Fayed
Assistant Professor
PhD, Electrical and Computer Engineering, The Ohio State University (2004)

Research interests: Integrated power management for mixed-signal System-on-Chip, energy-harvesting for remotely-deployed and biomedical electronics, high-speed wire-line transceivers, data converters, analog and mixed-signal IC design

Selected publications:

- Ramadass, Yogesh K., Ayman A. Fayed, Baher Haroun, and Anantha P. Chandrakasan. "A 0.16mm2 Completely On-Chip Switched-Capacitor DC-DC Converter using Digital Capacitance Modulation for LDO Replacement in 45nm CMOS." In *Proc. IEEE International Solid-State Circuits Conference*, San Francisco, CA, February 7-11, 2010: 209–209a.
- Fayed, Ayman and M. Ismail. "A Low-Voltage, Low-Power CMOS Analog Adaptive Equalizer for UTP-5 Cables." *IEEE Trans. Circuits and Systems I* 55, no. 2, (March 2008): 480–495.

Randall L. Geiger
Richardson Professor in Electrical and Computer Engineering
PhD, Electrical Engineering, Colorado State University (1977)
- IEEE Fellow

Research interests: Analog VLSI design, VLSI testing, high-speed data converters

Selected publications:

- Jin, L., D. Chen, and R. L. Geiger. "SEIR Linearity Testing of Precision A/D Converters in Non-stationary Environments with Center-Symmetric Interleaving." *IEEE Trans. Instruction and Measurement*, (October 2007): 1776–1785.
- Jiang, H., B. Olleta, D. J. Chen, and R. L. Geiger. "Testing High-Resolution ADCs with Low-Resolution/Accuracy Deterministic Dynamic Element Matched DACs." *IEEE Trans. Circuits and Systems I*, (May 2007): 964–973.

Jaeyoun Kim
Assistant Professor
PhD, Electrical Engineering, University of Michigan at Ann Arbor (2003)

Research interests: Photonics, plasmonics, application of optical nanostructures for bioengineering, optical bioMEMS, biomimetic optics

Selected publications:

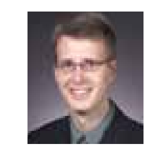
- Lee, Jiwon and Jaeyoun Kim. "Numerical Investigation of Quasi-Coplanar Plasmonic Waveguide-based Photonic Components." *Optics Express* 16, (2008): 9691–9700.
- Lee, Jiwon and Jaeyoun Kim. "A Quasi-Coplanar Plasmonic Waveguide for Ultra-compact Photonic Integrated Circuits." In *Proc. Conference on Lasers and Electro-Optics*, San Jose, CA, May 4-9, 2008.

Mani Mina
Senior Lecturer
PhD, Electrical Engineering, Iowa State University (1989)

Research interests: High-speed systems, magneto optics, applied electromagnetics, education

Selected publications:

- Kemmet, S., M. Mina, and R. J. Weber. "Fiber-based Magneto-Optic Sagnac Optical Modulator." *IEEE Trans. Magnetics* 45, no.10, (October 2009): 4892–4894.
- Kemmet, Sasha, M. Mina, and R. Weber. "Sagnac Interferometric Switch Utilizing Faraday Rotation." *Journal of Applied Physics* 105, no. 7, (April 2009): 07E702–07E702-3.



Nathan Neihart
Assistant Professor
PhD, Electrical Engineering, University of Washington (2008)

Research interests: Radio-frequency analog and mixed-signal IC design, MIMO, cognitive radio

Selected publications:

- Neihart, N. M., K. W. Cheng, J. S. Walling, S. Yoo, and D. J. Allstot. "A 4-antenna Transmitter in 0.18um CMOS Using Space-time Block Codes." In *Proc. IEEE Radio Frequency Integrated Circuits Symposium*, Boston, MA, June 7-9, 2009: 361–364.
- Luo, L., N. M. Neihart, S. Roy, and D. J. Allstot. "A Two-stage Sensing Technique for Dynamic Spectrum Access." *IEEE Trans. Wireless Communications* 8, (June 2009): 3028–3037.

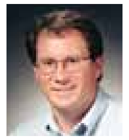
Jiming Song
Associate Professor
PhD, Electrical Engineering, Michigan State University (1993)

Research interests: Fast and efficient algorithms in computational electromagnetics; interconnect and RF component modeling; electromagnetic nondestructive evaluation; metamaterials for antenna applications

Selected publications:

- Hu, F.G. and J. M. Song, "Integral equation analysis of scattering from multi-layered periodic array using equivalence principle and connection scheme," *IEEE Trans. Antennas and Propagation*, 58, no. 3, (March 2010): 848–856.

- Hu, F. G., J. M. Song, and M. Yang. "Error in Projection of Plane Waves Using Various Basis Functions." *IEEE Antennas and Propagation Magazine* 51, no. 2, (2009): 86–98.



Gary L. Tuttle
Associate Professor
PhD, Electrical Engineering, University of California, Santa Barbara (1991)

Research interests: Semiconductor materials, nanoelectronics, photonic crystals, negative-index materials

Selected publications:
- Moussa, R., B. Wang, G. Tuttle, T. Koschny, and C. M. Soukoulis. "Effect of Beaming and Enhanced Transmission in Photonic Crystals." *Physical Review B* 76, no. 235417, (2007).
- Kohli, P., C. Christensen, J. Muehlmeier, R. Biswas, G. Tuttle, and K. M. Ho. "Add-Drop Filters in Three-Dimensional Layer-by-Layer Photonic Crystals Using Waveguides and Resonant Cavities." *Applied Physics Letters*, no. 231103, (2006).

Robert J. Weber
Professor
PhD, Electrical Engineering, Iowa State University (1967)
- IEEE Fellow

Research interests: Electromagnetics, microwave circuits and systems, MEMS/bio-MEMS, electrooptics, fiber-optics

Selected publications:
- Kemmet, Sasha, Mani Mina, and Robert J. Weber. "Sagnac Interferometric Switch Utilizing Faraday Rotation." *Journal of Applied Physics* 105, no. 7, (April 2009): 07E702–07E702-3.
- Cao, Haibo and R. Weber. "Three-port Conversion Scattering Parameters Characterization for Microwave Mixers." In *Proc. 51st Midwest Symposium on Circuits and Systems*, Knoxville, TN, August 10-13, 2008: 414–417. ■

Departmental Strategic Research Areas

Faculty in the ECpE department conduct research that is categorized under five strategic research areas:

■ **Bioengineering:** This area encompasses fields such as bioinformatics, biomedical engineering, biodynamics/biomechanics, biosensors, biotechnology, bio-signal processing, quantitative microscopy, systems engineering, and tissue engineering.

■ **Cyber Infrastructure:** The department's focus in this group includes areas such as computing and networking infrastructure, embedded systems, software engineering, computer and Internet security, real-time systems, and computing architectures.

■ **Distributed Sensing and Decision Making:** Faculty in this area specialize in research on sensor networks, complex systems, wireless technology, and distributed computing.

■ **Energy Infrastructure:** Research efforts in this area focus on power system dynamics and control, solar energy, wind energy, operational decision making, distribution systems, power system reliability, voltage security, economic systems and markets, asset management, power electronic systems, power systems security, national energy infrastructure planning, and the smart grid.

■ **Small-scale Technologies:** This area encompasses research in MEMS, circuit design and testing, data converters, electromagnetics, fiber optics, photonics, microelectronics, nanotechnology, and nondestructive evaluation.

Departmental Core Research Areas for Graduate Study

The ECpE department offers graduate degree programs to students that involve 10 traditional core research areas. Students can choose to specialize in one of these areas to receive their Master of Science, Master of Engineering, or PhD degree:
- Bioengineering
- Communications and signal processing
- Computing and networking systems
- Electric power and energy systems
- Electromagnetic, microwave, and nondestructive evaluation
- Microelectronics and photonics
- Secure and reliable computing/information assurance
- Software systems
- Systems and controls
- VLSI

Staff and Other Appointments

ADDITIONAL FACULTY APPOINTMENTS

Research Professor
- Maneesha Aluru, Research Assistant Professor (ECpE)
- Jaroslaw Zola, Research Assistant Professor (ECpE)

Adjunct Faculty
- Raj Aggarwal, Adjunct Professor (ECpE)
- George Amariucai, Adjunct Assistant Professor (ECpE)
- Viren Amin, Adjunct Assistant Professor (Center for Nondestructive Evaluation)
- Rana Biswas, Adjunct Professor (Ames Lab/Physics)
- Brett Bode, Adjunct Assistant Professor (Ames Lab)
- Ruth Shinar, Adjunct Professor (Physics)
- Masha Sosonkina, Adjunct Associate Professor (Ames Lab)

Faculty Courtesy Appointments
- Jennifer Davidson, Courtesy Associate Professor (Mathematics)
- Baskar Ganapathysubramanian, Courtesy Assistant Professor (Mechanical Engineering)
- Brian Hornbuckle, Courtesy Associate Professor (Agronomy)
- Zhinqun Lin, Courtesy Assistant Professor (Materials Science and Engineering)
- Glenn R. Luecke, Courtesy Professor (Mathematics)
- James Oliver, Courtesy Professor (Mechanical Engineering)
- Joseph Shinar, Courtesy Professor (Physics)
- Sanjeevi Sivasankar, Courtesy Assistant Professor (Physics)
- Costas Soukoulis, Courtesy Distinguished Professor (Physics)
- Leigh Tesfatsion, Courtesy Professor (Economics)
- Lizhi Wang, Courtesy Assistant Professor (Industrial and Manufacturing Systems Engineering)
- Qingze Zou, Courtesy Assistant Professor (Mechanical Engineering)

POSTDOCTORAL APPOINTMENTS
- Sudhansu Dash
- Juan Jose Jaramillo
- Sunggeun Jin
- Siddartha Kumar Khaitan
- Lucien Ouedraogo
- Julie Rursch
- Onur Turkcu
- Chun Xu

SUPPORT STAFF

Administrative Support
- Ginny Anderson, Information Assurance Center Secretary
- Tom C. Baird, EPES Program Manager
- Susana Bucklin, Administrative Specialist
- Stephanie Drake-Zierke, EPES Account Clerk
- Sara K. Harris, Assistant to the Department Chair
- Deena Klesel, Accountant
- Karen Knight, Secretary
- Dana McCullough, Communications Specialist

Computing Support Group
- Jason Boyd, Lab Coordinator
- Cory Farver, System Support Specialist
- Leland Harker, Electronic Technician
- Steven Kovarik, System Support Manager
- Steve Nystrom, System Support Specialist
- Mark Shamblin, System Support Specialist

Student Services
- Lindsay Diers, Academic Advisor
- Kristi Hetland, Secretary
- Deb Martin, Academic Advisor
- Tony Moore, Academic Advisor
- Pam Myers, Records Analyst
- Vicky Thorland-Oster, Program Manager

For the Wii-mote football drop, *right*, students placed Wii-motes inside a foam football, dropped them from a tall staircase, and recorded measurements on a computer.

Department Engages Students With Innovative Projects Involving **Wii-motes, Rock Band**

CprE 185 and CprE 186, the ECpE department's two introductory computer engineering and problem solving courses, aren't what they used to be. A few years ago, Senior Lecturer **Thomas Daniels** began revamping the courses to engage first-year students and show them how information they learn in many of their general education classes, such as physics and mathematics, are applied in practical computer engineering applications. The Technology Association of Iowa recognized Daniels' efforts earlier this year by giving him its Prometheus Award for Innovation in Education: Best Use of Innovation in Teaching.

Daniels introduced his teaching innovation to students in 2007 when he developed a set of exercises based on Nintendo Wii Remotes for freshmen to do and introduced those hands-on assignments to the class. Last fall, Daniels added a new aspect to the Wii-mote exercises: a Wii-mote Football Drop. The students packed their Wii-motes in a foam football to protect them, and dropped them from the top of the grand staircase in the ECpE Building Addition's atrium to measure how far and fast they drop.

"It's like an airbag in your car. It's experiencing over 10 Gs of acceleration when it hits the ground and bounces," Daniels says. "When students do their work in the lab, it'll work just fine, but when they get out in the real-world and drop the Wii-motes from the staircase where air resistance is important, it doesn't work, so it forces them into a problem-solving mode where they have to work out issues they didn't think about before to solve this real-world problem."

Daniels says that because many students are new at developing problem-solving strategies, they create contraptions where they "slap a little of this, and a little of that together." By the end of the project, the students realize that if they had spent more time writing down a coherent plan or simplifying their design it could have saved them a lot of time and improved their final product.

"The goal of this lab is for students to do real-world problems and try to get them to understand why they need to understand physics in the future," Daniels explains. "Then, when they get into their physics or advanced mathematics classes, they can see the reason why they need to be there in order to be a computer engineer."

For the past two years, students in Daniels' class also have done hands-on assignments incorporating the popular Rock Band video game. The students research a different aspect of the game, such as how the controllers work, and report their findings back to the class. To culminate this portion of the class, the class holds a Rock Band Night event each spring, where students and the public can see short, fun technical presentations about video game technology and a student Rock Band competition. ■

More Online

To view a video of Thomas Daniels' students experimenting with Wii Remotes during their Wii-mote Football Drop, go to *www.youtube.com/watch?v=tPCBfyQP4eE*.

ECpE Mission Statement

The mission of the Department of Electrical and Computer Engineering (ECpE) is to:

- provide an outstanding educational program that enables our graduates to become leaders in their profession by imparting fundamental principles, skills, and tools to innovate and excel;
- pursue the discovery of fundamental knowledge and its applications to position the department among the leaders in research; and
- respond to the needs of the State of Iowa and the nation by building a strong outreach program that serves industry and the engineering profession.

ECpE Vision and Priorities

Vision

Students will become broadly educated in the fundamentals of electrical and computer engineering principles with an emphasis on skills that enable them to adapt to the regular paradigm shifts in technological and engineering landscapes. We will aim to produce leaders who will shape the future technological arena.

The faculty will focus on research that is creative, innovative, and meaningful. The faculty vigorously will pursue and lead new emerging areas that have the potential to revolutionize the electrical and computer engineering and other related scientific and technological disciplines. The faculty will create, share, and apply the knowledge according to the land-grant mission of the university.

Priorities

Education:

- Impart the ability to learn
- Encourage leadership
- Maintain high standards and an excellent international reputation
- Attract top students from reputed national and international schools
- Form strategic alliances with industry and research labs to enhance opportunities for research collaboration and student exposure

Research:

- Sustain faculty composition to have strength in core disciplines with adaptability
- Create centers of excellence in bioengineering, cyber infrastructure, distributed sensing and decision making, energy infrastructure, and small-scale technologies
- Create strategic partnerships with reputed research labs, universities, and industry
- Build strong support infrastructures
- Encourage the process of technology transfer

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