\[ x' = f(x, p^*) + B_1 w \]
\[ y = G_1(x, p^*) \]
Any number of unpredictable factors can combine to cause rolling blackouts. One ECpE researcher is working to predict the unpredictable.

\[ \dot{x} = f(x, p'') + \beta_1 W \]

\[ y = G_1(x, p'') \]

Spotting Uncertainty

Umesh Vaidya is using Ergodic theory to find uncertainties within network systems and promote efficiency.

Speed Test

Degang Chen has developed an algorithm to dramatically reduce testing time and production costs for high-performance semiconductors.
WELCOME

LETTER FROM THE CHAIR

It is my pleasure to present you with our 2012 Research Highlights biennial report. Our faculty members have advanced the department with a number of research grants, awards, and honors and we are pleased to include highlights of their accomplishments within these pages.

The department continues to concentrate research in five strategic areas: bioengineering; cyber infrastructure; distributed sensing and decision making; energy infrastructure; and materials, devices, and circuits. This focus continues to guide our research efforts and direct the advancement of our department.

Four faculty members: Santosh Pandey, Aditya Ramamoorthy, Umesh Vaidya, and Joseph Zambreno were awarded National Science Foundation (NSF) CAREER Awards in 2012, bringing the department’s CAREER award total to 11 in the last five years (page 8). Suraj Kothari and Dionysios Aliprantis were awarded sizeable grants (page 4), while three of our faculty were named fellows of their respective professional associations.

Many of our faculty have made major advancements in their fields. Degang Chen has developed an algorithm to dramatically reduce testing time and production costs for high-performance semiconductors (page 24). Our faculty members are researching transcranial magnetic stimulation for use in treating Post Traumatic Stress Disorder and other brain disorders in veterans. Zambreno is advancing the march toward exascale computing, among other things (page 20), while Vaidya is developing algorithms to identify uncertainties in network systems (page 16).

We remain committed to our educational goals, as well. This fall, the nation’s first Wind Energy Science, Engineering, and Policy (WESEP) Ph.D. program will begin at Iowa State (page 6). Harpole Professor James McCalley will lead the program, which is designed to advance wind energy knowledge and develop leaders in the wind energy field.

Overall, the department continues to succeed. We hope you find this report of our most recent accomplishments informative and useful.

Best regards,

David C. Jiles
Palmer Department Chair in Electrical and Computer Engineering
Anson Marston Distinguished Professor

DEPARTMENT FACTS

FAST FACTS
■ Established: 1909
■ Alumni: More than 11,000
■ Research Centers & Institutes: 11
■ Endowed Professorships & Chairs: 11

NEW FACILITIES & EQUIPMENT (2010-12)
■ Mixed-signal processing lab acquired
■ Processing equipment for solar cells acquired
■ Laser lithography system acquired

HONORS (2010-12)
■ New IEEE Fellows: 3
■ Best Paper Awards: 4
■ Patents Awarded: 17
■ Journal Editorships: 39
■ Conference Keynote Speakers: 5

FUNDED RESEARCH PROPOSALS
■ FY10: $22.3 million
■ FY11: $9.8 million
■ FY12: $14.4 million

PRIVATE FUNDING (2010-12)
■ Organization Gifts: Nearly $1.2 million
■ Individual Gifts: Nearly $450,000 annually
■ Scholarships Awarded: Nearly $400,000 annually

FACULTY/STAFF DETAILS
■ 54 faculty
■ 18 NSF CAREER Award winners
■ 13 fellows (out of 17 full professors)
■ 1 ACM Distinguished Engineer
■ 20 staff

FULL-TIME EQUIVALENT (FTE) FACULTY DATA (2010-12)
■ Faculty FTE: 48.8
■ Ph.D degrees awarded per FTE: 1.55
■ MS/MEng degrees awarded per FTE: 2.21

STUDENT ENROLLMENT (FALL 2012 PROJECTED)
■ BS: 303
■ MS/MEng: 108
■ PhD: 76

DEGREES AWARDED (2010-12)
■ BS: 1408
■ MS/MEng: 119
■ PhD: 189

RESEARCH EXPENDITURES

BS: $8.9
MS/MEng: $10.2
PhD: $10.7
Ahmed, Vikram Tirthapura's three entries represented the most from any researcher invited to this conference. Tirthapura's papers propose new approaches for organizing databases of rectangle subsampled data streams, find the optimal curve was optimal for the class of queries accepted to PODS in 2008. Aggregates in Out-of-order Streams,” was accepted to PODS in 2008.

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Iowa State University will soon become the first institution to award students Ph.D. degrees in Wind Energy Science, Engineering, and Policy (WESEP) thanks to a $3.1 million, five-year grant from the National Science Foundation (NSF) Integrative Graduate Education and Research Traineeship (IGERT) program.

James McCalley, Murray J. and Ruth M. Harpole Professor in Electrical Engineering, is leading the program, which aims to advance wind energy knowledge, develop high impact wind leaders, and impact the wind energy community. His team is comprised of four co-principal investigators and 15 faculty members from Iowa State's College of Liberal Arts and Sciences, College of Agriculture and Life Sciences, and College of Engineering, including fellow ECpE faculty members Assistant Professor Dionysios Aliprantis and Associate Professor Nicola Elia.

The program, which is a collaborative effort with the University of Puerto Rico – Mayagüez, will support a total of 28 domestic Ph.D. students over the next five years, and will provide them with multidisciplinary training in the skills required for conducting research in engineering, science, and policy-related disciplines.

According to McCalley, the program’s research is focused on increasing wind energy growth rate, reducing costs, and extending penetration limits of wind energy. “Our nation’s most pressing problem today is arguably meeting energy needs while reducing global climate impacts. Because wind energy emits no greenhouse gases and is relatively low-cost, broad consensus exists that the future U.S. energy portfolio must contain a large wind energy component,” McCalley says.

“The vision is to strengthen the nation’s wind energy resources by producing technical experts, effective communicators, and ethical decision-makers who lead the progression of wind energy technology,” McCalley says.

Co-principal investigators on the project include Lisa Brasche, scientist at the Center for Nondestructive Evaluation; John Jackman, associate professor in industrial and manufacturing systems engineering; Partha Sarkar, professor in aerospace engineering, and Gene Takle, professor in agronomy and geological and atmospheric sciences. Other Iowa State faculty members involved include Bruce Babcock, professor in economics; Carmen Bain, assistant professor in sociology; Bill Gallus, professor in geological and atmospheric sciences; Frank Peters, associate professor in industrial and manufacturing systems engineering; Sri Sritharan, distinguished professor in industrial and manufacturing systems engineering; Lulu Rodriguez, professor in industrial and manufacturing systems engineering; Bill Meeker, distinguished professor in statistics; Frank Peters, associate professor in industrial and manufacturing systems engineering; and Lichi Wang, assistant professor in industrial and manufacturing systems engineering.

The second level includes a group of additional courses within the other thrust areas as needed for their research, but the requirement ensures students are research-capable in two thrust areas.

Two additional advanced “specialization” team-taught courses will be developed for the third curriculum level. The courses will provide students with depth in the research areas most closely aligned with their dissertation topic.

Additionally, a real-time research collaborative course will be required of all WESEP students and faculty each semester and will serve to integrate teams and develop research skills. Research teams of three to four students and their supervising faculty will address a research objective that corresponds with the students’ objectives.

Industry/International: The industrial and international features of the program will promote interaction with industry and national labs via the Project Advisory Board as well as a three to six month internship, while the international features will include a 3+ month visit to one of the program’s international partner universities in Ireland, Germany, Denmark, China, or Spain.

“The internship and international experiences will provide practical applications for students’ research without extending their time-to-degree since students will be able to continue work on their dissertation topics,” McCalley says. IGERT fellows will receive an annual stipend of $30,000, as well as tuition, fees, and health insurance for two years. Additional support will be available for textbooks, journals, short courses, and professional travel. In the following years, they will be supported via research grants and other funding sources and/or as teaching assistants. The expectation is that all IGERT fellows will be provided a total of three to five years of support depending on the nature of their research and continued progress on adequate progress toward the degree.

While there is currently a lot of wind energy research being done at Iowa State right now, the WESEP program is still in its initial stage of recruiting students. “The key to the program is the ability to recruit highly capable domestic students to enter a Ph.D. program,” McCalley says. “To this end, Iowa State WESEP faculty have developed a multifaceted recruiting plan that engages with the very best students in universities around the nation through frequent faculty recruiting trips, campus recruiting events, and summer undergraduate research programs.”

“Co-principal investigators on the project include Lisa Brasche, scientist at the Center for Nondestructive Evaluation; John Jackman, associate professor in industrial and manufacturing systems engineering; Partha Sarkar, professor in aerospace engineering, and Gene Takle, professor in agronomy and geological and atmospheric sciences. Other Iowa State faculty members involved include Bruce Babcock, professor in economics; Carmen Bain, assistant professor in sociology; Bill Gallus, professor in geological and atmospheric sciences; Frank Peters, associate professor in industrial and manufacturing systems engineering; Sri Sritharan, distinguished professor in industrial and manufacturing systems engineering; Lulu Rodriguez, professor in industrial and manufacturing systems engineering; Bill Meeker, distinguished professor in statistics; Frank Peters, associate professor in industrial and manufacturing systems engineering; and Lichi Wang, assistant professor in industrial and manufacturing systems engineering.”
Bigelow received his award to research the applications of ultrasound technology with regard to cancer treatment. Bigelow is working on methods to use ultrasounds to destroy cancerous tumors without surgery or thermal ablation. His methods can provide a less-invasive process that allows patients to recover more quickly and with fewer side effects.

Yong's award was to develop techniques to verify locations of mobile wireless devices and ensure the integrity of information provided by sensors and other devices. With location-based access control, an employee dealing with sensitive materials could access classified documents only from a designated work computer, helping prevent classified information from being leaked.

Alprantis won a CAREER award to research methods to decrease the weight and size of motors and generators and improved their efficiency and cost-effectiveness. He is exploring how electric motors can be improved by optimizing performance in a preferred direction of rotation and wrote a computer modeling program that incrementally changes the design of the motors and calculates when the surface shape is just right.

Ramamoorthy is researching atomic force microscopy, which uses a thin cantilever to examine materials at high resolutions. With soft or fragile materials, observers use what is called tapping mode. This mode involves oscillating the cantilever at a certain frequency and observing the effects of oscillation without damaging the medium. Ramamoorthy’s research involves the use of signal processing algorithms to characterize and image soft materials in a fraction of the time taken by conventional methods.

Zambreno is researching ways to combine CPU and GPU processors into a single, hybrid chip. Traditional computer architecture includes a CPU and a GPU handling separate tasks. Today’s “fused” chips feature integrated CPU/GPU designs, which promote faster interfacing and more efficient use of processor power. However, today’s model utilizes a CPU and a GPU performing the same rules they always did, just in closer proximity. Zambreno wants to combine the two chips to get the best of both.

Pandey is developing a new engineering platform to visualize, analyze, and modulate interactions between plant roots and pathogens. His research aims to develop effective and sustainable control strategies against plant diseases. He plans to develop a plant-in-chip system for the growth of Arabidopsis plants, realize chemical schemes for sensing and modulating auxin in plants, and build on-chip electrical schemes for sensing root health and manipulating pathogenic interactions with roots.

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, and wireless sensor networks used for medical technologies and unmanned surveillance of U.S. borders. His research will help address and provide solutions for three long-standing weaknesses of wireless communication: bandwidth, channel fading, and interference.

Ramamoorthy’s research involves the use of signal processing algorithms to characterize and image soft materials in a fraction of the time taken by conventional methods.

Chaudhary’s project continues his effort to improve organic solar cell efficiency and also improve the technology for widespread applications. In the short term, he hopes to increase the efficiency of the cells from 5 percent to almost 10 percent, which would be useful in charging small electronic devices. By introducing ferroelectrics into the organic layers used to fabricate polymer solar cells, Chaudhary hopes to make the technology available to consumers in the near future.

Vaidya’s work identifies uncertainties within network systems and then proposes ways to make those systems run as efficiently as possible given the uncertainties. Vaidya is applying aspects of ergodic theory to identify critical factors that are responsible for complex changes in a network system. Vaidya finds uncertainty in network systems and determines how that uncertainty affects the system as a whole in order to make the system run more efficiently.
In September 2011, an Arizona Public Works employee, performing a routine procedure at the North Gila substation near Yuma, tripped off a 500-kilovolt line and began a series of failures that left more than 2 million people without power in the Southwest United States. Both trigger events were small, seemingly inconsequential incidents. Both resulted in massive power outages by setting off an effect called cascading failure, a topic of considerable study for Ian Dobson, Arend J. and Verna V. Sandbulte Professor in Engineering.

“What happens is, a failure occurs somewhere and weakens the system a bit,” Dobson says. “On a bad day, something else happens. Usually it doesn’t, but on that day, let’s say, it does. If it’s a really bad day, then a third thing happens and the system becomes degraded. You’re in a situation where it’s more likely that the next failure is going to happen because the last failure already happened. That’s the idea of cascading failure.”

The failure of the Walton Hills line, a relatively minor occurrence given the size and scale of the power grid, reverberated through the network and helped cause a series of events that brought down a sizable chunk of the nation’s power infrastructure. The initial point of failure in Ohio shifted the power burden to other points down the line and made a malfunction in these points much more likely – a classic case of cascading failure.

“What we’re talking about is the big power grid that stretches from here to Florida and Maine and Canada – everything east of the Rockies is all connected together, all humming together,” Dobson says. “Something trips out the line and the power system wobbles a little bit, Dobson says. “Under normal operation you’ve already designed for normal faults. With anything that commonly goes wrong with the system, engineers and everyone in the utility industry rushes around and makes sure that it doesn’t happen again. Most common, understandable, or easy to figure out things are already mitigated. Unusual stuff – rare interactions, unusual combinations of things when the system is already degraded – is a lot harder to control.”

Dobson’s research goes beyond what can be anticipated and attempts to figure out the overall likelihood of large-scale blackouts, like the events in 2003 and 2011, by studying the interactions between various points in the system using a series of math equations and simulations. In effect, Dobson is using models to simulate the “perfect storm” in the power grid, though he disputes the terminology.

“People always say ‘It was the perfect storm.’” Dobson says. “But these large blackouts happen because of the...
Cascading effect. You’re never going to get 20 different independent failures to happen at the same time because that’s vanishingly unlikely. But if the first couple events make the next events more likely, then those events happen and make the next ones more likely – then you get those rare events happening. This is the typical way that large complicated systems have catastrophic failures, and it is not really a perfect storm.

Cascading failure is difficult to analyze because of the huge number of unanticipated variables. In other words, researchers don’t know what they don’t know. In addition, the dependence of individual failures on previous failures and their effect on subsequent failures creates an incredibly complex system of dependent variables. Large blackouts involve the failure of many interconnected variables, each of which affect how variables down the line interact with each other.

If the first couple events make the next events more likely, then those events happen and make the next ones more likely – then you get those rare events happening.

“Imagine you’re very, very tightly scheduled on a certain day,” Dobson says. “Then, things start getting delayed in the morning and things get worse and worse throughout the day. Because your first appointment was delayed, it’s more likely that the next one will be delayed. Pretty soon you start missing appointments altogether in the afternoon. That’s a very small example of cascading failure.”

There are a few common attributes, like critical loading, that researchers can look for when studying cases of cascading failure. A power grid’s critical loading can be defined as a point somewhere between a very low load and a very high load where the risk of a blackout increases sharply. If the amount of electricity flowing through the system is higher than the power grid critical load, the likelihood of a blackout spikes. The power grid’s critical load acts as a reference point for cascading failure; stay below it and the system will likely be fine. Go above it, and the risk of a blackout is more severe.

“If a transmission line carrying its usual load fails, other lines can pick up the slack without much trouble,” he says. “But if the power grid as a whole is carrying a load that is above its critical loading, its burden has a much greater effect on the other lines. That’s something we look for.”

Dobson uses a number of models and power system simulations of cascading failure to develop risk analysis methods for the power grid. Much like businesses use risk analysis procedures to identify and assess potential shortcomings within a project or account, Dobson uses his models to quantify the size and cost of a blackout given data on the power grid and its internal interactions. His findings can eventually be used to recommend upgrades in the power grid and determine the value and necessity of those upgrades.

“There’s a difference between recommending power grid upgrades and recommending prudent and cost-effective power grid upgrades,” Dobson says. “We have to figure out the best places to upgrade and focus resources there.”
As of 2008, more than two million soldiers had served in Iraq and Afghanistan. Of those two million soldiers, more than 320,000 have some degree of traumatic brain injury and over 300,000 have PTSD. “Traumatic brain injury can occur when improvised explosive devices (IEDs) or roadside bombs, go off. The IEDs radiate shock waves that can travel through the brain, causing skull movement and the loss of brain function,” Ron Steptoe, CEO of the Steptoe Group, says. “Our major issue is that what works for some people doesn’t work for everyone.”

Currently, the company is working to develop new ways, and developing a training program, to look at patients based on characteristics such as their age, gender, ethnicity, work, environment, and more. Currently, the company is working to increase awareness of the growing and detrimental impact mental health and behavioral mental health conditions are having on the military and veteran communities, as well as deliver unique technologies to improve injury recuperation.

“Some of the brain can cause interruptions in individuals’ speech, while the field penetrates very differently than they initially expected, they were able to rework their coil designs to reach inside the brain, increasing the field strength by a factor of four at 70 mm. When the coils were tested on a number of patients suffering from different brain disorders, the results showed some interesting effects. “By stimulating the brain, you can cause involuntary movement in the limbs, which is beneficial for stroke rehabilitation,” Jiles explains. “When paralysis occurs, muscle tone deteriorates. You can stimulate muscles using TMS to recover some of the muscle toning.”

In an ischemic stroke, the blood supply to the brain is cut off. If the individual survives, the blood supply is restored but the victim will suffer from brain damage. “TMS can be used to treat this because it ‘bathes’ the entire brain in a magnetic field, which stimulates the entire brain and not just the outer region,” Jiles says. “The difference between the old and new coil is the distance between the field and the coil. When you stimulate the brain, the most stimulation occurs where the field is largest,” Jiles says. “On the old coil, the field decreases quickly as it goes into the brain, but the configuration of the new coil enables the magnetic field to penetrate even deeper into the brain.”

While the group has uncovered several useful findings and continues to make new discoveries, Jiles says that the interaction between the field and the brain is only crudely understood. “The passage of the field, which is very different from almost any other kind of technology.”

Kanthasamy, an expert on animal diseases—specifically Parkinson’s disease and other neurodegenerative disorders—will aid in the research by testing the efficacy of the non-invasive magnetic field in an animal model of Parkinson’s disease, while Bigelow will investigate transcranial ultrasound stimulation in the treatment of traumatic brain injury.

“We will determine the ultrasound thresholds for brain stimulation both with and without an accompanying electromagnetic field,” Bigelow says. “While considerable work has been done showing that it is possible to stimulate neurons with ultrasound, the thresholds have not been explored when a magnetic field was also applied. Therefore, we will systematically explore the ultrasound parameters necessary for brain stimulation in both in vitro and in vivo models both with and without a magnetic field.”

Jiles adds that the potential benefits of the research and development partnership with the Steptoe Group are enormous. “Let’s find out what we can do non-invasively, optimize that, and bring it to its best capabilities,” Jiles says. While the partnership is still in its early stages, the team members are already hard at work pursuing additional funding sources, including the U.S. Department of Defense, National Institutes of Health (NIH), National Science Foundation (NSF), and Roy J. Carver Charitable Trust, among others.
ONE ECpE RESEARCHER IS APPLYING ERGODIC THEORY OF DYNAMICAL SYSTEMS TO MAKE COMPLEX SYSTEMS RUN MORE SMOOTHLY

by BROCK ASCHER
Mesh Vaidya, Associate Professor in the Department of Electrical and Computer Engineering at Iowa State University, recognizes that uncertainties in network and control systems are inevitable due to real-life engineering problems. His research, theoretical yet practical, aims to mitigate these uncertainties to make systems more efficient and robust.

Vaidya's work focuses on network systems, such as electric power grids and buildings, to identify and mitigate uncertainties. He applies methods and tools from ergodic theory of dynamical systems to locate uncertainties within these networks. This involves understanding complex behaviors like voltage collapse in power systems or the variability in energy consumption within buildings due to factors such as weather and occupancy.

Through his research, Vaidya seeks to improve the performance of network systems by determining the best locations for ducts and vents, and by understanding how to mitigate the effects of uncertainty. His work on buildings, for instance, involves modeling the air temperature and air quality within various rooms. Opening windows, closing doors, and changing the number of people in a room can alter the air flow and temperature, which are considered uncertain variables.

Vaidya's approach is to use mathematical models to predict the outcomes of these uncertainties and to design systems that can adapt to these changes. This is particularly important in the context of renewable energy sources, such as wind and solar, which can be highly variable and uncertain.

In conclusion, Vaidya's research is crucial for designing network systems that can operate efficiently and robustly under uncertain conditions. His work not only contributes to the field of systems and control engineering but also has implications for improving the energy efficiency and comfort of buildings, among other applications.
The future of computer architecture isn’t just about creating bigger, faster, and stronger chipsets. For ECPE’s Joseph Zambreno, it’s mostly about creating smarter chipsets.

Joseph Zambreno, Associate Professor in the Iowa State department of Electrical and Computer Engineering, is drawing from three frontiers of computer architecture—Exascale computing, data mining, and “fused” chipsets—to propose new approaches to data collection and chip design.
“Computer engineering is considered an enabling discipline,” Zambreno says. “We have the physicists, the chemists, the people who work on bioinformatics, who need us. They have algorithms that need as much computing power as they can get. If we can provide them efficient, scalable chips, that could be what leads to the breakthrough that eventually cures cancer or something of that nature.”

THE EXASCALE ERA

Today, most computer users measure space in terms of gigabytes and, more recently, terabytes. Large-scale data users like Google and Facebook measure their server farms in terms of petabytes, equal to 1,024 terabytes. A petabyte is a staggeringly large unit of measurement.

To watch one gigabyte of high-definition video, for example, you would have to watch for about seven minutes. To watch one petabyte of HD video, you would have to watch for 13 years and four months. With funding provided by a National Science Foundation Computer Systems Research Grant Using a field-programmable gate array (FPGA)-based machine programmed to act like an exascale-era chip, Zambreno can run numerous tests to find strengths and weaknesses for multiple architectural setups.

“We’re testing out architecture ideas that won’t be ready to market for 10 years, or something of that nature,” Zambreno says. “We have software that won’t be ready to market for 10 years, either. We tend to optimize for either performance or power consumption, but what do we need to do to be able to build that next generation system, the exabyte system, that’s even a thousand times bigger than that? That’s what we’re working toward.”

Some of the world’s largest databases have already begun to break the exabyte (1,024 petabytes) barrier, but computing performance has lagged behind the rate of data expansion. In short, we have all this data, but not enough computing power to sort through it.

Zambreno is setting his sights on recasting that situation, one step at a time. With funding provided by a National Science Foundation Computer Systems Research Grant Using a field-programmable gate array (FPGA)-based machine programmed to act like an exascale-era chip, Zambreno can run numerous tests to find strengths and weaknesses for multiple architectural setups.

We’re testing out architecture ideas that won’t be ready to market for 10 years, or something of that nature,” Zambreno says. “We have software that simulates what the chip would look like and what its characteristics would be. We tend to optimize for either performance or power consumption, but other aspects like programmability or security are common, too.”

Though the actual creation of an exascale system is likely several years away, the push toward the exascale era has resulted in many useful breakthroughs.

“If you look at the processor in the iPhone or the Samsung Galaxy— they have processors that would have been state-of-the-art desktop processors just a few years ago,” Zambreno says. “By pushing to make state-of-the-art desktop processors that much better and power-efficient, you get those really nice little side effects. It trickles down, and now your mobile phone is faster than your previous desktop.”

As transistors get smaller and smaller and we can fit more and more on a chip, what do we do with them?

He doesn’t consider his goal of aiding future researchers the most important aspect of his work. Zambreno is much more interested in what those future exascale chips could be used for.

DATA MINING AT EXASCALE

When processors are powerful enough to sort through exabytes of data, finding useful patterns in that data—data mining—will be vital to businesses and future researchers.

“Data mining, as an application, is still in its infancy,” Zambreno says. “People have written a whole bunch of software algorithms, but they haven’t really focused that much on what the architecture should look like for those algorithms.”

Data mining has an enormous number of potential uses; from businesses using it to predict the buying habits of potential customers, to scientists employing it to map relationships between strands of DNA and study disease. Today, however, the gap between the amount of data available and the amount of data that processors are able to handle is widening, Zambreno’s work involves shrinking that gap and figuring out how to build computer architecture that takes every advantage of its increased power.

“As transistors get smaller and smaller and we can fit more and more on a chip, what do we do with them?” he asks. “We can add extra cores, so we go from eight cores to 16, for example, but there are diminishing returns to where we can go with regard to that kind of acceleration. If we have all these transistors, let’s allocate some to work on data mining. We might as well spend part of these chips on something that could be really useful once we need it.”

Creating ever-larger and ever-faster chips will always be the goal of computer engineers, but creating a smarter chip is another part of Zambreno’s research.

FUSED CHIPS

Traditional computer architecture revolves around a central processing unit (CPU) carrying out instructions, handling logic and performing computations while a graphics processing unit (GPU) renders graphics, handles display output, and works with multi-threaded tasks. Today’s “fused” chips, including the AMD Fusion, the Intel Tegra, and the NVIDIA Tegra, feature integrated CPU/GPU designs, which promote faster interfacing and more efficient use of processor power. However, today’s “fused” chip model utilizes a CPU and a GPU performing the same roles they always did, just in closer proximity. Zambreno wants to turn this line of thinking on its head.

“The trend now is the so-called ‘fused architecture,’ or a CPU and a GPU on the same die,” Zambreno says. “But it’s kind of just glued together at this point. In the past, your CPU would be in one place, your GPU would be somewhere else and they’d be connected with a fairly high-speed bus. It’s better now, they’re physically closer together so things like locality are better and power efficiency is improved. But architecturally, it’s not that interesting. It’s sort of a logical consequence of what has been happening for years now.”

Funded by a National Science Foundation CAREER Award, Zambreno is working on a proposal for a hybrid chip, one that is the best of both a CPU and a GPU.

“We’re looking at what CPUs do very well and what GPUs do very well and figuring out how we can get the best of both worlds in terms of memory efficiency, computational density, and in terms of power efficiency,” he says.

Zambreno’s work in exascale computing, data mining, and “fused” chip design represents the cutting edge of computer architecture. Still, Zambreno defines his work in terms of service to other fields.

“Our innovations [as computer engineers] are not very broadly impacting just by themselves,” he says. “Increasing processor power isn’t important unless you’re saying ‘now that we have that extra computing power, maybe that enables us to do things that we didn’t think were possible.’”

Joseph A. Zambreno has been with the Department of Electrical and Computer Engineering at Iowa State University since 2006. He currently co-directs the Reconfigurable Computing Lab (RCL). Prior to Iowa State he was at Northwestern University in Evanston, IL, where he graduated with his Ph.D. degree in electrical and computer engineering in 2006, his M.S. degree in electrical and computer engineering in 2002, and his B.S. degree summa cum laude in computer engineering in 2001.

He is a recent recipient of a National Science Foundation (NSF) CAREER award (2012), the ISU Award for Early Achievement in Teaching (2012), and the IEEE Warren B. Boast Undergraduate Teaching Award (2009, 2011).

ZAMBRENO

JOSEPH

Associate Professor, Electrical and Computer Engineering
DEGANG CHEN HAS DEVELOPED AN ALGORITHM TO DRAMATICALLY REDUCE TESTING TIME AND PRODUCTION COSTS FOR HIGH-PERFORMANCE SEMICONDUCTORS.

by THANE HIMES

High-performance semiconductors are individually tested to guarantee quality before they can be shipped to customers. This is done by inputting precisely known data values into a part and measuring accurately how the part responds to the input data. As Moore’s law continues to push up performance and push down prices, the test time has become a significant part of the semiconductor manufacturing cost. For certain high performance parts, the test cost can be as high as 73-percent of the overall cost of build.

“We use high-performance semiconductors for things like medical instruments and defense applications, so when you test these parts, you want the test to be very accurate, in both the total value and in the small increments,” says Degang Chen, professor of electrical and computer engineering. “This roughly corresponds to integral non-linearity (INL) and differential non-linearity (DNL).”

The INL and DNL test is the most time consuming among many parameters to be tested. Many researchers from both academia and industry have been working on various methods to reduce INL/DNL test time. After years of trying various ideas, Chen and graduate student June Yu developed a new algorithm for an analog-to-digital INL/DNL test that is hundreds of times faster and far more precise than the current test method, known as the standard histogram test.

“The standard histogram test has two hidden, gross inefficiencies,” Chen said. “The first is that it treats all the hundreds of thousands of INL/DNL errors as independent random quantities, whereas in reality they are all determined by the much smaller number of circuit components. Also, the most precise quantity in the INL/DNL test set-up is the input source, but the standard histogram test throws away the input information.”

Chen submitted his findings to the IEEE International Test Conference, but his paper was rejected because his results were deemed “unbelievable.” This led Chen to contact Texas Instruments. Chen allowed TI to try the technology, hoping that their findings would provide “credibility” to the “unbelievable” results. At the invitation of the chief technologist of the company’s High Performance Analog division, Chen went to Texas Instruments last summer after collaborating with them via email during the spring 2011 semester.

“After seeing the initial measurement data, they thought the algorithm had great potential, and they asked me to come down,” Chen said. “I was there for about eight weeks to teach them the new algorithm and help their engineers to implement and validate the algorithm.”

Chen was successful. His algorithm was significantly more precise than the standard histogram tests that use 64 to 256 times more data than Chen’s algorithm required. Since test time is dominantly data acquisition time, the new method was much faster.

Chen submitted his findings to the ITC premium conference, but his paper was deemed “unbelievable.”

“Our method takes about 0.4 percent of the original test time, but our result is more accurate,” Chen said. “One of the ways Chen validated his algorithm’s accuracy was by using the servo loop method, a method that is very accurate but takes a very long time to conduct. Using the servo loop method to test a high-performance 16-bit SAR ADC took 18 minutes. Using Chen’s new algorithm, the same test was finished in less than one-tenth of a second, and the test results matched those from the servo loop extremely well.”

The next step for Chen’s research is to introduce the new algorithm to technology producers. TI is doing additional statistical evaluations before using the new method in mass production. They are currently working on implementing the new algorithm in several of their product groups, including touch screen technology.

“Technology adoption is a serious matter and involves a pretty slow process. It will probably take more than a year,” Chen said. “Once one company adopts the new algorithm and shows good results, others will follow.”

Chen will return to TI periodically to continue working on the project. He also has submitted a new paper with his results to the ITC, and is waiting for a reply.
Researchers in the department of ECpE have been looking into ways to enhance security on the web from external threats.

Joe Idziorek, a Ph.D. student in ECpE; Doug Jacobson, University Processor in ECpE; and Mark Tannian, an ECpE Ph.D. candidate, collaborated to look for solutions to the problem of fraudulent uses of cloud resources on the internet.

Idziorek was first drawn to the idea for the challenge of finding something new.

“It has only been in recent years that all these technologies have matured to the point where a synthesis of these components could be realized,” Idziorek said.

“Therefore, the challenge in this research area is finding genuinely new problems that cloud computing presents and not simply relabeling old problems.”

Fraudulent Resource Consumption (FRC) attacks, the exploitation of the utility pricing model in a cloud computing web application, was easy to exploit. Jacobson was immediately intrigued.

“Because this is an open, impactful, and challenging problem that has not been previously addressed by the security research community, Dr. Jacobson and I agreed that this was a research problem worth exploring,” Idziorek said.

In a utility price model in a cloud computing application, consumers only pay for the resources they consume (i.e., storage, bandwidth, and computer hours), similar to public utilities like electricity and water. However, this pricing system can be exploited by external attackers.

In a cloud utility model, botnets consisting of bot clients can infiltrate a cloud network and consume resources by mimicking the behavior of legitimate clients. The application itself isn’t aware of the bot’s intentions, and the cost of addressing those bots is assessed to the legitimate cloud consumers. This would be meaningless if it was only a one-time attack. But this subtle method of resource consumption can be quite costly in the long term.

One of the research team’s biggest challenges was accurately and concisely describing the vulnerability of the utility pricing model. Defending against an FRC attack is quite a challenge to a cloud consumer due to the subtle, unassuming nature of the attack.

“Once the problem was defined and accepted, the second main challenge of this research was to formulate prevention, detection, attribution, and mitigation solutions for a new problem, which itself had no direct body of previous research,” Idziorek said.

The biggest goal of this research was to create awareness of FRC attacks, given that there have been no known public acknowledgements of an FRC attack occurring on the public cloud. By identifying the problem and offering foundations for potential solutions, further research can be conducted. Idziorek is happy with the results of the research, but plans to continue making improvements.

“Methodologies can always be improved, algorithms can always be more efficient, and detection and attribution schemes can always be more accurate,” Idziorek said. “Because I thoroughly enjoy my research topic and there is an incredible amount of work that is still to be done in this space, I plan to continue this research as a life-long challenge.”

ECpE GRADUATE STUDENT JOE IDZIOREK IS WORKING TO PROTECT DATA IN CLOUD-BASED APPLICATIONS AND PREVENT THOSE APPLICATIONS FROM BEING EXPLOITED.

by THANE HIMES
Microsoft's 2012 Imagine Cup competition was designed around the theme of technology solving the world's biggest problems. Teams designed their projects to address one of the competition's several stated goals, which included ending world hunger, reducing child mortality, fostering environmental sustainability, and more.

Entering the competition as “Team Exsolvo,” ECpE undergraduate students Andrew Kies, Tushar Vashisth, Gavin Monroe, and Michael Naughton decided to focus on combating Parkinson’s disease.

“Team Exsolvo quickly came up with the idea to experiment with the Xbox Kinect, one of the specific technologies the contest required use of, to help combat Parkinson’s,” said Andrew Kies, senior in computer engineering and leader of the project. “We knew that ISU’s Kinesiology department conducts research into motor control and learning, and realized that perhaps we could find a project related to their work, which would let us collaborate directly with experts in the field.”

According to Ann Smiley-Oyen, an associate professor of kinesiology who has conducted extensive research on Parkinson’s disease at Iowa State, one of the biggest challenges of doing research with Parkinson’s patients is the repetitive nature involving the completion of certain tasks, like drawing inside the lines of a box. The patient’s performance is recorded and measured to standards set by the researcher. The games are designed and coded to be easily customizable to better serve a particular patient or researcher’s needs.

“Two team members, Andrew and Gavin, will be working for Microsoft after graduation, and thus they may serve as Microsoft advisors,” Rover said. “We will be proposing this as a continued project in the senior design course.”

Team Exsolvo received positive feedback. Team Exsolvo didn’t make it to the final round of the competition, but the team plans to continue developing the system and enter it again next year.

“Team Exsolvo gained a lot of experience in the competition, and their exposure will benefit future ECpE teams interested in the competition.”

Microsoft liked the project, and thus the team plans to continue developing the system and enter it again next year.

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“A TEAM OF ECpE STUDENTS IS DEVELOPING A SYSTEM TO UTILIZE THE XBOX KINECT TO HELP COMBAT PARKINSON’S DISEASE

by THANE HIMES

Patients are often unable to come to a lab frequently, and sending researchers to patients’ homes is costly.

Team Exsolvo worked with Smiley-Oyen to design a system using the Kinect to help solve this logistical problem.

“Our team had very little knowledge about Parkinson’s or physical therapy, but thankfully Dr. Smiley-Oyen was extremely enthusiastic and helpful in providing us with all the information we needed,” Kies said. “We collaborated with her a great deal when designing the system.”

The team named their system “Exsolvo Kinetics.” Using an intuitive interface, patients can utilize the Kinect to conduct their movement therapy in the form of movement-centric games, all in the comfort of their own homes.

Using an intuitive interface, patients can utilize the Kinect to conduct their movement therapy in the form of movement-centric games, all in the comfort of their own homes.

Diane Rover, professor of electrical and computer engineering, supervised the team as a faculty advisor, helping the students manage the complexity of the competition and of their project.

“This is the first time the ECpE department has entered a senior design team in the Imagine Cup competition,” Rover said. “It was a challenge to navigate the logistics of the competition as well as institute the first time the ECpE department has entered a senior design team in the Imagine Cup competition.”

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RESEARCH HIGHLIGHTS

Intrusion detection, network attribution, computer security, cyber-physical security of the smart grid, cyber physical systems, computer and network security, security testbeds, wireless network protocols, computer security, digital forensics, wireless security, privacy-enhancing technologies for the Internet.

SELECTED PUBLICATIONS:

RESEARCH HIGHLIGHTS

- High-performance computing, bioinformatics and systems biology, combinatorial scientific computing, applied algorithms.
- Intrusion detection, network attribution, computer security, cyber-physical security of the smart grid, cyber physical systems, computer and network security, security testbeds, wireless network protocols, computer security, digital forensics, wireless security, privacy-enhancing technologies for the Internet.
- RESEARCH HIGHLIGHTS

SELECTED PUBLICATIONS:

SELECTED PUBLICATIONS:

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

SELECTED PUBLICATIONS:

RESEARCH INTERESTS: Critical infrastructure monitoring and protection, optical fiber networking, reliability-performance-energy tradeoffs in dependable computing and networking systems.

SELECTED PUBLICATIONS:

RESEARCH INTERESTS: Computer architecture, parallel and distributed computing, hardware support for security.

SELECTED PUBLICATIONS:

SELECTED PUBLICATIONS:

RESEARCH INTERESTS: Reconfigurable computing, graphics processing and architecture, embedded systems.

SELECTED PUBLICATIONS:

RESEARCH INTERESTS: Computer architecture, parallel and distributed systems, trusted computing base, private circuit synthesis.

SELECTED PUBLICATIONS:

RESEARCH INTERESTS: Embedded systems, trusted computing base, private circuit synthesis.

SELECTED PUBLICATIONS:

RESEARCH INTERESTS: Electrical and Computer Engineering, University of Illinois at Chicago.

SELECTED PUBLICATIONS:

RESEARCH INTERESTS: Statistical signal processing theory and applications.

SELECTED PUBLICATIONS:

RESEARCH INTERESTS: Networked control systems, communication with feedback, control with communication constraints, network distributed optimization systems, advanced controller design methods.

SELECTED PUBLICATIONS:
RESEARCH HIGHLIGHTS

Control, diagnosis, and verification of distributed networked event-driven, real-time and hybrid systems, and their applications to cyberphysical systems, embedded systems and software, sensor and embedded networks, web-services, precision farming, power systems.

SELECTED PUBLICATIONS:

RESEARCH INTERESTS:
- Wireless networking and mobile computing.

SELECTED PUBLICATIONS:

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

SELECTED PUBLICATIONS:

ENERGY INFRASTRUCTURE

SELECTED PUBLICATIONS:

RESEARCH INTERESTS:
- Photovoltaic energy conversion, electronic and optical materials and devices, plasma processing.

SELECTED PUBLICATIONS:

RESEARCH INTERESTS:
- Control of complex dynamical systems with applications to power systems, fluid flow problems, and aerospace applications, analysis and control of uncertain network systems.

SELECTED PUBLICATIONS:

RESEARCH INTERESTS:
- Electric machines and drives, power systems, electric vehicles, and wind and solar photovoltaic energy, smart grid applications.

SELECTED PUBLICATIONS:
**JAMES MCCALLEY**

HARPOLE PROFESSOR  
PhD, Electrical Engineering, Georgia Tech (1982)  
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:**

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**CHRIS CHONG-NUEN CHU**

ASSOCIATE PROFESSOR  
PhD, Computer Science, Texas (1999)  
IEEE Fellow  

**RESEARCH INTERESTS:** Physical design of VLSI circuits.

**SELECTED PUBLICATIONS:**

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**Johnny B. 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:**

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**Aymun Fayed**

ASSISTANT PROFESSOR  
PhD, Electrical and Computer Engineering, Ohio State (2004)

**RESEARCH INTERESTS:** Embedded power management, conversion, and delivery for mixed-signal SoCs and multi-core processors; energy harvesting for power restricted and remotely deployed devices, and high-speed wire-line transceivers.

**SELECTED PUBLICATIONS:**

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**Randall L. Geiger**

DOLUCA PROFESSOR  
PhD, Electrical Engineering, Colorado State (1977)  
IEEE Fellow  

**RESEARCH INTERESTS:** Analog VLSI design, VLSI testing, high-speed data converters.

**SELECTED PUBLICATIONS:**

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**Jaeyoun Kim**

ASSOCIATE PROFESSOR  
PhD, Electrical Engineering, Michigan (2003)

**RESEARCH INTERESTS:** Bio-inspired engineering, plasmonics, bio-MEMS, and micro-photonics.

**SELECTED PUBLICATIONS:**

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**Nathan Neihart**

ASSISTANT PROFESSOR  
PhD, Electrical Engineering, Washington (2008)

**RESEARCH INTERESTS:** Radio-frequency analog and mixed-signal integrated circuit design, reconfigurable circuits and systems for cognitive radio applications, fabrication and application of memristors to analog and mixed-signal circuit design, synthetic biology and circuits for biomedical applications.

**SELECTED PUBLICATIONS:**

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**Jiming Song**

ASSOCIATE PROFESSOR  
PhD, Electrical Engineering, Michigan State (1993)

**RESEARCH INTERESTS:** Fast and efficient algorithms in computational electromagnetics, modeling of VLSI interconnects on silicon, electromagnetic nondestructive evaluation, wave propagation in metamaterials, antenna analysis and design.

**SELECTED PUBLICATIONS:**
RESEARCH HIGHLIGHTS

**Semiconductor materials, nanoelectronics, photonic crystals, negative-index materials.**

**SELECTED PUBLICATIONS:**

F. Xiu et al. “Electric field-controlled ferromagnetism in high-Curie-temperature Mn0.05Ge0.95 quantum dots.” Nature Materials, 9, pp. 337-344. 2010.


**RESEARCH INTERESTS:**

- Dilute magnetic semiconductors for spintronics devices
- Topological insulators for dissipationless applications

**STAFF AND OTHER APPOINTMENTS**

**ADDITIONAL FACULTY APPOINTMENTS**

**RESEARCH PROFESSOR**

- Manoresh Abu, Research Assistant Professor (ECpE)
- Jaroslav Zola, Research Assistant Professor (ECpE)

**ADJUNCT FACULTY**

- Raj Aggarwal, Adjunct Professor (ECpE)
- George Amaritazari, Adjunct Assistant Professor (ECpE)
- 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)
- Raskar GanapathySubramanian, Courtesy Assistant Professor (Mechanical Engineering)
- Brian Hornbuckle, Courtesy Associate Professor (Agronomy)
- Zhiquing 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)
- Leigh Tesfarsion, Courtesy Professor (Economics)
- Lichi Wang, Courtesy Assistant Professor (Industrial and Manufacturing Systems Engineering)

**JOURNAL FACULTY**

- David Weiss, Professor (Software Engineering)
- Samik Basu, Associate Professor (Software Engineering)

**RESEARCH HIGHLIGHTS**

**ADDITIONAL FACULTY APPOINTMENTS**

**RESEARCH PROFESSOR**

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

**RESEARCH HIGHLIGHTS**: Dilute magnetic semiconductors for spintronics devices, surface states of topological insulators for dissipationless applications.

**SELECTED PUBLICATIONS:**

- F. Xiu et al. “Electric field-controlled ferromagnetism in high-Curie-temperature Mn0.05Ge0.95 quantum dots.” Nature Materials, 9, pp. 337-344. 2010.

**RESEARCH INTERESTS:**

- Dilute magnetic semiconductors for spintronics devices
- Topological insulators for dissipationless applications

**STAFF AND OTHER APPOINTMENTS**

**ADDITIONAL FACULTY APPOINTMENTS**

**RESEARCH PROFESSOR**

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- 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)

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- Brian Hornbuckle, Courtesy Associate Professor (Agronomy)
- Zhiquing 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)
- Leigh Tesfarsion, Courtesy Professor (Economics)
- Lichi Wang, Courtesy Assistant Professor (Industrial and Manufacturing Systems Engineering)

**JOURNAL FACULTY**

- David Weiss, Professor (Software Engineering)
- Samik Basu, Associate Professor (Software Engineering)
DEPARTMENTAL STRATEGIC RESEARCH AREAS

- **Bioengineering:** This area encompasses fields such as bioinformatics and systems biology, BioMEMS, biosensing, bio-optics, and bioimaging.
- **Cyber Infrastructure:** The department's focus in this group includes computer architecture, cybersecurity, dependable and real-time systems, embedded systems, high-performance computing, high-speed networking, and software systems and engineering.
- **Distributed Sensing and Decision Making:** Faculty in this area specialize in research on compressed sensing, information theory, networked control systems, signal processing theory and applications, and wireless communications, sensors, and networks.

DEPARTMENTAL CORE RESEARCH AREAS FOR GRADUATE STUDY

- **Bioengineering**
  - Microelectronics and photonics
  - Secure and reliable computing/information assurance
  - Software systems
  - Systems and controls
  - Very-large-scale integration (VLSI)

- **Communications and signal processing**
- **Computing and networking systems**
- **Electric power and energy systems**
- **Electromagnetic, microwave, and nondestructive evaluation**

ECpE RESEARCH LABS

- **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**
- **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 Automation/Allen Bradley Power Electronics and Drive Systems Laboratory**
- **Scalable Software Engineering Research Laboratory**
- **Software Defined Radio Laboratory**
- **Very-large-scale integration (VLSI)**
- **Materials, Devices, and Circuits:** This area encompasses research in analog and mixed-signal VLSI design and testing, BioMEMS, computational electromagnetics and non-destructive evaluation, magnetic materials and devices, metamaterials for antenna applications, microelectronic devices, optical nanostructures for bioengineering and biomimetic optics, and power management, conversion, and delivery for electronic devices.

**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

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 technological arena.

**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 technological and engineering landscapes. We will aim to produce leaders who will shape the future technological arena.

**PRIORITIES**

**EDUCATION:**
- Instill 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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