RESEARCH HIGHLIGHTS

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2014
Year-In-Review

Inside

Your Phone Isn't Safe

ECpE researchers, funded by a $4.1 million DARPA grant, are building the latest anti-malware tools for Android

IOWA STATE UNIVERSITY
Department of Electrical and Computer Engineering

www.ece.iastate.edu

Department Chair:
David C. Jiles

Editor:
Brock Ascher

Faculty Portraits Photographers:
Grant Steinfeldt, Bob Elbert

Contributing Writers:
Brock Ascher
Michael Still
Mike Krapfl
Tedi Baron

Designer:
Brock Ascher

Cover Illustration:
Amy Donaghy

Research Highlights is published annually by the Department of Electrical and Computer Engineering at Iowa State University. Suggestions, comments, and letters to the editor are welcome. Please direct inquiries to the following address:

Department of Electrical and Computer Engineering
2215 Coover Hall
Iowa State University
Ames, IA 50011-3060
(515) 294-5929
ascher@iastate.edu
www.ece.iastate.edu

@ ISU_ECpE

ISU Department of Electrical and Computer Engineering

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ECpE researchers, funded by a $4.1 million DARPA grant, are building the latest anti-malware tools for Android.

BY MICHAEL STILL

On the Cover
ISU junior graphic design major Amy Donaghy created cover's Little Red Riding Hood-inspired pencil art.

GREETINGS FROM IOWA STATE

It is my pleasure to present the Department of Electrical and Computer Engineering's Research Highlights annual report. This 2014 year-in-review contains a number of highlights from some of the department's very best faculty members and we are pleased to include their accomplishments within these pages.

Department faculty continue to distinguish themselves among peers and garnered a number of national and international awards in 2014. Two department faculty members, **Manimaran Govindarasu** and **David Weiss**, were named IEEE Fellows. Their election puts the total ECpE tally at 15 IEEE Fellows, a number the department takes great pride in.

In addition, **Vikram Dalal** was named an Anson Marston Distinguished Professor by Iowa State. Dr. Dalal's contribution to solar energy research is impressive and certainly makes him worthy of this honor.

I would be remiss if I didn't mention my own award. I had the honor of being elected to the Royal Academy of Engineering in the United Kingdom. It is a great honor and I am grateful to both Iowa State and to the numerous talented students and colleagues I've worked with over the years.

The department's faculty awards are summarized on the opposite page along with a number of other indicators. These indicators, including enrollment, scholarship money, gifts, and funded research proposals, are all trending upward. This reflects the steady growth ECpE has seen over the last five years and demonstrates the prosperity of the department.

In this issue, you can read about some of our most promising research projects, including **Suresh Kothari's** $4.1 Million DARPA grant to build the latest anti-malware tools for the Android operating system. This project fits into ECpE's new Cyber Security and Cyber/Physical Security strategic research area.

The department's strategic research areas have evolved to better reflect its strengths and to better direct the advancement of department research. This renewed focus represents the latest evolution in ECpE's research strategy. The department's strategic research areas now include Bioengineering, Cyber Security and Cyber/Physical Security; Materials, Devices, and Circuits; and Energy Infrastructure.

In addition to Dr. Kothari's project, you can read about **Liang Dong**'s greenhouse on a chip, **Meng Lu**'s biotechnology efforts, and **Kathryn Stolee**'s search engine for code. Finally, **James McCalley**, **Ian Dobson**, and **Venkataramana Ajjarapu** are working with Southern California Edison to help shield its power grid from extreme events.

Overall, the department continues to make strong progress. Continued growth, collaboration, and diversification remain at the forefront of our efforts. I hope you find this report of our most recent accomplishments informative, exciting and useful.

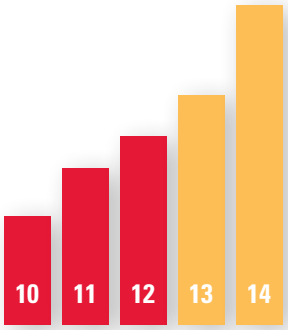
Best regards,

David Jiles

David C. Jiles
Anson Marston Distinguished Professor
Palmer Endowed Department Chair

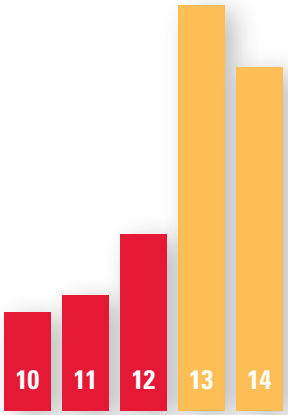
TRENDING UPWARD

The department is seeing positive growth across the board - from record enrollment to increased giving and research expenditures. Faculty numbers are growing steadily and ECpE faculty members consistently rank among the world's best.



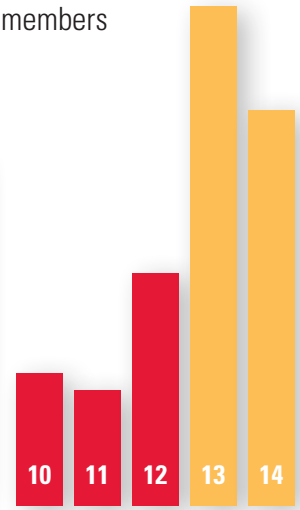
Enrollment

2014: 1,991
2013: 1,649
2012: 1,573
2011: 1,459
2010: 1,264



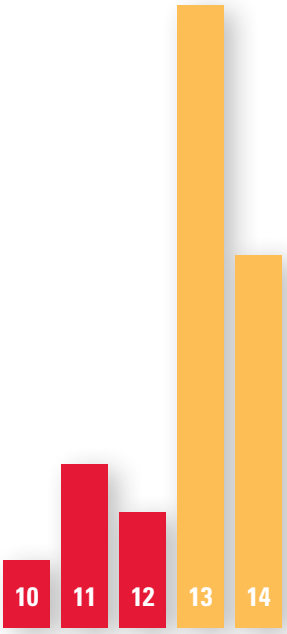
Gift Fund Scholarships

2014: $240,518
2013: $285,550
2012: $170,223
2011: $113,179
2010: $112,350



Organizational Gifts

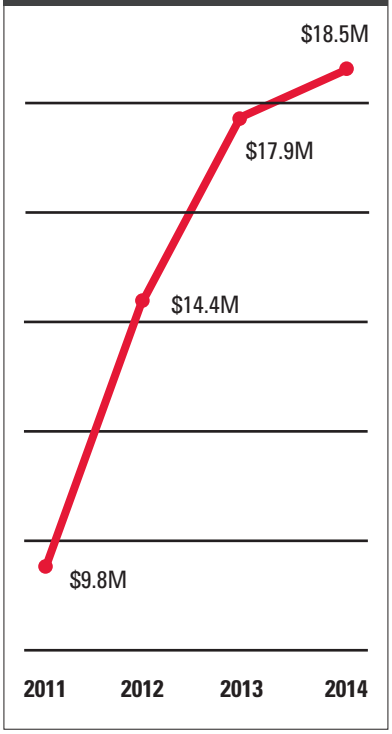
2014: $753,400
2013: $770,510
2012: $495,105
2011: $331,163
2010: $355,400



Individual Gifts

2014: $1,224,104
2013: $2,223,430
2012: $112,675
2011: $243,970
2010: $73,804

Funded Research Proposals



Faculty Facts

60 Total Facutly
17 Fellows
21 NSF CAREER Award Winners
1 Royal Academy of Engineering Fellow

JILES ELECTED TO ROYAL ACADEMY OF ENGINEERING

Becomes department's first RAE Fellow and fourth fellow of a national academy of engineering

BY **BROCK ASCHER**

David C. Jiles, Palmer Endowed Chair in the Department of Electrical and Computer Engineering at Iowa State, has been elected to the Royal Academy of Engineering, the United Kingdom's national academy for engineering. Jiles is the ECpE department's first RAE Fellow.

He was cited for his seminal contributions to the scientific understanding and engineering applications of magnetism. This has encompassed power, aerospace, automotive and medical engineering. His most influential work – the development of a model for non-linear magnetic hysteresis – is the internationally accepted standard and has been widely cited.

"I'm honored to be elected to the Royal Academy of Engineering for my research contribution," said Jiles. "But I also owe a debt of gratitude to a number of talented students and colleagues over the years, without whom this would not have been possible"

Jiles, an Anson Marston Distinguished Professor, has chaired the ECpE department since 2010. He is a Fellow of several societies including the American Physical Society, the Institute of Electrical and Electronics Engineers, the Magnetics Society, the Institution of Electrical Engineers (UK), the Institute of Physics (UK), the Institute of Materials, Minerals and Mining (UK), and the Institute of Mathematics and its Applications (UK) and an Honorary Fellow of the Indian Society for Nondestructive Testing and a member of many more professional and scientific societies. He earned a DSc from the University of Birmingham (1990), a PhD from the University of Hull (1979), an MS from the University of Birmingham (1976), and a BS from the University of Exeter (1975).

Jiles arrived in Ames in 1984 as a research fellow at the Ames Laboratory and became a professor of electrical & computer engineering and materials science & engineering in 1990. He attained the rank of Anson Marston Distinguished Professor in 2003. He was Director of the Wolfson Centre for Magnetics at Cardiff University from 2005 until 2010. He was then appointed the first Palmer Endowed Department Chair in Electrical & Computer Engineering in 2010.

"I am very grateful to Iowa State University which has provided me with an outstanding research environment in which to work over the last thirty years," Jiles said. "This achievement would not have been possible without continued support and encouragement from ISU."

Jiles' research interests include nonlinear and hysteretic behavior of magnetic materials; magnetoelasticity, magnetostriction, and magnetomechanical effects; nondestructive evaluation; and transcranial magnetic stimulation (TMS) for the treatment of brain disorders – among other areas. His model for non-linear magnetic hysteresis is the internationally-accepted standard and his research into TMS has uncovered the potential for new treatments of a number of brain diseases. He holds a courtesy appointment with the Department of Materials Science & Engineering and is an Associate of the U.S. Department of Energy's Ames Laboratory.

Election to the Academy is by invitation only; about 50 Fellows are elected each year by peer review from nominations made by existing Fellows. They are distinguished by the title "Fellow of the Royal Academy of Engineering" and the post nominal FREng.

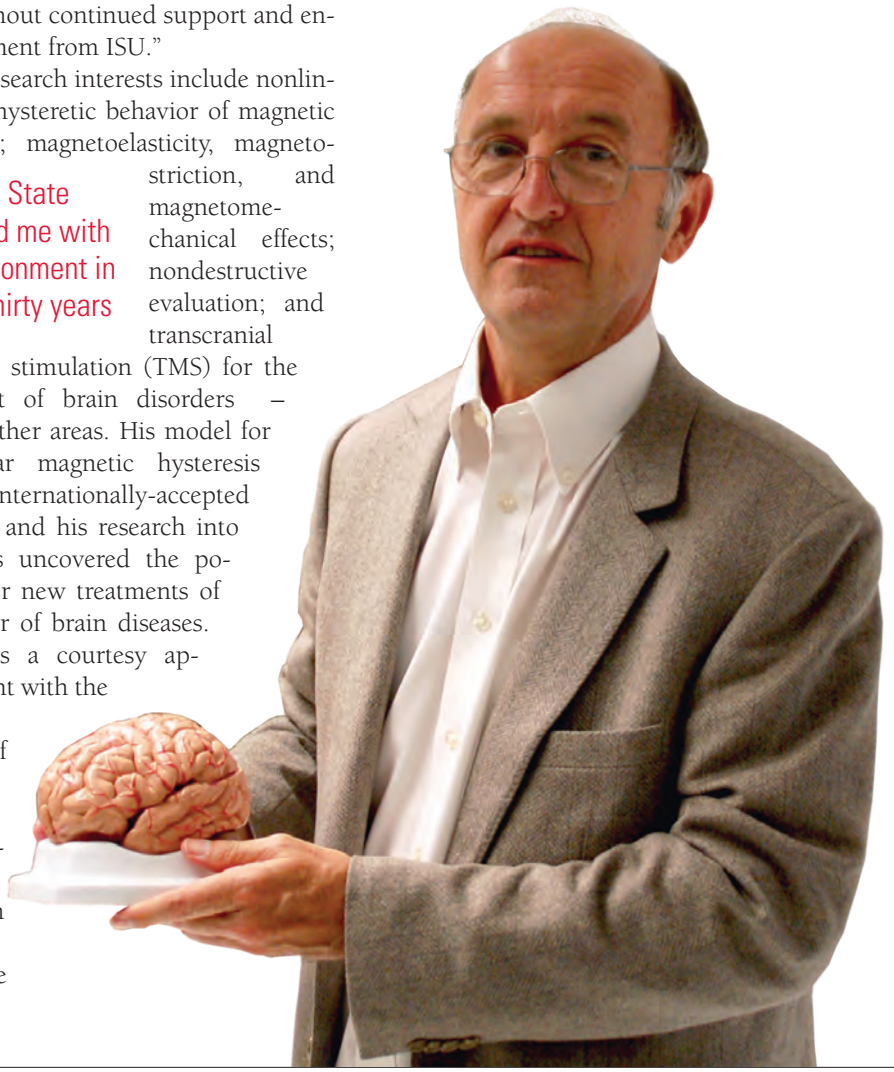
Jiles is the ECpE department's first RAE Fellow and fourth fellow of a national academy of engineering. **Paul M. Anderson** (BSEE '49; MSEE '58; PhDEE '61), **Aziz Fouad** (PhDEE '65), and **Vijay Vittal** (PhDEE '82) are ECpE faculty who have been elected to the United States National Academy of Engineering (NAE).

/// PALMER ENDOWED DEPARTMENT CHAIR

DAVID C. JILES

PhD, Applied Physics,
University of Hull, United Kingdom (1979)

I am very grateful to Iowa State University which has provided me with an outstanding research environment in which to work over the last thirty years



DALAL NAMED ANSON MARSTON DISTINGUISHED PROFESSOR

BY **BROCK ASCHER**

Vikram Dalal, Thomas Whitney Professor of electrical and computer engineering and director of the Microelectronics Research Center (MRC) was named an Anson Marston Distinguished Professor by Iowa State Senior Vice President and Provost **Jonathan Wickert** in a ceremony on Sept. 22.

Dalal, who has directed the MRC since 1999, has been working in the solar energy research field for four decades. He is a Fellow of the IEEE, the APS, and the AAAS and served as Associate Chair of the Department of Electrical and Computer Engineering from 2006-10.

"It is an honor to be recognized for many years of work in the field of solar energy research," said Dalal. "Solar energy technology is very important for people in developing countries who lack grid-connected electricity and I am very happy to be working in that exciting field."

/// ANSON MARSTON DIST. PROFESSOR

VIKRAM DALAL

PhD, Electrical Engineering, Princeton (1969)

Dalal has extensive experience in both industry and academia. After earning a PhD in electrical engineering from Princeton in 1969, he served as a research scientist at Princeton and as the manager of the device group at the University of Delaware's Institute of Energy Conversion. Dalal spent eight years in industry prior to his 1988 appointment at Iowa State, including a three-year term (1981-83) as Vice President of Research and Development at Chronar Corporation.

"I was at a stage in my life where I felt that, with my industrial research experience, I would be able to contribute both to the education and research training of young people in important technological fields, and to continue important research on solar energy materials," Dalal said. "Iowa State offered an excellent opportunity to pursue that dream."

Dalal has graduated 28 PhD students, and holds 11 U.S. patents.

The Distinguished Professorship within the College of Engineering is named for Anson Marston, the first Dean of Engineering and namesake of Marston Hall, the Marston Medal, and the Marston Water Tower.

THE DISTINGUISHED PROFESSORSHIP

A Distinguished Professorship is awarded for exemplary performance in research and/or creative activities as reflected by a national or international reputation in the awardee's discipline. A Distinguished Professor's accomplishments in research, and/or creative activities must have significantly impacted, or improved the quality of, that discipline. In addition, a Distinguished Professor must have demonstrated outstanding performance in at least one other area of faculty responsibility: teaching and advising; extension/professional practice; or institutional service. A base salary addition of $6,500 is granted, and the awardee retains the title for the remainder of his or her career at the university.

WEISS NAMED IEEE FELLOW

David M. Weiss, Professor in the Department of Electrical and Computer Engineering and the Computer Science Department at Iowa State, has been elected a Fellow of the Institute of Electrical and Electronics Engineers (IEEE) for his contributions to software measurement and product line engineering.

"I am very pleased to have been elevated to the position of IEEE Fellow, and very appreciative of my opportunities to work with a variety of excellent colleagues in research and development," Weiss said. "Without them I would never have been able to develop and apply the ideas that led to this award. "

Weiss brought a wealth of research laboratory experience upon his arrival at Iowa State in 2009. Prior to his appointment as a professor of ECpE and Computer Science, Weiss directed the Software Technology Research Department at Avaya Laboratories. Previously, he headed the Software Production Research Department at Lucent Technologies Bell Laboratories and held numerous other positions in industry and government. His team at Avaya was ranked among the best industrial software engineering research organizations in the world by the Association for Computing Machinery. He invented the goal-question-metric approach to software measurement and is the primary inventor of the FAST process of product-line software engineering.

"It has always been important to me to have interesting ideas and to see these ideas applied by working software engineers," Weiss said. "Looking back at my career, I can see how my ideas have had an impact on industry, and how working with industry has had an impact on the ideas that I have had. Such a combination shows to me the importance of research in advancing our technology."

Weiss earned a bachelor's degree in mathematics from Union College in 1964 and received his master's in computer science from the University of Maryland in 1973. He earned a Ph.D. in computer science from Maryland in 1981. After arriving at Iowa State in 2009, Weiss was the inaugural recipient of the Lanh and Oanh Nguyen Professorship in software engineering. In 2012, Union College honored him with an alumni award for significant contributions to Computer Science.

"Iowa State is a wonderful, nurturing environment for those who want to pursue new ideas and are interested in and willing to encourage innovation in student thinking and achievement," Weiss said.

PROFESSOR

DAVID WEISS

PhD, Computer Science, Maryland (1981)

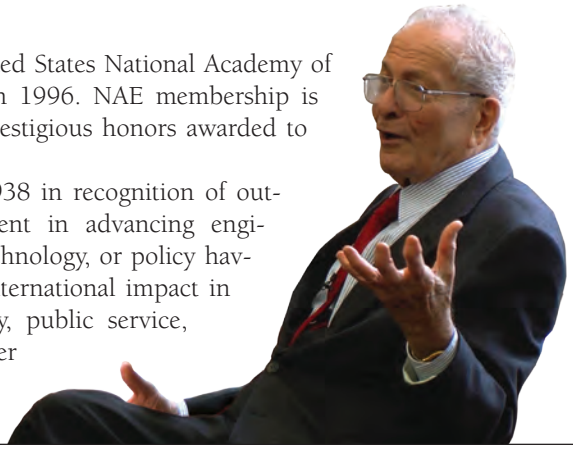
FOUAD RECEIVES MARSTON MEDAL

Aziz Fouad (PhDEE '56), distinguished professor emeritus of ECpE, was honored with the presigious Anson Marston Medal at a ceremony October 10. Fouad became the 22nd ECpE Marston Medal winner.

"Whether you've been gone 10 years or 20 years – and I've been gone 20 – Iowa State will be the same as it has ever been to you," Fouad said. "It's a wonderful place to be at and to be from."

Fouad joined the Iowa State faculty in 1960 as an assistant professor and rose through the ranks to earn numerous honors and awards, culminating in his election to the United States National Academy of Engineers (NAE) in 1996. NAE membership is among the most prestigious honors awarded to engineers.

Established in 1938 in recognition of outstanding achievement in advancing engineering science, technology, or policy having national and international impact in academics, industry, public service, government, or other venues



GOVINDARASU NAMED IEEE FELLOW

Manimaran Govindarasu, Mehl Professor in the Department of Electrical and Computer Engineering, has been elected as a Fellow of the Institute of Electrical and Electronics Engineers (IEEE) for his contributions to security of power grids.

"I am humbled and honored to receive this recognition from a professional organization that I value a great deal," Govindarasu said. "I sincerely thank my professional colleagues and the IEEE for this recognition."

Govindarasu received his master's degree in computer technology from the Indian Institute of Technology – Delhi in 1994. He earned a Ph.D. in computer science and engineering from IIT – Madras in 1998. In 1999, Govindarasu joined the ECpE Department at Iowa State as an assistant professor. He was promoted to associate professor in 2005 and to full professor in 2011. In 2011, he was appointed associate chair of ECpE and in 2013 he was named the Ross Martin Mehl and Marylyn Munas Mehl Professor of Computer Engineering.

"Iowa State provided me a wonderful opportunity to build my academic career and it's a great place to conduct research that can have an impact on society," Govindarasu said. "Over the years, I have had the good fortune of working with several great mentors, colleagues and dedicated students whose contributions have helped my professional career immensely. I am grateful to all of them and to Iowa State."

His research focuses on cyber security for the smart grid, including risk modeling and mitigation against cyber-attacks on the power grid using a cyber-physical systems (CPS) approach. He is also involved with designing attack-resilient monitoring, protection, and control algorithms for the smart grid, and also has developed a CPS security testbed for attack-defense experimentations.

"Research in cyber security of the power grid is a national priority. Our interdisciplinary research and educational programs --funded by the NSF, DHS, DOE, and industries-- make fundamental contributions to make the grid more secure and resilient, and contribute to the workforce development in this important field."

Govindarasu was honored by the ISU College of Engineering with the Young Engineering Faculty Research Award in 2003 and the ISU Award for Mid-Career Achievement in Research in 2013. He was a 2009 recipient of the Mervin S. Coover Distinguished Service Award and a 2010 recipient of the Warren B. Boast Undergraduate Teaching Award – both from the ISU Electrical and Computer Engineering Department.

MEHL PROFESSOR

MANIMARAN GOVINDARASU

PhD, Computer Science and Engineering,
Indian Institute of Technology, Madras (1998)

IEEE DEPARTMENT FELLOWS

Fifteen ECpE faculty have been elected IEEE Fellows:

Venkataramana Ajjarapu
Chris Chu
Vikram Dalal
Ian Dobson
Randall Geiger
Manimaran Govindarasu
Doug Jacobson
David C. Jiles
Ahmed Kamal
Ratnesh Kumar
James McCalley
Sarah Rajala
Arun K. Somani
Jiming Song
David Weiss

Established in 1912, the IEEE Fellow distinction is an honor reserved for select IEEE members whose extraordinary accomplishments in any one of the IEEE fields of interest are deemed fitting of this grade elevation. The IEEE Grade of Fellow is conferred by the IEEE Board of Directors, and the total number of recipients in any one year cannot exceed one-tenth of one percent of the total voting membership. IEEE Fellow is the highest grade of membership and is recognized by the technical community as a prestigious honor.

ELECTRONICS TECHNOLOGY GROUP AREA RENOVATION FINISHED

The area that houses the Electronics Technology Group (ETG, formerly the Computer Support Group), completed a five-month renovation and opened for student and departmental use in December. The project provides new equipment and a modernized space, and will further streamline how the department deploys its technological resources.

Additionally, the former Computer Support Group was renamed ETG. This change better reflects the group's continuing role within the department: To aid students, faculty and staff in getting the most from department hardware, software, and electronic resources.

ETG
ELECTRONICS TECHNOLOGY GROUP

TIRTHAPURA WINS SECOND-STRAIGHT IBM FACULTY AWARD

Srikanta Tirthapura, associate professor of electrical and computer engineering, has been selected as a recipient of the 2014 IBM Faculty Award, his second-straight selection. The IBM Faculty Award is an annual, worldwide competitive program intended to foster collaboration between researchers at leading universities, and those at IBM.

"It's a competitive process," Tirthapura said. "Every year there's a competition that happens and a lot of people get nominated. I'm honored to win again."

Tirthapura received the award in recognition of his research and education program in the area of large- scale data analysis and mining.

"I work closely with a team at IBM T.J.Watson Research Center." Tirthapura said. "They're the research group behind the streaming data platform that is an important component of IBM's "big data" thrust. We are designing scalable algorithms that run on such platforms." The $30,000 award will be used to fund students and further Iowa State's big data education and research initiatives.

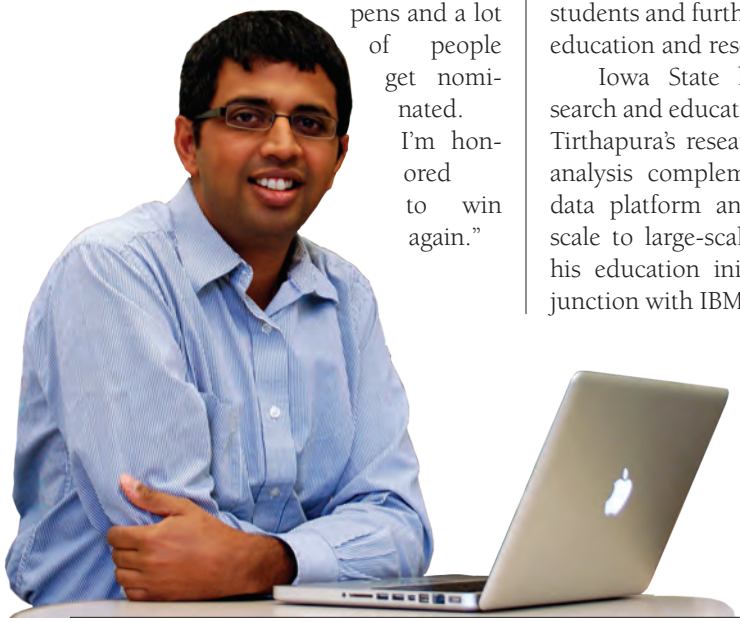
Iowa State has a synergistic research and education program with IBM. Tirthapura's research on streaming data analysis complements IBM's streaming data platform and helps the platform scale to large-scale tasks. A number of his education initiatives work in conjunction with IBM software and he holds multiple United States patents jointly with IBM.

"It's a good match," said Tirthapura of his relationship with IBM "IBM is keenly interested in the work we do here."

AN IBM FACULTY

ECpE has been awarded at least one IBM Faculty Award in each of the last eight years.

Professor	Year
Srikanta Tirthapura	2014
Srikanta Tirthapura	2013
Arun Somani	2013
Vikram Dalal	2012
Vikram Dalal	2011
Chris Chu	2010
Chris Chu	2009
Chris Chu	2008
Thomas Daniels	2007



ASSOCIATE PROFESSOR

SRIKANTA TIRTHAPURA

PhD, Computer Science, Brown (2002)

CYBER-PHYSICAL INFORMATION ASSURANCE

ECpE has expanded its Information Assurance Graduate Program and Cyber Defense Competition to include a Cyber-Physical System (CPS) Security focus beginning in the fall 2014 semester. The expansion will improve two premiere components of the department's cybersecurity and information assurance education initiatives. These initiatives helped earn Iowa State's re-designation as a **National Center of Academic Excellence** in Information Assurance/Cyber Defense Education by the National Security Agency (NSA) and the Department of Homeland Security (DHS).

"Adding a cyber-physical component to our lineup of cyber defense competitions (CDC) enables Iowa State to maintain its leadership in inquiry-based cyber defense competitions," said **Doug Jacobson**, University Professor and Director of the Iowa State Information Assurance Center. "Our CPS-based CDC will become a model for other schools across the country and will be included in our nationwide release of the CDC software."

The Information Assurance Graduate Program will feature a new course and will update existing courses to reflect the program's increased focus on cyber-physical security. Iowa State has one of the nation's oldest information assurance graduate programs and these additions provide students with additional options.

NATIONAL CENTER OF ACADEMIC EXCELLENCE

Iowa State University has once again won designation as a National Center of Academic Excellence in Information Assurance/Cyber Defense Education. Iowa State was one of the first seven universities to earn the designation in 1999 and has had it ever since.

"This goes to show our leadership in this area," said **Doug Jacobson**, a University Professor of electrical and computer engineering and chair of the university's Information Assurance Center.

Iowa State is the only Iowa school to win the designation from both the National Security Agency and the Department of Homeland Security. Jacobson said the agencies have raised their expectations for this round of designations, requiring schools to demonstrate a higher commitment to information assurance faculty, curriculum and research.

"The rules have changed," he said. "It was a more difficult process this time. It was a much more rigorous process."

Iowa State is the only Iowa school to win designation from both the National Security Agency and the Department of Homeland Security.

Karen Leuschner, the director of the Centers for Academic Excellence program at the National Security Agency, acknowledged the new expectations in a letter informing Jacobson of Iowa State's renewed designation:

"Your ability to meet the increasing demands of the program criteria will serve the nation well in contributing to the protection of the national information infrastructure."

Leuschner's letter also noted "the importance of higher education as a solution to defending America's cyberspace."

/// COVER STORY

YOUR PHONE ISN'T SAFE

ECpE researchers, funded by a $4.1 million DARPA grant, are building the latest anti-malware tools for Android

BY **MICHAEL STILL**

Believe it or not, there was a time before Siri and GPS tracking when a phone was just a phone. Software plays a major role in making our phones do what they do which impacts in the way we live, work, and play. As a result, our safety and security depend heavily on the accuracy of that software. The slightest problem has the potential to cause catastrophe.

Suraj Kothari, Richardson Professor of Electrical and Computer Engineering at Iowa State University, understands that attacks on a phone's confidentiality, availability and integrity can be done in ways that elude the security measures that we currently use. Staying safe is not as easy as slapping a password on your phone or logging out of your email account.

"Someone could do something to the software in your phone that gives them access to your GPS location, and from there they can pinpoint your exact location at all times," Kothari said. "This could become an especially serious problem if someone gained access to a soldier's phone and interfered with important communication."

Kothari conducts his research in software engineering, developing appropriate theoretical foundations and building practical tools for improving the productivity and quality of software. He focuses on using smaller mathematical models to dissect and conquer larger, more complex problems.

For an example, he turns to the world of medicine. Like software, our bodies are complex and have complex problems. To better understand this complexity, doctors use Magnetic Resonance Imaging (MRI) scanners.

"Without the MRI, a doctor may suspect a patient has a brain tumor and perform open brain surgery, but that's very risky. The same principles apply when dealing in software," said Kothari. "If you have mundane problems, you can get away with what you're doing, but if you have serious problems, you need something very sophisticated to help solve that problem."

The MRI scanner is extremely useful

in diagnosing serious and complex problems, and without it, medicine would not be as advanced as it is today. In the world of software engineering, Kothari is working on his version of the MRI scanner, devoting research to creating tools to help analyze complex software.

"It's very difficult for humans to go through millions of lines of code because humans make mistakes. So I had the idea to develop a tool that will transform code," said Kothari. "We are building software like the Egyptians built the pyramids, using the sheer force of human labor."

The U.S. Government's Defense Advanced Research Projects Agency (DARPA) has taken an interest in cyber security, and is concerned with the probability of a digital war in our country's future. This leaves the Department of Defense searching for the latest and greatest tools in software protection.

"The United States has the most sophisticated fighter jet in the world. With 24 million lines of code, they call it a flying computer," said Kothari. "Rather than spend the time and money to develop a plane like that, who's to say enemies won't focus on trying to sabotage the software in the fighter jet?"

Earlier this year, several nuclear reactors in Iran were attacked by the "Stuxnet" virus. Developed by a joint partnership between the U.S. and Israel, the Stuxnet Virus disabled nearly one-fifth of Iran's nuclear centrifuges by making them spin out of control. Though Stuxnet represents a very sophisticated, high-end attack, Kothari says this kind of infiltration can happen to anyone, and it doesn't only affect military software.

"Today, cars have so much software built in - the newest models are even connected to the Internet," said Kothari. "People have already shown they can get control of a car and make it do what they want it to do. Without proper security, accidents can be caused this way."

The safety and assurance that software is going to work the way it was designed to work is a critical issue, and the U.S. Department of Defense has developed three focused programs to help aid in the understanding of software.

The first program focuses on controlled systems software, the kind that is used to control complex machines and nuclear reactors. The second program centers on communication infrastructure and handles the way information flows through the Internet and other connected networks. The third program works with smartphone software. This is where Kothari's research has proven most helpful.

When Raj Aggarwal, Iowa State College of Engineering's director of Industrial Research Initiatives and managing director of Advanced Research and Technology, told Kothari the Defense Department was looking for software tools to aid in security measures, he was ready to start working.

"This defense project didn't happen overnight," said Kothari. "We've been doing this for years – even when it wasn't a hot research area. It takes time to develop software and experiment with it. And we have a background of working with real-world software."

Funded by a $4.1 million, 3.5-year DARPA grant, the project's objective is to develop a tool that will detect malware placed unknowingly within applications on the mobile devices.

"The world has been trying to solve security issues by watching what goes through a network, finding suspicious things and then stopping them," he said. "But now we also need to worry about internal threats and software sabotage. There's a need to analyze software."

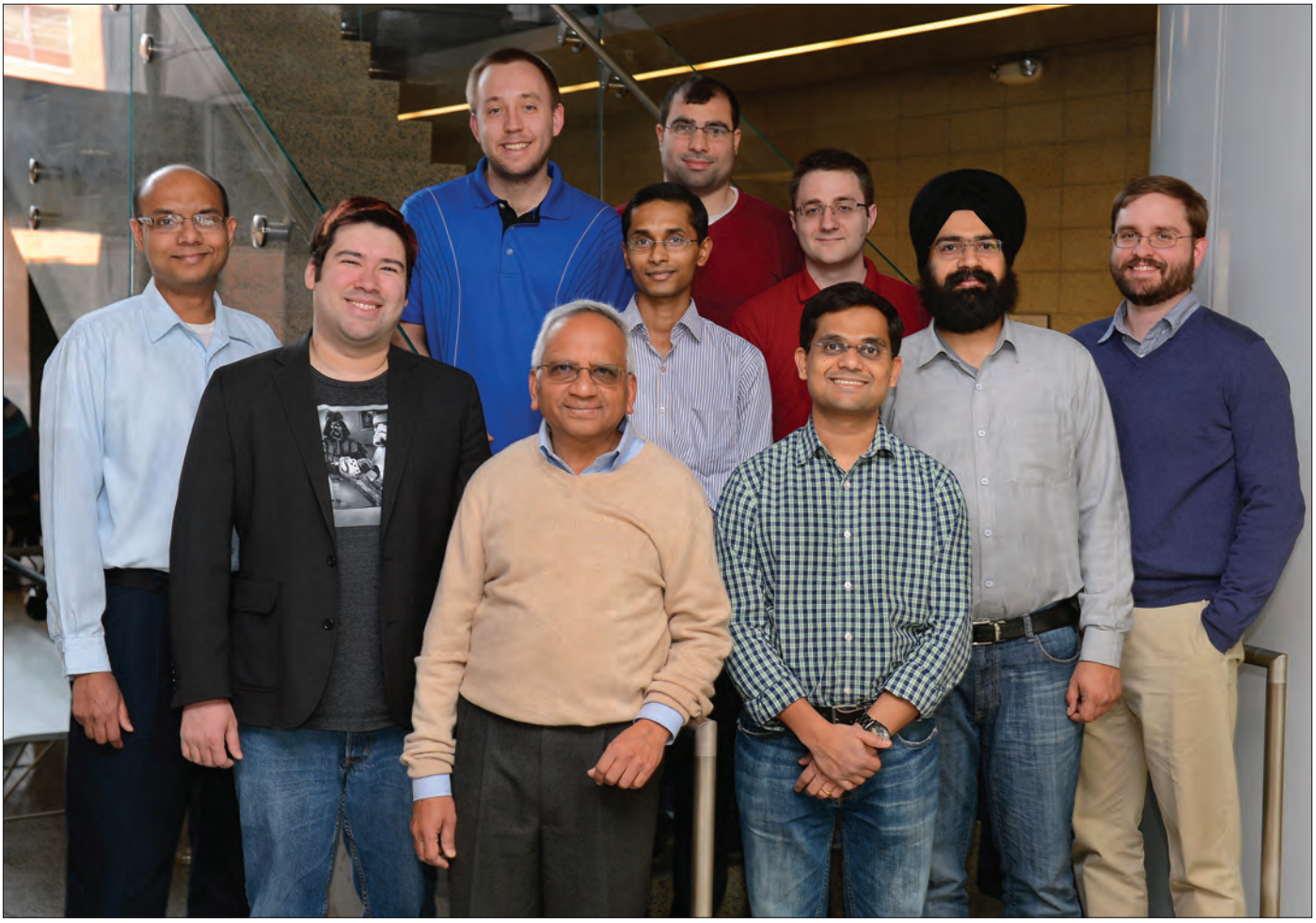
Among the teams awarded smartphone security projects by DARPA, Kothari's team at Iowa State has earned top rankings based on the speed and accuracy of detecting malware in the challenges posed by the research agency.

"In the end, we'll have a tool that the Defense Department and other government agencies can use," Kothari said. "And eventually we'll be able to make a phone security tool commercially available."

All of that, he said, will help secure the Defense Department's smartphones from dangerous attacks and saboteurs.

"We are looking at malicious software that leaves a scattered footprint and that exhibits behaviors that blend with legitimate functionalities of a given application," he said.

The tool Kothari and his team are designing includes a framework that gathers important information about an app



Front, L-to-R: Akshay Deepak, Jeremias Sauceda, Suraj Kothari, Nikhil Ranade, Damanjit Singh, Jon Mathews, Middle: Sandeep Krishnan, Iowa State. Back: Tom Deering, Ahmed Tamrawi, Ben Holland. Photo by Bob Elbert.

as it scans code for malware. This data is presented in a digestible form that can be analyzed by a person, allowing for more accurate assessments about an app's intentions than systems currently in place.

"Detecting malware on mobile devices using a completely automated process hasn't been successful in producing consistent, valuable results," said Kothari. "We needed a solution that included human interaction, but we also needed to ensure the person analyzing the results could do so without having to parse enormous amounts of information."

Kothari has partnered with Xuxian Jiang, assistant professor of computer science at North Carolina State University, and Jeremias Sauceda, chief technology officer at EnSoft Corp., on the project.

The team is currently designing, programming, and testing the tool, and is also creating a "cookbook" of properties the tool will use to identify malware-like code. Once implemented, the tool will be flexible enough to be refined and extended to address future malware attacks.

Looking back at his many years of research, Kothari has faced his fair share of challenges and hardships. One of the biggest roadblocks came up early in the process as Kothari was seeking financial assistance with his research.

"Originally, what we were doing was very different from what the funding agencies were interested in, so there were many years where we were not able to get funds. That created a serious problem," said Kothari. "Funding organizations didn't start giving much funding to this kind of research until 2011 when the Department of Defense deemed it necessary."

Despite the challenges he's encountered, Kothari's research has resulted in the development of many products and tools that are now being used by more that 250 large companies in 18 countries, including all major auto makers in US, Europe, Japan, and Korea.

"I think one of the biggest rewards is that the work he have done is ultimately being used in the real world. In that way, we are making a difference in everybody's life," said Kothari. "Another reward has been working with my colleagues and team of grad and post doc students. Their collaboration has been valuable in our research process."

Future problems in software security will not easily be solved within the next year or two. According to Kothari, there is still a lot of work that needs to be done. He plans to keep tackling the complexity of software problems, but he can't do it alone.

"We have to rely on intelligent, motivated, and hard working people to help solve our future problems," said Kothari. "Those are the kinds of people we need."

RICHARDSON PROFESSOR

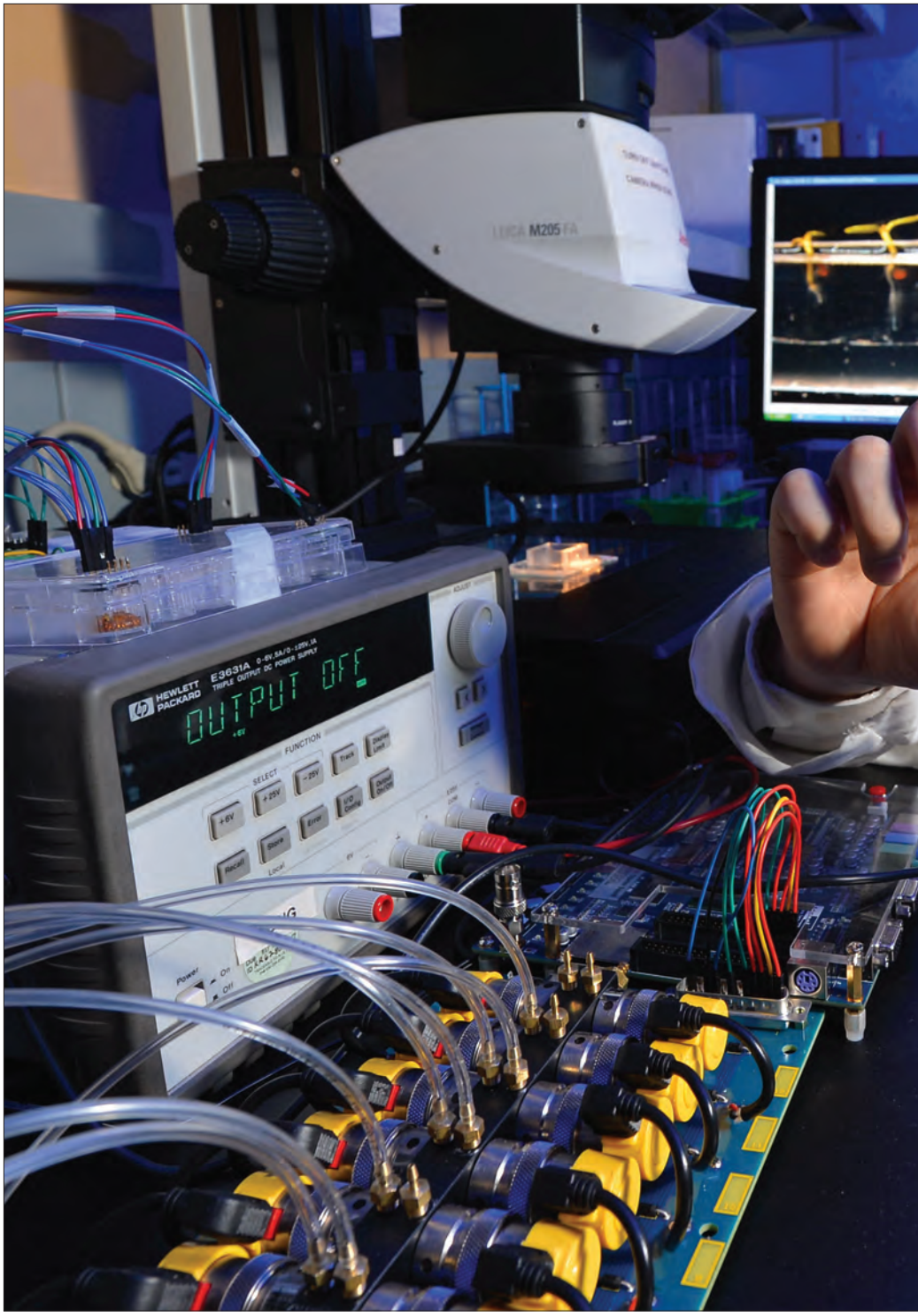
SURAJ KOTHARI

PhD, Mathematics,
Purdue (1977)

A GREENHOUSE ON A CHIP

Liang Dong is leading a research team that's developing an accessible instrument with the scale, flexibility and resolution needed to study how genes and environmental conditions affect plant traits.

BY **MIKE KRAPFL**



Let's say plant scientists want to develop new lines of corn that will better tolerate long stretches of hot, dry weather.

How can they precisely assess the performance of those new plants in different environmental conditions? Field tests can provide some answers. Greenhouse tests can provide some more. But how can plant scientists get a true picture of a plant's growth and traits under a wide variety of controlled environmental conditions?

That job has been too big and too precise for most laboratories. There are a few labs around the world that can do the work, but the studies are expensive, limited and require time and labor. There hasn't been an accessible test instrument with enough scale, flexibility and resolution to produce all the data scientists need, said **Liang Dong**, an Iowa State University associate professor of electrical and computer engineering.

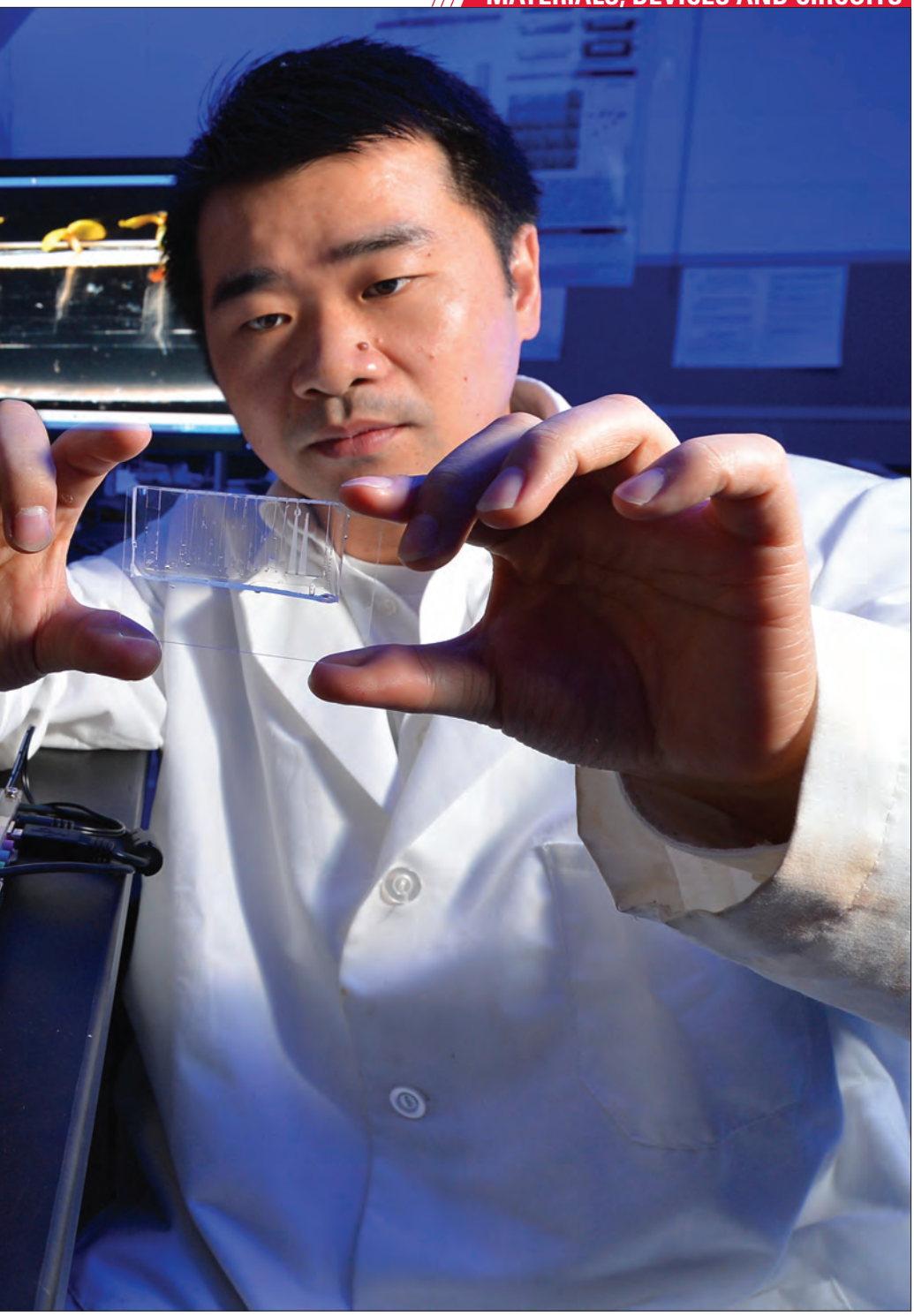
That has Dong leading a research team that includes **Namrata Vaswani**, an Iowa State associate professor of electrical and computer engineering; **Maneesha Aluru**, formerly of Iowa State and now a senior research scientist at Georgia Institute of Technology in Atlanta; three doctoral students and four undergraduates who are all working to build a high-tech solution for plant scientists. His idea is a greenhouse on a chip – an instrument that incorporates miniature greenhouses, microfluidic technologies that precisely control growing conditions and big data tools that help analyze plant information.

He calls his instrument a "transformative leap" in the study of plant phenotypes – the look, size, color, development and other observable traits of plants.

"The instrumentation will make breakthroughs toward solving grand-challenging, large-scale problems in the field of phenomics," Dong said. "We are building resources to benefit plant biology researchers and hopefully the new instrumentation will create a paradigm shift in the plant phenomics area by placing powerful data analysis capability in the hands of researchers."

The project started nearly two years ago with a $119,500 seed grant from Iowa State's Plant Sciences Institute and is now supported by a three-year, $697,550 grant from the National Science Foundation.

The research project has already produced a technical paper, "Plant chip for high-throughput phenotyping of Ara-



ASSOCIATE PROFESSOR

LIANG DONG

PhD, Electronics Science and Technology, Tsinghua University, China (2004)

bidopsis," published online and in the April 7 issue of the journal Lab on a Chip.

To date, Dong and his research team have been building the necessary components for a phenotyping instrument. Now they're working to integrate the parts and pieces into a complete, flexible system that can handle a variety of research projects.

"We're building a toolkit that people can assemble and use to meet their needs," Dong said. "We originally thought this would look at seeds growing in a cube. But now this can be scaled-up, depending on the growth stage researchers want to study. If it's a plant's first 10 days, we can make parts of the instrument smaller. If it's four weeks, we make them bigger."

Here's how the instrument will work: Dong and his team will build miniature greenhouses that precisely control light intensity, humidity, temperature, carbon dioxide, chemicals and even pathogens. Plant scientists will fill the miniature greenhouses with clear, vertical and disposable chips containing seeds that will grow into seedlings.

Hundreds of the chips-in-mini-greenhouses can grow thousands of plants at the same time, each greenhouse providing different environmental conditions. Dong's current goal is to get 128 of the growth chambers working simultaneously and independently.

As the plants within all those chambers grow, a camera attached to a robotic arm takes thousands of images of cells, seeds, roots and shoots. The images record traits such as leaf color, root development and shoot size, giving researchers clues to the relationship between a plant's genotype, the growing conditions and the observable traits of its phenotype.

It will take big data tools to help researchers store, manage and analyze all the photo data collected by the instrument.

The new instrument's capabilities are significant to researchers: "The system will largely facilitate plant phenotyping experiments that are impossible by current techniques," Dong said.

He said he's already using some components of the instrument to work with Iowa State agronomists **Thomas Lubberstedt**, who's studying germination of pollen at different temperatures, and **Madan Bhattacharyya**, who's studying how fungal pathogens interact with soybean seeds at different moisture levels.

As the toolkit develops, Dong said he hopes to move beyond plants and use it for studies of insects or even small fish.

One day, he hopes to have a commercial instrument that can be used by biological researchers around the world.

"I'm making small things here," Dong said, "but hopefully they can make a big impact."

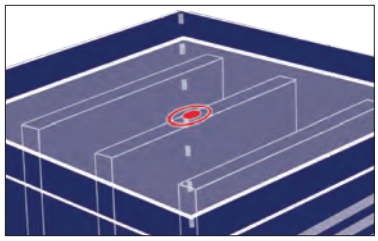
Courtesy, Iowa State News Service

GREENHOUSE CONSTRUCTION

Liang Dong's greenhouse-on-a-chip plant phenotyping device could revolutionize how we study plant-environment interaction, biotic and abiotic stress response, photosynthesis, and genome-environment interaction.

The greenhouse locks into a 3D microfluidic chip containing the **basement**, which helps regulate the conditions within the greenhouse. **Sensors** within the greenhouse detect changes in gases, while the **ceiling** regulates how much light is allowed inside. Multiple plants are grown on Dong's **plant-on-a-chip** setup and numerous chips are inserted into every greenhouse.

CEILING



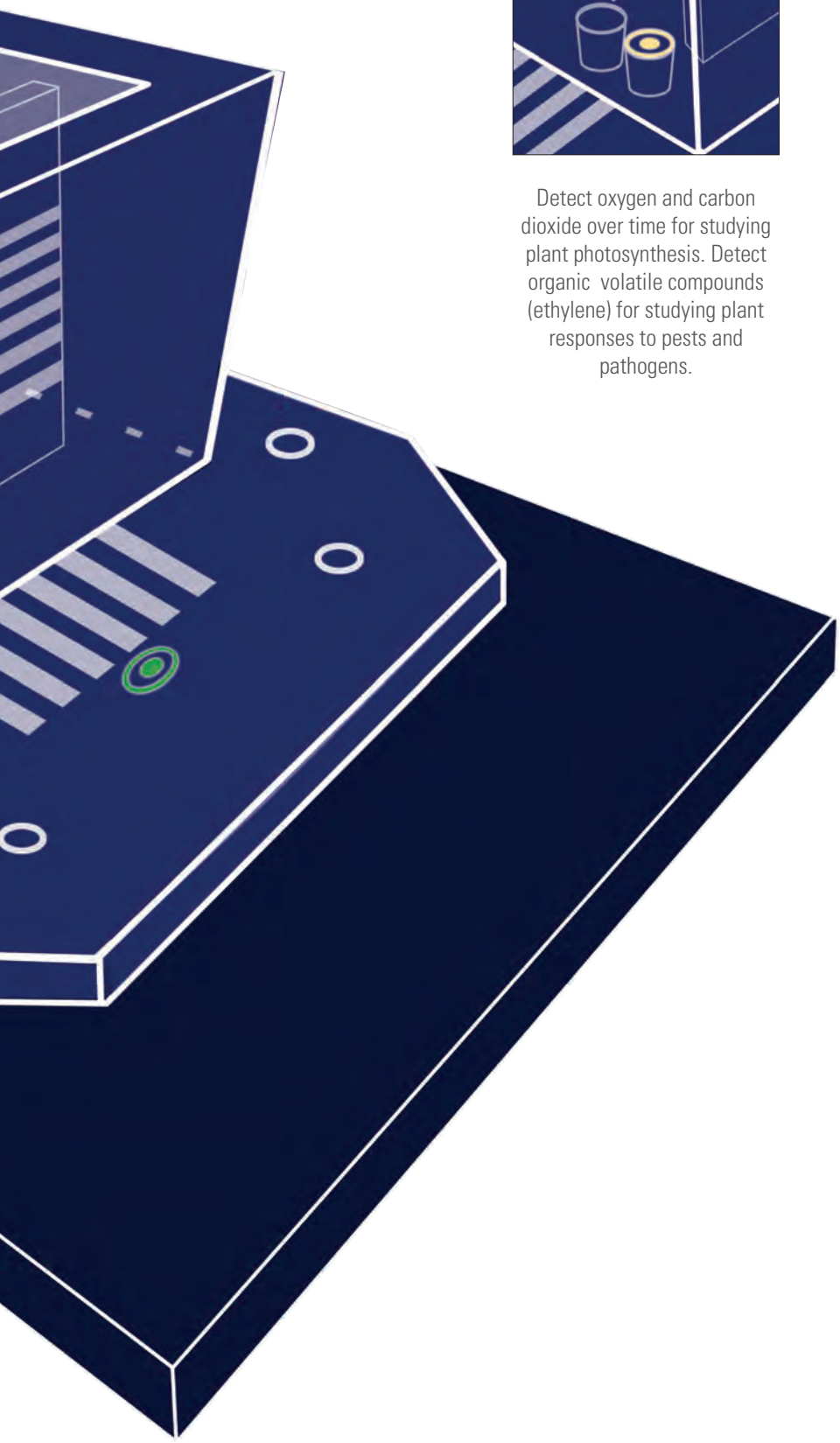
The liquid crystal-based ceiling allows changing the internal light intensity by up to 60-fold.

BASEMENT (MOISTURE)

The microfluidic plumbing system in the basement regulates humidity and carbon oxide concentration, among other things.

BASEMENT (PATHOGEN)

The microfluidic plumbing system in the basement regulates plant pathogens.

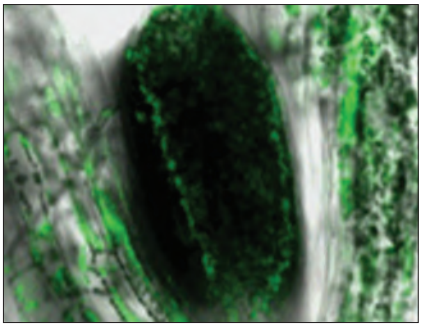


SENSORS

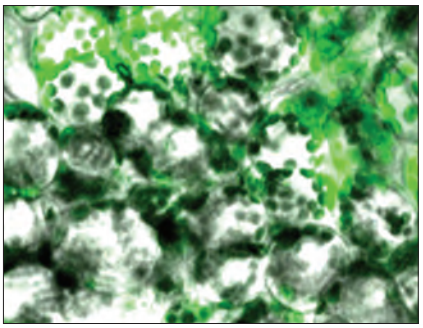
Detect oxygen and carbon dioxide over time for studying plant photosynthesis. Detect organic volatile compounds (ethylene) for studying plant responses to pests and pathogens.

PLANT ON A CHIP

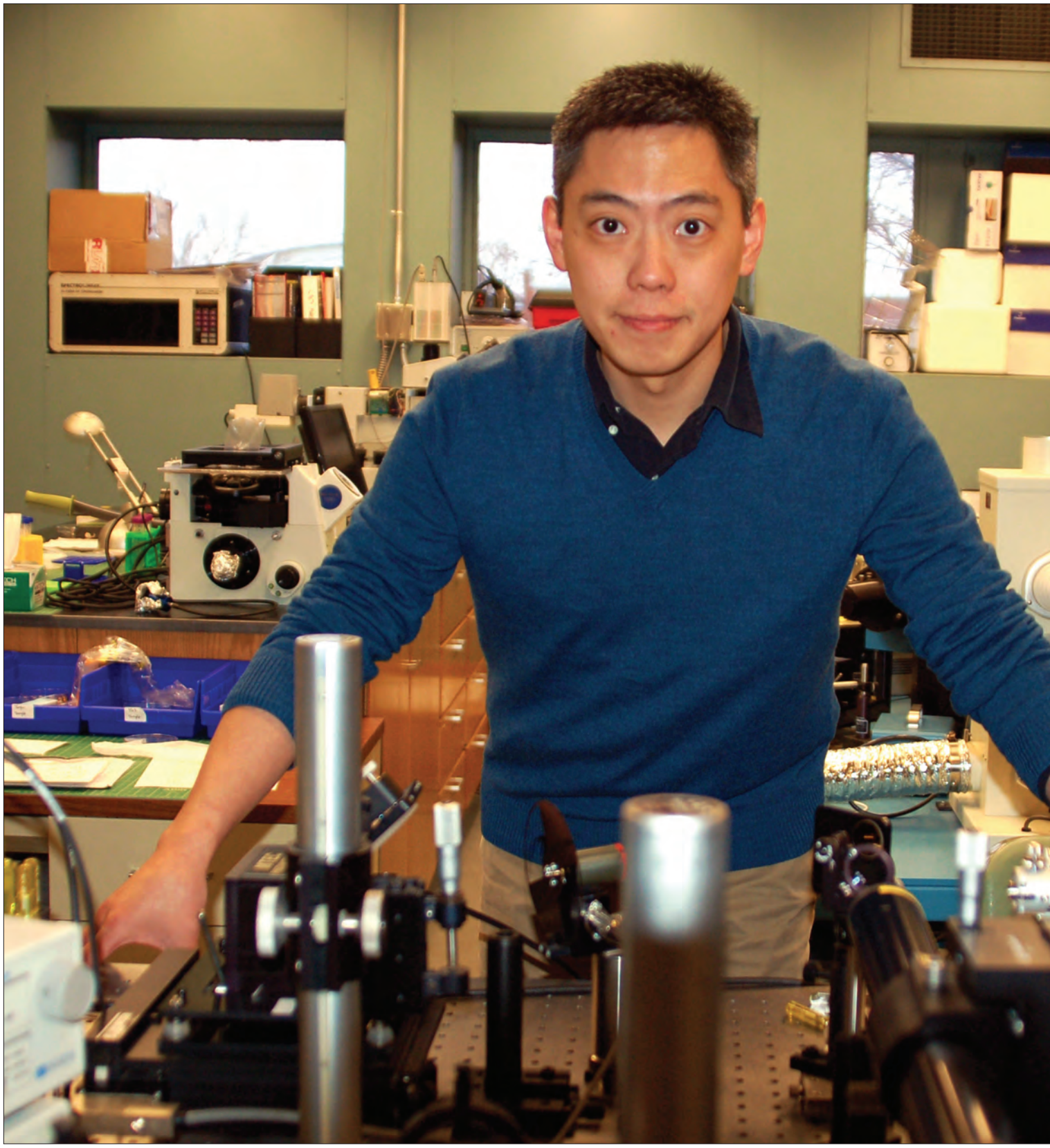
Multiple plants are grown in the plant chip. The microfluidic chip is capable of regulating growth temperature, and introducing different plant nutrients and hormones. This facilitates the study of plant tolerance to biotic and antibiotic stresses.



The greenhouse is able to interface with confocal laser scanning microscopy to perform in vivo IM gene expression analyses at both cellular and whole-organism levels.



The greenhouse allows plant scientists to observe IM expression of the chloroplasts within individual cells in green tissues by the presence of green fluorescence around the embryo.



BIOTECHNOLOGY AND LU

Meng Lu's numerous projects have the aim of improving biotechnology and furthering disease prevention.

BY **MICHAEL STILL**

/// ASSISTANT PROFESSOR

MENG LU

PhD, Electrical Engineering, Illinois (2008)

What interests me most, is fostering innovative research projects that directly respond to the challenges set by commercial demands," explained **Meng Lu**, assistant professor at Iowa State University with a joint appointment in the Department of Electrical and Computer Engineering and the Department of Mechanical Engineering.

Lu graduated from the University of Illinois and received his Ph.D. in 2008. After that, he spent three years as a research scientist at a startup company marketing a biosensing technology that could analyze the binding affinities and kinetics of biomolecules. But all that time, there was something that Lu missed about being around school.

"I always believed that academia provides extraordinary opportunities to pursue exciting science and broaden the impact of technology through the education of students," said Lu.

Then, in 2012, Lu's wife was offered a teaching position at Iowa State. When she accepted, Lu was fortunate enough to be offered a position as an assistant professor, and he found himself back in the classroom, ready to share his passion for learning.

"When I walked through the buildings and saw the laboratories, I was excited," said Lu. "I explored the facilities on campus and decided that Iowa State is the place where I wanted to work."

Today, Lu leads a research group of six graduate students in actively developing optical sensors for various applications, including chemical and biomolecule sensing, microscopy imaging, and soil analysis.

The group's vision in exploring biophotonics lies at studying the intersection of biological and micro/nano scale systems through a wide variety of optical phenomena.

"For example," explained Lu, "one of our research projects aims at developing a new immunosensing technology that allows people to hear the biomolecules."

To do this, Lu's team is working working in collaboration with Dr. **John McClelland** in the Ames Laboratory to apply the photoacoustic spectroscopy for measurement of disease biomarkers.

"If successfully developed, our technology will result in a point-of-care testing system that can rapidly diagnose infections, allergies, cardiovascular diseases, and even cancers," said Lu.

Graduate student and member of Lu's team, **Yunfei Zhao**, is working on designing the signal transducer, prototyping the compact read-out system, and developing the immunoassay for hepatitis. With Zhao's efforts, Lu hopes that their research will benefit home healthcare by providing an affordable and portable solution for early diagnosis of diseases.

In the past, Lu has worked on a number of research projects and covered many different topics, ranging from computational electromagnetics to microplasma light emitters and laser-based sensors.

"My favorite research project to date is an external cavity laser (ECL) sensor that was demonstrated as an optical signal transducer to perform very challenging detection of small molecules, like drugs," said Lu.

Lu also mentioned that while at Illinois, he was part of a team that built a state-of-the-art narrowband laser using a semiconductor optical amplifier. It was then applied to detect tiny changes induced by the absorption of biomolecules.

Back to his team at Iowa State, Lu identified their traditional strengths as being in the area of new optical nanostructures and micro/nano fabrication.

"We have performed experiments with which we study the basic characteristics of nanophotonics and nonfluidics," said Lu. "Our goal is exploring the nanoscale interface between photonics and fluidics, and using that information to develop new sensing mechanisms."

Lu is working with this young, energetic research group to develop the next generation of technology that will solve challenging problems in the areas of life science, agriculture, the environment, and sustainable energy.

At the end of the day, Lu has found a way to combine his love for innovative research and his passion for broadening the impact of technology through the education of students.

POWER GRID DEFENSE

The department's Electric Power and Energy Systems research group has a few ideas to strengthen the Southern California power grid

BY **BROCK ASCHER**

Researchers at Iowa State University are working with Southern California Edison, which provides electricity for much of Southern California, to create a set of coordinated, automatic measures intended to ensure that the overall SCE power system is protected against major disturbances involving a number of contingencies. Members of the Iowa State Electric Power and Energy Systems (EPES) research group, including professors James McCalley, Ian Dobson, and Venkataramana Ajjarapu – among others – are leading the effort.

"There are various problems that can bring down a power system," said McCalley, the Harpole Professor of Electrical Engineering. "Part of our project centers on providing a dial that operators can watch so they can effectively identify stress conditions and mitigating measures that they can take. The philosophy of the project is to find new measures that can mitigate multiple kinds of problems and have wide-ranging impact."

The team has identified three potential approaches, which, used in conjunction, are designed to minimize and reduce the severity and consequence of extreme events and to prevent system collapse. The approaches include stress monitoring and risk control, network control, and an automated safety net. Once developed, these approaches will enhance the SCE grid's capability to handle extreme contingencies – disturbances in the power system with potentially high impact but with a low probability to occur – without constraining system operations.

"The loss of one component," McCalley said, "that's a high probability event. The industry studies that carefully and they're prepared for it. It's the loss of two or three components, followed by some cascading or something similar, that we consider to be the more likely of the 'low-probability' events. In other words, they're the low-probability events that have the best chance of happening."

Stress Monitoring and Risk Control

The team's first step involves improved monitoring of the SCE grid with emphasis on stability indicators (Voltage, Oscillatory, transient, and frequency instability), power-flow-based stress indicators, and cascade monitoring. Ajjarapu and others at Iowa State have developed a systematic approach to measure voltage instability using data from phasor measurement units for online monitoring. The design, which uses Lyapunov exponents as a certificate for stability, is still being investigated. Specifically, the placement of the phasor measurement units within the grid is of the utmost importance.

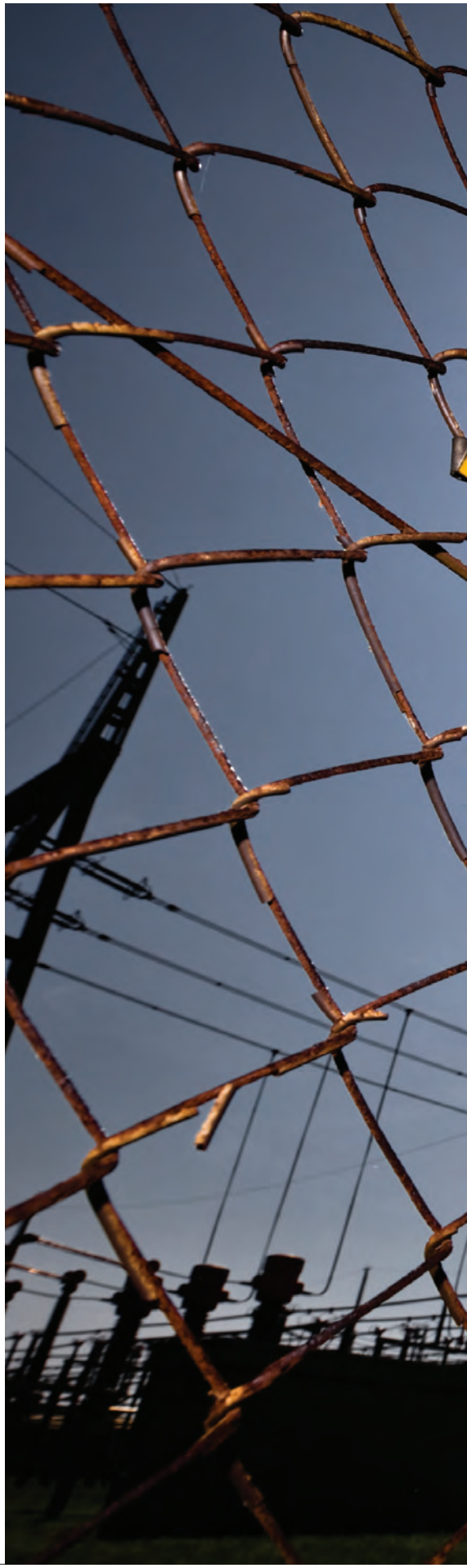
"Since system-wide instability is predicted based on local measurements, the location of PMUs in the system is crucial," said Ajjarapu, the Nicholas Professor of Electrical Engineering. "We propose clustering contingencies into different groups based on the voltage response at different buses. This classification is used to rank the most severely affected buses for each contingency cluster. Information about the node adjacencies can be used to reduce the PMU's required."

Further investigations to de-

HARPOLE PROFESSOR

JAMES McCALLEY

PhD, Electrical Engineering, Georgia Tech (1992)




Danger
High Voltage

SANDBULTE PROFESSOR

IAN DOBSON

PhD, Electrical Engineering, Cornell (1989)

termine the most appropriate set of stability indicators for the SCE grid will include the use of Iowa State's real-time simulator test bed, which allows researchers to test the impact of noise, communication delays and other variables on a simulated power system. The test bed has been a valuable tool in the team's project.

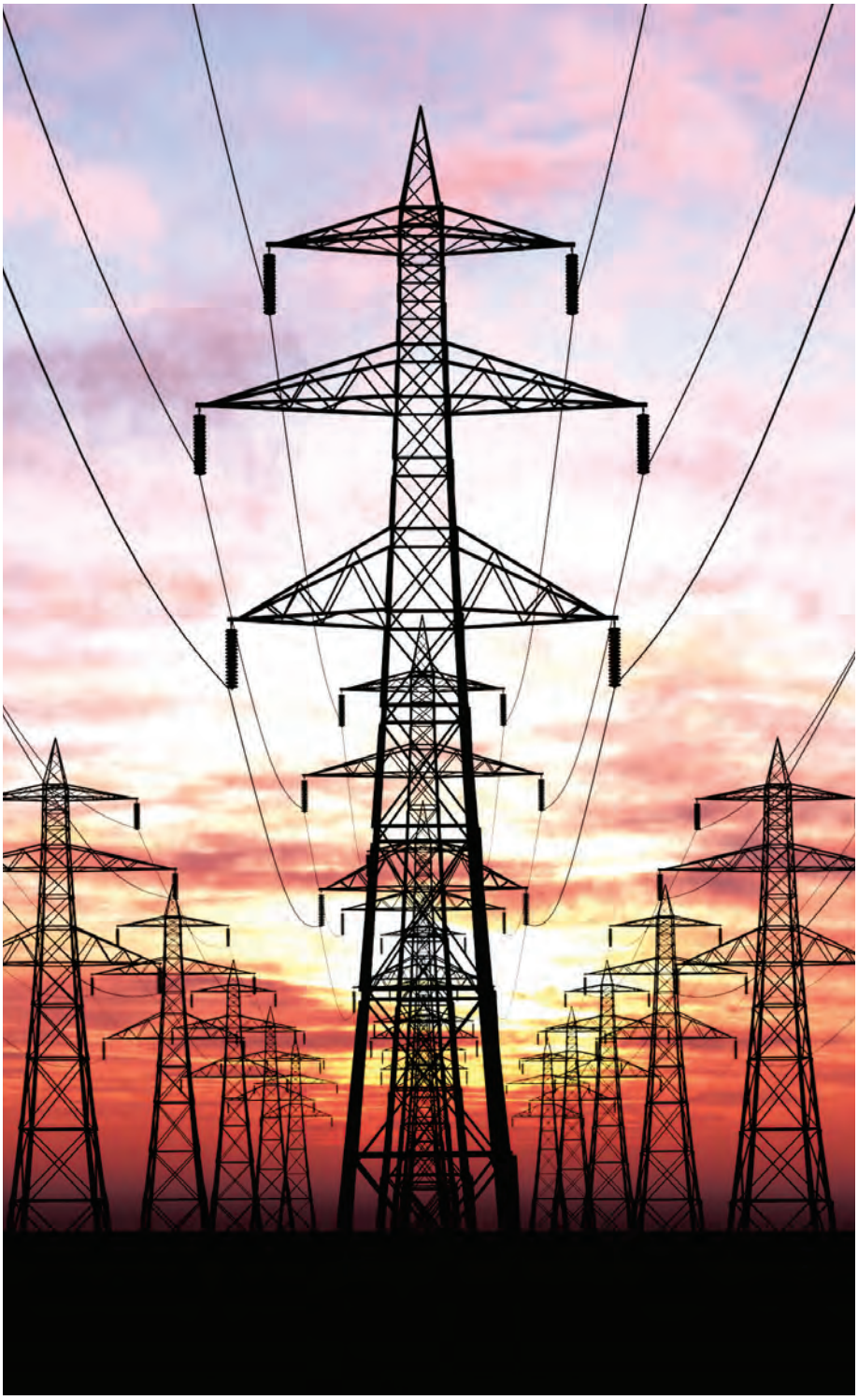
"Traditionally, communication parameters were not an important consideration in development of analytical tools in power systems," Ajjarapu said. "However, the introduction of PMUs is changing that perception. Their high bandwidth and low latency requirements can lead to dependency on other errors in the communication channel. To understand this, we are proposing to implement the developed algorithms in a real time test bed to analyze the effect of packet dropping and other communication issues on short term and long term voltage stability assessment results."

Dobson, the Sandbulte Professor of Electrical Engineering, will process records of transmission line outages in Southern California to learn how sequences of outages propagate in the grid. Since the grid is designed to be robust and resilient, almost all of these sequences stop before any customers lose power, but the performance of the grid for these benign sequences can indicate how resilient it is to the more impactful, cascading outages that can lead to blackouts.

"Quantifying how far cascading outages spread is a useful step toward improving methods to mitigate the risk of large blackouts," said Dobson. "It will be exciting to be able to work with SCE on real data, and get feedback to improve the methods we are developing."

Network Control

The team is considering a number of different types of network control, including reconfiguration, and the use of High-Voltage Direct Current (HVDC) lines using voltage-source converters (VSC). Taken together, these approaches can reshape the power grid into a more robust system that is better able to resist major disturbances.



Network reconfiguration is exactly what it sounds like: Switching out lines, upgrading circuits, building new lines, etc. Switching out lines is an inexpensive reconfiguration tactic, but more expensive tactics like building new lines and upgrading circuits are often needed. Since one of the end goals of the project is to save SCE time and money, and building new transmission lines in Southern California is difficult, additional investments must be well-vetted.

"A key problem is finding the best places to put new components into the grid," McCalley said. "We can't just put them wherever we want, so finding a location that best serves the entire grid is both prudent and efficient."

Second, the team is considering the use of strategically-placed controllable

links – connections between two nodes that have some flow control capability. Placing controllable links, VSC-based HVDC in this case, in strategic areas of the SCE grid would put more control of the lines into operator hands. With this control, operators can attempt to mitigate major disturbances before they spread. Of course, operator actions come with their own set of risks.

"Being an operator is a tough job," McCalley said. "When things happen, they have to diagnose the problem and then find the right medicine for it. The operator is always worried they're going to choose the wrong medicine, and if they do, that they'll make things worse. They need to trust the tools they use to guide their decisions."

Automated Safety Net

Another approach involves using computer models to simulate problems in the power grid and looking for mitigating measures within the simulation. This would be a computing tool that continuously tests extreme events via simulation and identifies mitigation measures for those resulting in catastrophic grid conditions. The hurdle with this approach, McCalley says, is scale.

"The problem space is almost infinite," McCalley said. "You have thousands of components and each one could fail by itself or in conjunction with any number of others. The problem becomes intractable quickly."

> It's like looking for a thousand needles in several hundred thousand haystacks

With thousands of components and many millions of outage combinations, the team's automated safety net tool would need enormous computing power.

"It's like looking for a thousand needles in several hundred thousand haystacks," McCalley said.

Regardless, the team remains focused on finding new measures that can alleviate several different problems simultaneously. Using a combination of approaches, the team hopes to provide SCE with its recommendations in 2015 and to demonstrate their effectiveness on the SCE grid in 2016.

THESE EVENTS WERE EXTREMELY UNLIKELY... UNTIL THEY OCCURED

Western Electricity Coordinating Council, December 14, 1994:
At 1:25 am, a single phase-to-ground fault occurred on a 345kV line at the 3-terminal substation in Idaho, causing inadvertent tripping of an additional 345 kV line in the same station. Substation configuration caused the remaining line to open, resulting in an N-3 event, and an interruption of 5GW.

Brazil, March 11, 1999:
At 10:16pm, a phase-to-ground fault occurred on the Bauru 440kV busbar, and a breaker failed to open, resulting in an N-5 event and a loss of 24.7GW.

Northeast United States, August 14, 2003:
After two generator trips during the 90 minutes previous, at 1:31pm, the Eastlake Unit 5 unit tripped on over-excitation, causing increased loading on the Stuart-Atlanta 345kV line, which sagged and made contact with underlying trees, tripping at 2:02pm. This resulted in increased flows on adjacent lines, for which tree growth had not been maintained, and five 345kV lines tripped between 3:05pm and 4:05pm, a loss of nine components in total, leading to an interruption of 62GW.

London, August 28, 2003:
With two 275kV lines near Hurst substation out on maintenance, an alarm indicated gas accumulation inside a transformer at Hurst. Disconnecting the transformer required outaging another circuit from Hurst, loading up a remaining circuit. An incorrectly rated protection device interpreted the power flow increase as a fault and disconnected it, leading to a loss of 724 MW.

Scandinavia, December 1, 2005:
At 3:02pm, a fault on a 420kV breaker at the Swedish Porjus power plant correctly triggered the breaker failure protection, and the Porjus 420kV busbar was disconnected. This led to the remaining power transfer corridor out of northern Scandinavia becoming overloaded. The overloading should have led to instantaneous triggering of an RAS to limit the damage, but the RAS did not work as intended, leading to islanding and a loss of 2450MW of generation.

NICHOLAS PROFESSOR

VENKATARAMANA AJJARAPU

PhD, Electrical Engineering,
University of Waterloo (1986)

A SEARCH ENGINE FOR CODE

Kathryn Stolee's Satsy could revolutionize the way amateur (and professional) coders search.

BY **MICHAEL STILL**

From L: Kaitlin McAbee, Carl Chapman, Kathryn Stolee, Cody Hoover, Cole Groff, Trevor Lund

Writing software is kind of like solving a puzzle," said **Kathryn Stolee**, the Harpole-Pentair Assistant Professor of Software Engineering.

Any programmer who has suffered long hours in search of missing code can an attest to this analogy. But now, thanks to Stolee's research and development of Satsy, a new code-specific search engine, digging up those final missing pieces has become easier than ever.

"I wanted to find a way to help programmers reuse existing code so they don't have to re-invent the wheel." said Stolee, who added that much of the programming code we write today has likely been written in the past. "I also wanted to assist novice programmers who don't have much experience or formal training. I think that's who will find the most value; people who know what they want to do, but aren't quite sure how to do it."

"Google wasn't designed specifically for code search"

The first thing Stolee did was conduct a survey of programmers and their code searching habits to understand their needs and how to meet them. She gathered information on how often they search for code, what information they were looking for, and what tools they used.

After analyzing data from the survey, Stolee was not only surprised to learn just how frequently programmers searched for code, but she also was surprised to find out where they were searching for it. The survey revealed that Google search was the most frequently used tool among programmers, despite the numerous code-specific search engines available.

"It's surprising, because Google wasn't designed specifically for code search," said Stolee. "It was designed for general search, and although it currently serves as the best tool, I think that for certain types of searches, we can do better."

The survey results seemed to show a demand for a code-specific search engine that is accurate, efficient, and able to give Google a run for its money.

This is where Satsy comes in.

Satsy is the program that Stolee developed to help programmers search for code quickly and efficiently. Unlike Google where you search using a question or phrase, Satsy utilizes input values and output values to locate source code that best matches the programmer's needs. By eliminating the textual query, Satsy is able to search by using the behavior of a function, rather than by the way the function is written into a search bar.

"You provide concrete examples of inputs and concrete examples of outputs for your desired code. Then, Satsy uses a constraint solver to find existing functions that satisfy the examples," said Stolee. "It's not easy, which may be why it hasn't been done before, but it is more intuitive than a textual search and can achieve higher precision. By using a constraint solver, we also can find code that approximately or partially matches the examples when an exact match does not exist."

Satsy scans through a library of source

/// HARPOLE-PENTAIR ASSISTANT PROFESSOR
KATHRYN STOLEE
PhD, Computer Science, Nebraska (2013)

code called a repository, and pulls out any and all functions that satisfy the user's initial values using an SMT solver to determine if a function matches the provided examples. A ranking system is then applied to these functions to determine which ones are most likely to satisfy the programmer's needs.

After developing her approach, the next step in Stolee's research was to evaluate how Satsy would hold up in practice when compared to the competition; in this case, Google and a pre-existing code-specific search engine called Merobase. Stolee gave programmers simple tasks that required them to run searches using each tool. Afterward, she collected data to determine which search engine provided the most satisfying results from the programmer's standpoint.

Stolee's evaluation was promising, showing that Satsy out-performed Merobase in providing relevant search results. While Google still provided the most relevant search results of three tools, the results were competitive.

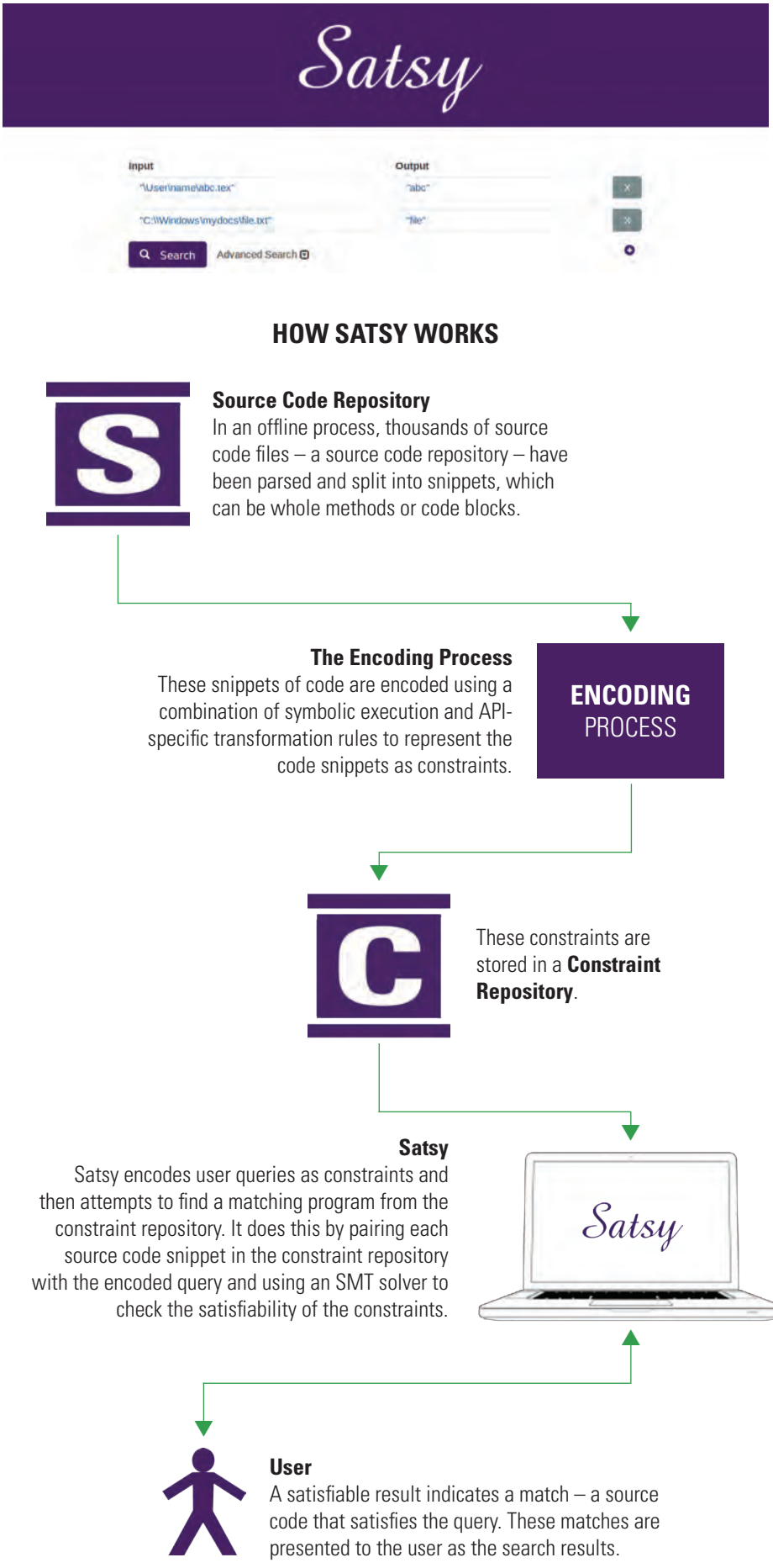
When the evaluation was complete, Stolee began looking at areas to improve. One area she hopes to tweak is the ranking system used in Satsy. By increasing the accuracy and effectiveness of the ranking system, Stolee believes it could match Google.

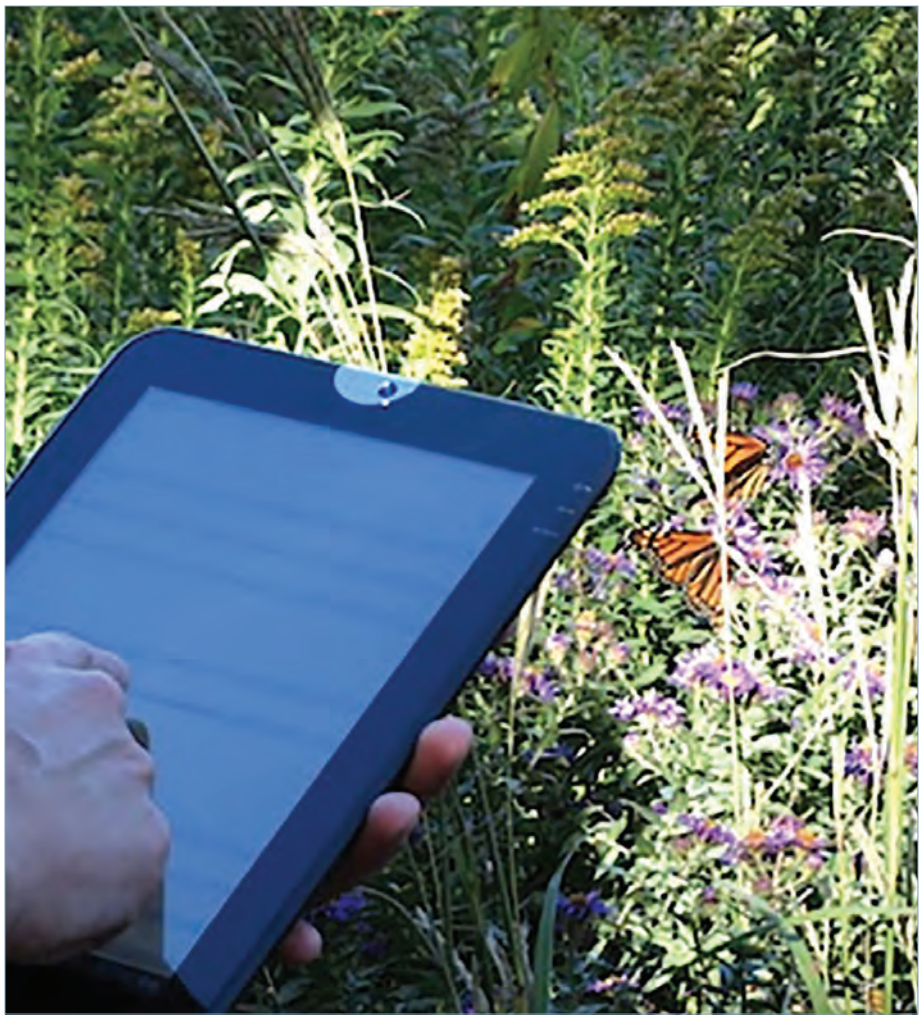
"Google wouldn't be as effective as it is if it didn't have its ranking system," said Stolee. "Without a good ranking system, it's hard for programmers to find what they want to use."

Now, as Stolee looks toward the future, she has identified multiple "next steps" that she plans to take toward improving Satsy to make it more helpful and effective. Most importantly, she hopes to gain more knowledge about what the programmer already knows, and what information they are looking for when conducting code searches.

Stolee also is working with a senior design team to create an interface that will make Satsy more user-friendly and efficient. Once the program is fully developed, further tests can be run and measured more accurately.

Looking ahead five years, Stolee hopes to make Satsy publicly available to programmers everywhere. She also hopes that it can be adopted and used in practice by students and professionals alike.





ECpE STUDENTS TRACKING BUTTERFLIES

An app designed by Iowa State University computer engineering students is catching the attention of butterfly researchers and monitors from Ames to Europe

BY **TEDDI BARRON**

An app designed by Iowa State University computer engineering students is catching the attention of butterfly researchers and monitors from Ames to Europe.

The Unified Butterfly Recorder (UBR) is a fully functional app for Android phones and tablets available on Google Play store. The app offers the world's butterfly enthusiasts a standardized and easy-to-use tool for recording data about butterfly population sightings.

[Photo] An app available for Android smart phones and tablets identifies at Reiman Gardens in Ames, Iowa.

According to Nathan Brockman, curator of the Reiman Gardens' Christina Reiman Butterfly Wing, networks of volunteers and researchers regularly survey butterfly diversity to indicate environmental changes. Reiman Gardens' staff record butterfly sightings on their grounds as part of the Iowa Butterfly Survey Network. However, Brockman said, current collection methods and surveys are not standardized, making data difficult to access and compare.

He had worked with ISU computer engineering students on three previous senior design projects, including Reiman Gardens' educational games about insects, "Build an Insect" and "Collect and Identify." So, he submitted a proposal for development of the app to Electrical and Computer Engineering Professor Diane Rover and her students — Ryan Scheel, Julie Tillman, Curtis Ullerich and Cameron Whipple. During the yearlong senior design project, they worked closely with Brockman to create the app for their client Reiman Gardens.

"I'm not exaggerating when I say that this design team could rival software development teams in industry," Rover said. "The students worked like professionals from day one.

"They were ambitious in their project goal to develop a fully functional app for the client that would be used by professionals and volunteers, locally, nationally and internationally," she added.

Ullerich, who just graduated and is headed to a software engineering job with Google, said the team wanted to work on the butterfly app project because it "is a project with real-world impact" that would be "deployed, used and provide some good in the world."

Last spring, the students sent a questionnaire to several butterfly professionals to get input on the app's features. After determining which features would be feasible and useable, they worked on the design and developed a prototype. During the summer, Brockman and several colleagues field tested the prototype and provided feedback.

"It's a fairly complex app and it was a very detailed process to develop it," Ullerich said. "We used every sensor the electronic devices have (such as GPS and environmental sensors), and dealt with complex lifecycle issues in terms of the application itself. And we needed to make it very useable for people who aren't necessarily tech savvy."

The app includes all 800 butterfly species in the United States and a separate list of all European species. Users can create their own lists of favorites (for example, the approximately 118 species found in Iowa or the 20 to 30 species found at Reiman Gardens).

The app is "extremely powerful," Brockman said. It automatically collects weather, location and timestamps

of sightings by selecting a butterfly from an editable list of species. Users also can take photos of specimens to include with records and input many other fields.

"And it's really neat because the students built the app so it can be used with any list — dragonflies, pollinators, trees, even rocks. You can change the list or customize it," Brockman said. "I see this as a great tool for researchers and schoolteachers."

Brockman and his colleagues are pleased with the finished product.

"I had high hopes and the group exceeded it," he said. "I think this will be a huge asset tool for the conservation community."

it's really neat because the students built the app so it can be used with any list — dragonflies, pollinators, trees, even rocks. You can change the list or customize it... I see this as a great tool for researchers and schoolteachers

Brockman has discussed the UBR app with colleagues in the Netherlands and Germany. As he shares it at professional conferences in the coming months, he expects the app will be "distributed worldwide and used in the field so we can see what tweaks still need to be made."

He has proposed the development of an iOS version for Apple to next year's computer engineering senior design class. And there is still some additional work to be done.

"We're working on species lists for other areas as well, outside of U.S. and Europe, including Africa and Neotropics," he said. "We will continue to add species to the master list until we have all of the continents with butterflies covered."

The Unified Butterfly Recorder app is available on Google Play store. Look for the icon of a monarch butterfly under "Apps."

/// FACULTY DIRECTORY

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

Samik Basu
Professor
PhD, Computer Science,
Stony Brook (2003)

Timothy Bigelow
Associate Professor
PhD, Electrical Engineering,
Illinois (2004)

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

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

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

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

Degang Chen
Jerry R. Junkins Chair
PhD, Electrical and Computer Engineering,
University of California, Santa Barbara (1992)

Chris Chong-Nuen Chu
Professor
PhD, Computer Science,
Texas (1999)
- IEEE Fellow

Vikram Dalal
Anson Marston Distinguished Professor
Thomas M. Whitney Professor
PhD, Electrical Engineering,
Princeton (1969)
- IEEE Fellow
- AAAS Fellow
- APS Fellow
- IEEE Distinguished Lecturer

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

Julie Dickerson
Professor
PhD, Electrical Engineering,
Southern California (1993)

Ian Dobson
Arend J. and Verna V. Sandbulte Professor
PhD, Electrical Engineering,
Cornell (1989)
- IEEE Fellow

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

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

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

Ayman Fayed
Associate Professor
PhD, Electrical and Computer Engineering,
Ohio State (2004)

Randall L. Geiger
Tunc and Lale Doluca Professor
PhD, Electrical Engineering,
Colorado State (1977)
- IEEE Fellow

Manimaran Govindarasu
Associate Department Chair
Ross Martin Mehl and Marylyne Munas Mehl Professor
PhD, Computer Science and Engineering,
Indian Institute of Technology, Madras (1998)
- IEEE Fellow

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

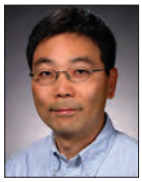
Doug Jacobson
University Professor
PhD, Computer Engineering,
Iowa State (1985)
- IEEE Fellow
- ACM Distinguished Engineer

David C. Jiles
Palmer Endowed Department Chair
Anson Marston Distinguished Professor
PhD, Applied Physics,
University of Hull, United Kingdom (1979)
- RAE Fellow
- IEEE Fellow
- APS Fellow

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

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

Jaeyoun Kim
Associate Professor
PhD, Electrical Engineering,
Michigan (2003)



Sang Kim
Associate Professor
PhD, Electrical Engineering,
Michigan (1987)

Suraj Kothari
Willard and Leitha Richardson Professor
PhD, Mathematics,
Purdue (1977)

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

Meng Lu
Northrop Grumman Assistant Professor
PhD, Electrical Engineering,
Illinois (2008)

James McCalley
Murray and Ruth Harpole Professor
PhD, Electrical Engineering,
Georgia Tech (1992)
- IEEE Fellow

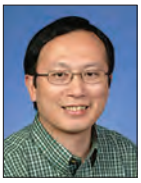
Mani Mina
Senior Lecturer
PhD, Electrical Engineering,
Iowa State (1989)

Nathan Neihart
Associate Professor
PhD, Electrical Engineering,
Washington (2008)

Tien Nguyen
Associate Professor
PhD, Computer Science,
Wisconsin (2005)

Santosh Pandey
Associate Professor
PhD, Electrical Engineering,
Lehigh (2006)

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



Long Que
Associate Professor
PhD, Electrical Engineering,
Wisconsin (2000)

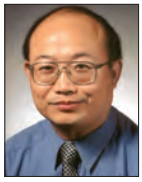
Sarah Rajala
Dean of Engineering
James & Katherine Melsa Professor
PhD, Electrical Engineering, Rice (1979)
■ IEEE Fellow ■ AAAS Fellow

Aditya Ramamoorthy
Associate Professor
PhD, Electrical Engineering,
UCLA (2005)

Diane Rover
Professor
PhD, Computer Engineering,
Iowa State (1989)
■ ASEE Fellow

Julie Rursch
Lecturer ISSL
PhD, Electrical Engineering,
Iowa State (2012)

Arun K. Somani
Associate Dean for Research
Anson Marston Distinguished Professor
Philip and Virginia Sproul Professor
PhD, Electrical Engineering,
McGill University, Montreal, (1985)
■ IEEE Fellow ■ AAAS Fellow ■ ACM Distinguished Engineer



Jiming Song
Associate Professor
PhD, Electrical Engineering,
Michigan State (1993)
■ IEEE Fellow

Kathryn T. Stolee
Harpole-Pentair Assistant Professor
PhD, Computer Science,
Nebraska (2013)

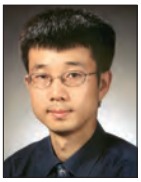
Alexander Stoytchev
Associate Professor
PhD, Computer Science,
Georgia Tech (2007)

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

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

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

Umesh Vaidya
Associate Professor
PhD, Mechanical Engineering,
University of California, Santa Barbara (2004)



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

Namrata Vaswani
Associate Professor
PhD, Electrical and Computer Engineering,
Maryland (2004)

David Weiss
Professor
PhD, Computer Science,
Maryland (1981)
- IEEE Fellow

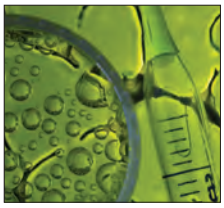
Johnny Wong
Software Engineering Program Director
Professor
PhD, Computer Science,
University of Sydney, Australia (1981)

Joseph Zambreno
Associate Professor
PhD, Computer Engineering,
Northwestern (2006)

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

STRATEGIC RESEARCH AREAS

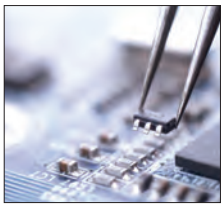
This year, the department has condensed its research efforts from five strategic research areas into four: Bioengineering; Cyber Security and Cyber/Physical Security; Materials, Devices, and Circuits; and Energy and Power Infrastructure. This renewed focus represents the latest evolution in ECpE's research strategy and better represents the goals and strengths of the department.



Bioengineering
The department aims to be a leader in combining biology, physics, mathematics, and engineering concepts to make advancements at the intersection of these disciplines.

Cyber Security and Cyber/Physical Security
The world's computing and networking infrastructure is vulnerable. The department, through projects in information assurance, cyber/physical security, and other areas, is a national leader in cyber security and at the front lines in the ongoing fight secure online information.

Energy and Power Infrastructure
The increasing demand for renewable energy continues to drive discovery in the department. ECpE faculty are leading projects in electric power systems, wind and solar energy, and energy planning that will help answer the challenges of growing worldwide energy demands.



Materials, Devices, and Circuits
Technology within the Materials, Devices ,and Circuits - including smartphones and HDTVs - has dramatically changed the world. The department continues its research with new impetus from micro-electro-mechanical systems (MEMS) and nanotechnology initiatives.

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
- 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.

VISION AND PRIORITIES

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.

Education Priorities:

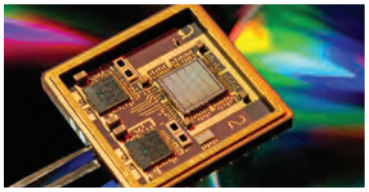
- Impart the ability to learn
- Encourage leadership
- Maintain high standards and an excellent international reputation
- Attract top students from reputed national and international schools
- Form strategic alliances with industry and research labs to enhance opportunities for research collaboration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

Research Priorities:

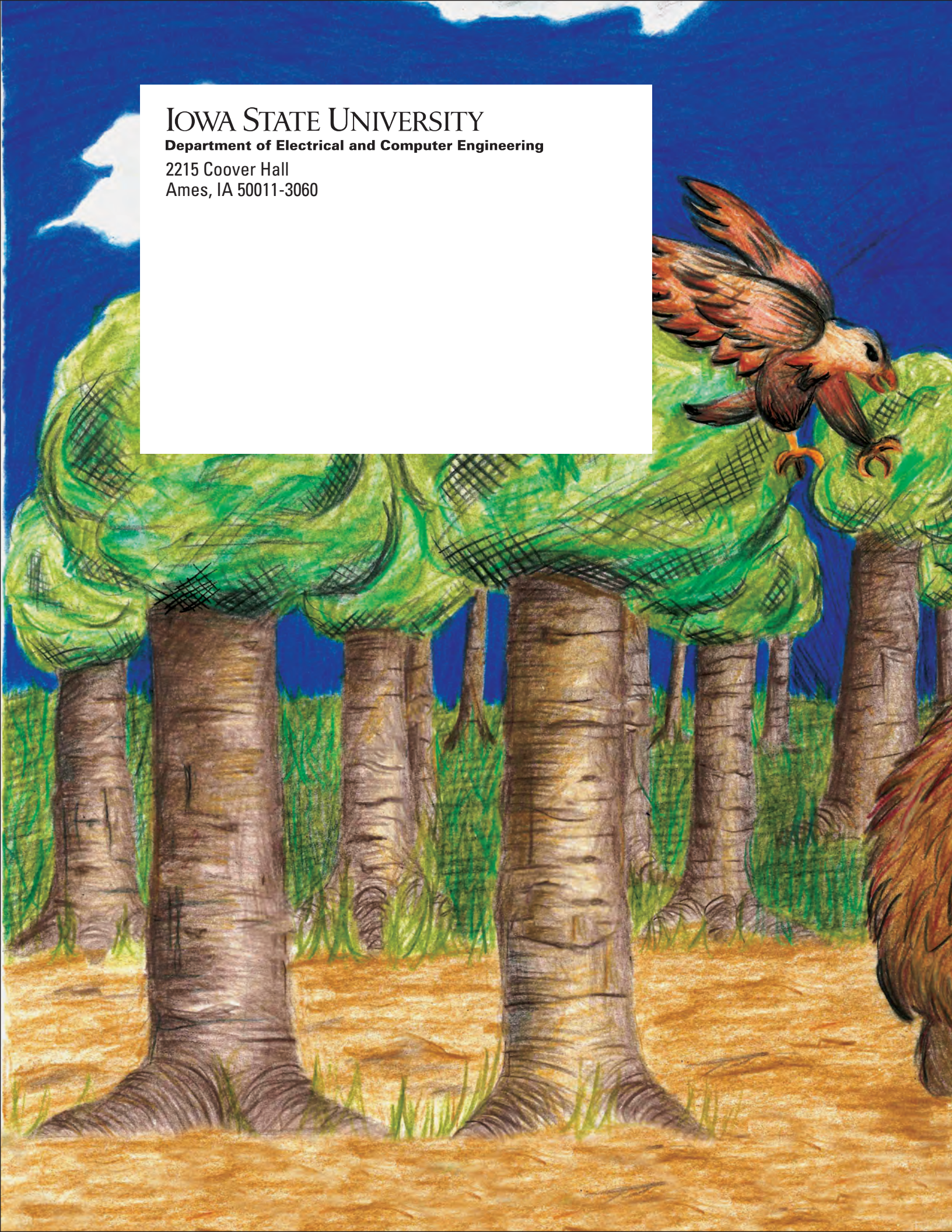
- Sustain faculty composition to have strength in core disciplines with adaptability
- Create centers of excellence in bioengineering, cyber infrastructure, distributed sensing and decision making, energy infrastructure, and small-scale technologies
- Create strategic partnerships with reputed research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

IOWA STATE UNIVERSITY

Department of Electrical and Computer Engineering



learn **invent** impact



IOWA STATE UNIVERSITY

Department of Electrical and Computer Engineering

2215 Coover Hall
Ames, IA 50011-3060