CSL: CONNECT
COORDINATED SCIENCE LAB

Nanoscale computing
continued from front page

The center seeks to create a new computing paradigm – using information processing instead of data processing – to extend scaling of nanoscale devices beyond what is feasible today. Computing devices today are primarily data pipes and data crunchers. By borrowing probabilistic techniques from the field of communications, SONIC researchers plan to transform these systems into statistical information processors that are able to infer intent and handle uncertainty while consuming much less energy than traditional computers.

SONIC is supported by STARnet, which will provide funding over the next five years to six centers at universities. Funded by the Department of Defense and U.S. semiconductor and supplier companies as a public-private partnership, STARnet projects help maintain U.S. leadership in semiconductor technology vital to U.S. prosperity, security and intelligence. The STARnet program is administered by the Semiconductor Research Corporation (SRC).

CSL, where four SONIC researchers are faculty members, will support SONIC's administrative activities. Other CSL faculty include **Rakesh Kumar** (ECE), **Rob Rutenbar** (CS) and **Andrew Singer** (ECE).

In addition to SONIC, University of Illinois researchers are also involved with two other STARnet research centers. **Douglas L. Jones**, a Professor of Electrical and Computer Engineering, will contribute to the TerraSwarm Research Center at the University of California, Berkeley, which aims to address pervasive integration of smart, networked sensors and actuators into our connected world. **Wen-mei Hwu** and **Deming Chen**, both Electrical and Computer Engineering faculty, will participate in the Center for Future Architectures Research (C-FAR), led by the University of Michigan. C-FAR will develop future scalable computer systems architectures that leverage emerging circuit fabrics to enable new commercial/defense applications.

ILLINOIS

Visit the new CSL website

The Coordinated Science Laboratory has launched its new virtual home at www.csl.illinois.edu. We hope you take a moment to check out the efforts currently underway to build next generation systems in areas ranging from high performance computing to robotics.
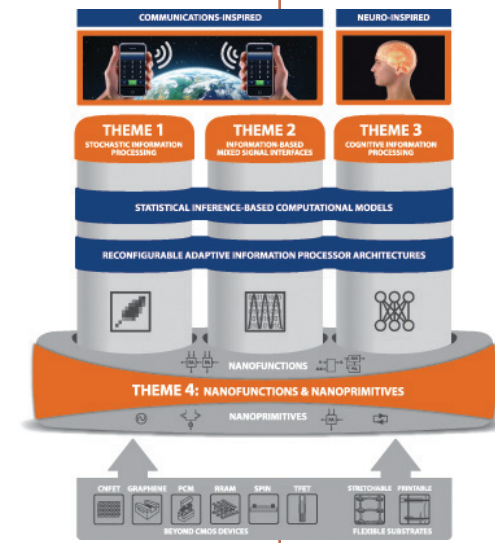**www.csl.illinois.edu**

Also, be sure to visit CSL's **Center for People & Infrastructures** new website at **infra-center.illinois.edu**. The site's background changes frequently to reflect the diversity of smart infrastructure systems, so make sure it's on your list of frequently visited sites.

New $30 million center seeks to transform nanoscale computing
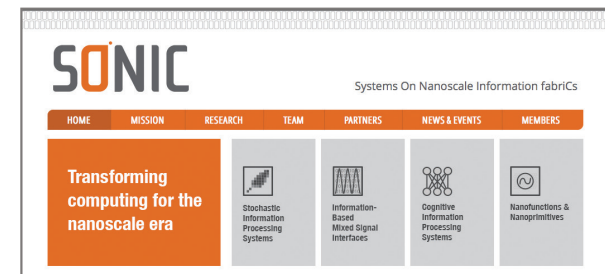
Led by faculty in the Coordinated Science Laboratory, a multi-university research team has received $30 million to launch the Systems On Nanoscale Information fabriCs (SONIC) Center. The center – part of a new $194 million initiative called the Semiconductor Technology Advanced Research network (STARnet) – will focus on substantially enhancing the information processing power and storage capacity of integrated circuits (ICs) and related systems, which is critical in maintaining reliability as devices continue to shrink and improve in energy efficiency.

Society is increasingly dependent on electronic information and has come to expect electronic devices – cell phones, tablets, laptops, cameras and others – to decrease in cost, offer more features and provide longer-lasting battery power. In the past, such advances have been made possible by the frequent reduction in size of a basic building block – the transistor switch.

Today, these switches are so small that their behavior is fraught with uncertainty due to quantum effects. The challenge is to design reliable and energy-efficient computing systems using the unreliable switches that arise as researchers seek to make devices even smaller and more energy-efficient. SONIC's innovative research agenda seeks to address this issue by treating the problem of computing using unreliable devices and circuits as one of communicating information over unreliable channels.

"Essentially, we're not going to try to build a reliable switch, but instead discover methods to build reliable systems," said SONIC Director **Naresh Shanbhag**, the Jack S. Kilby Professor of Electrical and Computer Engineering. "It turns out that while information resides at the highest level and nanoscale components at the lowest level, they can both be mathematically described with the same statistical framework. No one has successfully captured this similarity between them before."

Taking aim at preventing bird strikes

Crain's Chicago Business

The nation's airfields have, quite literally, gone to the birds.

Avian and other wildlife strikes annually cause more than $715 million in damage to aircraft each year, estimated the Federal Aviation Administration in a 2011 Wall Street Journal article. Consider the dramatic 2009 water landing of U.S. Airways Flight 1549 in the Hudson River, after a flock of geese collided with the plane during its climb out.

But CSL Assistant Professor **Soon-Jo Chung** has cried fowl, so to speak. He is working to develop robotic birds of prey that could chase flocks away from airfields, where birds are most likely to cause damage. The National Science Foundation will fund the research at nearly $500,000 for five years through its CAREER Award program.

"Robotic falcons could be an efficient and cost-effective solution, but will require significant advancements in control and sensing," said Chung, an assistant professor of aerospace engineering at Illinois.

Real birds of prey and guns have proved to be the most successful methods for removing flocks. But both come with significant challenges. While falcons were successfully deployed at J.F. Kennedy Airport and McGuire Air Force Base, for example, real birds are difficult to control and train. As they require human handlers in such cases, they are also expensive to maintain. Further, the most effective performers – peregrine falcons – are an endangered species.

Meanwhile, the use of guns has outraged animal rights groups, which successfully petitioned Kennedy – situated near a bird sanctuary – to quit using arms in 1993.

By creating a robotic falcon that can sense flocks and outfly them, Chung believes he can introduce a viable, though certainly not simple, solution.

"This is basically a grand control challenge problem," said Chung, who is a senior member of the American Institute of Aeronautics and Astronautics (AIAA) and the Institute of Electrical and Electronics Engineers (IEEE). "The dynamics are so complicated due to the complex nonlinear flapping flight dynamics with many articulated wing joints."

Chung, with his students, has been working on both the dynamic modeling and control challenges of bird-scale flapping flight. The team derived a limit-cycle-based control formulation for flapping flight while establishing PDE boundary control strategies for flexible, articulated-winged aircraft. "There are still some significant issues in flight control that must be resolved for them to work in the real world," he said.

Researchers also must develop algorithms that enable the robotic falcons to identify targets, and then navigate and herd the birds away from the airfield. A novel aspect of the project will focus on multi-agent pursuit-evasion algorithms that will help enable the robotic falcons to chase and navigate the birds away from the airfields.

"Birds are smart and can distinguish real falcons from robots," Chung said. "Our robots must fly like real falcons, look like real falcons and even sound like real falcons." Chung intends to leverage his prior work on distributed control, real-time optimization and synchronization of multi-vehicle systems, as well as game-theoretic or geometric formulations of pursuit-evasion.

In addition to the potential of solving an expensive and dangerous real-world problem, Chung is also excited about the opportunity to contribute to the fundamental understanding of avian flight. He said: "At its core, this is a scientific exploration of how birds fly so well."

Image by Luc Viatour

From the Director

CSL

CSL has long provided fertile ground for multidisciplinary initiatives to take root. From parallel computing to novel brain-machine interfaces, CSL has served as the launch pad for initiatives that have gone on to create a name in their own right.

So when the College of Engineering announced its support of six new interdisciplinary research projects through its Strategic Research Initiatives program last year, it makes sense that CSL would play in integral role. Of the six areas funded by the College, the Lab and its researchers support three. They are:

A Theory of Cognitive and Algorithmic Decision Making
CSL Professor **Andy Singer** (ECE) leads this project, which will imagine the next generation of human-machine decision systems by pairing Illinois strengths in decision theory and machine learning with expertise in social networks and human decision making. Applications range from data-driven and machine-aided battlefield decision making to financial forecasting. Other CSL faculty include **Tamer Başar** (ECE), **Maxim Raginsky** (ECE) and **Angela Nedich** (ISE), along with **Karrie Karahalios** (CS), co-director of CSL's Center for People and Infrastructures.

Beyond Speech: Towards an Interdisciplinary Study of Sound
Administered through CSL, this project aims to bring together all of Illinois' sound-related research under one umbrella. Researchers will explore such areas as audio recognition for computers and robotics, universal language applications and recordings and audio databases for applications such as sound and music retrieval, biomedical diagnosis, ocean monitoring and more. **Paris Smaragdis** (CS and ECE) will lead the project, with support from CSL's **Mark Hasegawa-Johnson** (ECE) and **Rob A. Rutenbar** (CS), among other researchers.

Digital/Cyber Security and Nuclear Security
Rizwan Uddin (NPRE) and I will be teaming up together with a group of colleagues who will develop new, advanced and nuclear-grade digital control and cyber security technologies. The goal is to marry the expertise available at Illinois to develop a center for digital control and cyber security for nuclear-specific applications.

While these projects are currently in early stages, I am confident that each will make major contributions in these areas in the future. And as the SRI program continues to grow, I believe CSL researchers will remain central to its success.

William H. Sanders

Alum wins early career award for control, information theory work

By Katie Carr

Coordinated Science Laboratory alumnus **Serdar Yüksel** has received the 2013 CAIMS/PIMS Early Career Award in Applied Mathematics. The award recognizes exceptional research in any branch of applied mathematics done primarily in Canada or in affiliation with a Canadian university.

The prestigious award is given jointly by the Canadian Applied and Industrial Mathematics Society and the Pacific Institute for the Mathematical Sciences. According to Yüksel, this award signifies that the mathematics community values research in control theory and information theory, where the majority of Yüksel's research lies.

"Serdar received this award in recognition of the fundamental contributions he has made to control and information theories since his graduation from Illinois," CSL Professor **Tamer Başar** said. "As his former advisor here at Illinois, I'm proud of his scientific achievements at his academic institution, Queen's, and am very pleased to see that the Canadian scientific community has given him the recognition he deserves."

Yüksel graduated from the University of Illinois with his Master's and Ph.D. in Electrical and Computer Engineering in 2003 and 2006, respectively. While at CSL, Yüksel worked in the Decision and Control Laboratory researching the interaction of information and control, primarily in the context of networked control systems.

Yüksel joined Queen's University in Ontario, Canada in 2007 and is currently an Assistant Professor in the Department of Mathematics and Statistics. He teaches graduate level courses on control theory and stochastic processes, in addition to classes on mathematical signal processing, applied analysis and ordinary differential equations. Additionally, he has been involved in organizing seminar courses on special topics, such as networked control and large deviations.

In receiving the award, Yüksel was recognized for his fundamental contributions to the study of control of systems under information constraints and decentralized control.

"CSL was, and continues to be, a primary source of innovation and a very collaborative, yet intellectually intense, environment with many inspiring and helpful professors and graduate students," Yüksel said. "I am continuing to work in the fascinating area of information and control in the context of decentralized systems, as well as information theoretic problems, and I am grateful to Prof. Başar for introducing the field to me."

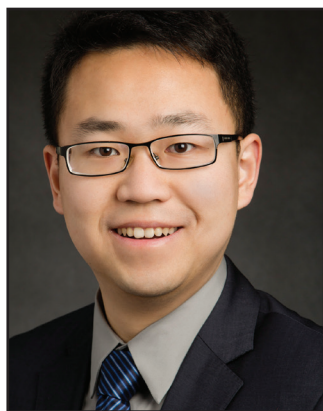## STUDENT-BUILT UAV TO COMPETE IN DRONE COMPETITION

A team of Engineering at Illinois students, including students of CSL professors **Seth Hutchinson** and **Soon-Jo Chung**, have designed and built a small drone aircraft to participate in a national Unmanned-Aerial-Surveillance (UAS) competition in October.

Organized by the Air Force Research Laboratory, Texas A&M University, and Raytheon, the challenge seeks to address current and future technologies for intelligence, surveillance and reconnaissance (ISR) missions.

Yihong Wu brings expertise in information theory, statistics to CSL

CSL Assistant Professor **Yihong Wu** comes to the university from a postdoctoral fellowship with the statistics department at The Wharton School at the University of Pennsylvania.

Wu, a member of Illinois' electrical and computer engineering faculty, received the Marconi Society Paul Baran Young Scholar Award in 2011 and winner of the Best Student Paper Award, IEEE International Symposium Information Theory (ISIT) in 2011. He received his Ph.D. in electrical engineering with minors in mathematics, operational research, and financial engineering from Princeton University in September 2011. He received his B.E. in electrical engineering from Tsinghua University, Beijing.

Wu's research combines information theory and statistics. One of the projects he is currently focusing on is sparse principal component analysis (sparse PCA). He is also interested in signal processing and communication problems.

"Principal component analysis is one of the major tools in dimension reduction in dealing with high-dimensional data," Wu said. "We want to understand, 'What is the optimal thing to do? What are the fundamental limits if we want to do PCA in the presence of sparsity in the data?'"

Wu's research in modern statistics deals with large and complex data sets, and consequently with models containing a large number of parameters far exceeding the number of available samples.

"One example is genomics where the number of factors can be much larger than the number of subjects," Wu said. "Conventional statistics usually operate in the regime of fixed dimension and large amounts of samples. In the presence of high-dimensionality, the fundamental question boils down to how to effectively take advantage of the underlying structure in order to perform optimal statistical inference efficiently."

Wu's research primarily focuses on information theory and statistics, which includes "applying information-theoretic tools to the modern high-dimensional statistics for big data."

"Many data are naturally high-dimensional, which makes it very difficult to store, transmit, or perform inference on these data," Wu said. "For example, there are about 500,000 to 1 million observations along the human genome of just one individual. There are many facets of challenges for big data."

Wu uses tools that originate from information theory to determine the fundamental limit of statistical inference on high-dimensional data. Wu will teach courses in the area of information theory. He will be teaching a graduate-level course in the fall, and he hopes to develop a course that introduces the use of information theory for high-dimensional statistics.

Wu continues to collaborate with faculty at The Wharton School, and he hopes to work with faculty in ECE and statistics.

"I really like the excellent colleagues, outstanding students, and the collegial atmosphere at the Coordinated Science Lab and the ECE Department," Wu said. "I am excited to be contributing to the innovative and multidisciplinary research at Illinois."

Engineering receives $100 million from Grainger

The Grainger Foundation has pledged $100 million to support the University of Illinois College of Engineering through the establishment of the Grainger Engineering Breakthroughs Initiative.

"We are tremendously grateful for this extraordinary gift from The Grainger Foundation, which is an investment in the future of engineering, the future of our engineering faculty and students, and, indeed, an investment in the campus as a whole," Chancellor Phyllis Wise said.

The gift will create an endowment for engineering chairs and professorships, provide an endowment for bioengineering and "Big Data" research, as well as provide scholarships for students and help with the renovation of Everitt Laboratory.

ITI to develop ambitious new digital forensics curriculum

By Jenny Applequist

ITI faculty received a grant from the National Science Foundation in October 2012 for a new undergraduate curriculum in digital forensics, in order to address a national shortage of cyber-security professionals.

Digital forensics is a type of forensics that deals with recovery and investigation of data in digital devices. Digital crime is growing dramatically in today's technology-dependent world and consequently, digital forensics is now a major part of many criminal investigations.

Unfortunately, the multidisciplinary nature of digital forensics has been a significant barrier to entry into the field. Those entering the field not only need expertise in computer science, but also legal procedures, laws of evidence and investigative techniques.

"There are all sorts of aspects of human behavior interacting with computers that are not addressed in a computer science program, not addressed in a sociology program, and so on," said **Roy H. Campbell**, the leader of the ITI effort. "For data forensics, you really want to have a body of professionals that understand all the needs."

To address that challenge, the ITI development team includes faculty in computer science, computer engineering, criminal justice, law, sociology, accounting and educational assessment.

The team will be hosting a workshop on campus in late May, inviting other universities who are interested in digital forensics programs. While several academic programs on digital forensics have been developed, the industry standards are still evolving.

"Part of the NSF goal for us is to develop courses and then give them to other universities," said Masooda Bashir, managing director and co-principal investigator of the program. "The goal of the workshop is to invite early adapters of our program or people that already have a program and exchange ideas and share information."

The University of Illinois will offer its first class in fall 2013, called Introduction to Digital Forensics.

JONES NAMED NEW DIRECTOR OF ADVANCED DIGITAL SCIENCES CENTER

The University of Illinois has named Professor **Doug Jones** as the new director of the Advanced Digital Sciences Center in Singapore. Jones is replacing **Marianne Winslett**, an Illinois professor of computer science, who will step down from her role and return to Illinois full-time as of June 30, 2013.

"We greatly appreciate and will miss Marianne's leadership at ADSC," said **Bill Sanders**, director of the Coordinated Science Laboratory and ADSC associate director. "We look forward to this new phase that ADSC is stepping into as Doug Jones begins to guide ADSC's future."

Since Winslett became director in 2009, ADSC received 12 best paper nominations, awards and other honors, while publishing over 150 papers in conferences and journals. Today ADSC employs almost 60 full-time researchers, in addition to an intern program that brought in over 40 interns in 2012.

"It's a unique opportunity to participate in research in Singapore, where we can bring the benefit back to Illinois and the U.S., as well as contribute to Singapore's knowledge-based economy," Jones said.

Jones has been on the faculty of Illinois' Department of Electrical and Computer Engineering since 1988, and is a professor in the Coordinated Science Laboratory and the Beckman Institute. Jones has been on the faculty of ADSC since July 2010. He is currently leading the project, RATEM: Realistic Audio Telepresencing for Entertainment and Meetings, in the center's interactive digital media theme.

"Singapore is an unparalleled living laboratory to plug into," Jones said about why conducting research in Singapore is beneficial to Illinois. "Singapore is very focused on the future and advancing technology, so it's great for us to plug into people who are interested in research and have different areas of emphasis that maybe aren't such a high priority in the U.S. or as effective in the U.S."

Nicol invested as Woelge Professor in Electrical and Computer Engineering
By Jamal Collier, ECE

David Nicol, a professor of Electrical and Computer Engineering at CSL, was invested as Franklin W. Woeltge Professors in Electrical and Computer Engineering on February 26, 2013, at the Beckman Institute.

Nicol is considered a leading expert on the modeling and simulation of discrete event systems, and is frequently called upon to consult with industry and government, particularly in the use of these techniques to assess the trustworthiness of systems that monitor and control critical infrastructure. Nicol joined the ECE faculty in 2003.

Liberzon, Viswanath named IEEE Fellows
By Elise King, CSL

CSL professors **Daniel Liberzon** and **Pramod Viswanath** have both been announced as IEEE Fellows for 2013 – Liberzon for his contributions to the analysis and design of switched, nonlinear and quantized control systems, and Viswanath for his contributions to the theory and practice of wireless communications. Both are faculty in Illinois' Department of Electrical and Computer Engineering.

The Fellow grade is the highest grade of membership within IEEE. Out of its 400,000 members from around the world, 298 individuals were named IEEE Fellows this year.

Vasudevan named ACM SIGDA oustanding new faculty
By Katie Carr, CSL

CSL professor **Shobha Vasudevan** was named the 2013 ACM SIGDA Outstanding New Faculty Award recipient. Vasudevan, an assistant professor of electrical and computer engineering, will be presented the award at the Design Automation Conference (DAC) in June.

The award is given by the Association for Computing Machinery (ACM) Special Interest Group on Design Automation (SIGDA). It is presented to one junior faculty member who displays outstanding potential as an educator and/or researcher in the field of electronic design automation during the initial years of their academic appointment.

Gropp named Siebel Chair and other recognitions
By Elise King, CSL

CSL Professor **William Gropp** was recently elected Member-at-Large for the Information, Computing and Communication section of The American Association for the Advancement of Science (AAAS), and began his four-year term in February.

Gropp's election comes on the heels of his being named of HPCWire's people to watch in 2013. He is also the chief applications architect for the Blue Waters petascale supercomputer, the General Chair for Supercomputing '13 and has recently been appointed the Thomas M. Siebel Chair in Computer Science at the University of Illinois at Urbana-Champaign.

Nahrstedt named ACM Fellow
By Jenny Applequist, CSL

ACM, the Association for Computing Machinery, has named **Klara Nahrstedt** a Fellow in recognition of her contributions to quality-of-service management for distributed multimedia systems.

Nahrstedt has long been a leading researcher in multimedia systems, having made multiple seminal contributions in quality of service (QoS) management for distributed multimedia systems. She is widely recognized as the world leader of the 3D teleimmersive systems and networking field.

Abdelzaher wins IEEE honor
By Computer Science Communications

CSL Professor **Tarek Abdelzaher**, a Donald Biggar Willett Scholar in the College of Engineering, was named the winner of the 2012 Outstanding Technical Achievement and Leadership Award by the IEEE Technical Committee on Real-Time Systems in December. The award is given for long-term technical achievement and leadership in the field of Real-Time Computing. Abdelzaher is the youngest of the 14 recipients to ever receive this award.

Photo: Mats Nygren