

# CONNECT



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**CENTER FOR AUTONOMY  
LAUNCHED TO DEVELOP  
RESEARCH, EDUCATION  
IN EMERGING FIELD**



Coordinated Science Lab  
COLLEGE OF ENGINEERING

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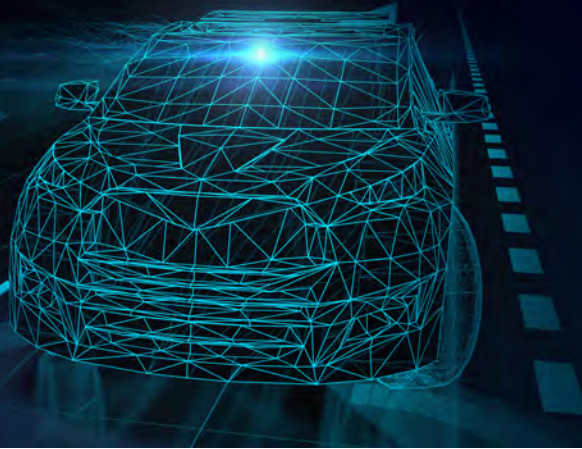
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## CONNECT

WINTER 2018

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## Director's Message | Klara Nahrstedt

Self-driving cars. Intelligent robotic assistants. And remote surgical systems. In the future, more systems will be able to function autonomously, or without human intervention. But in order for this to happen, we will have to invest in foundational and applied research, as well as education, to create systems that can function in a safe and reliable way.

In this issue of Connect, you will learn about CSL's new Center for Autonomy, which seeks to push through the grand challenges that impact advancements in autonomy, both technical and cultural in nature. Prof. Geir Dullerud (MechSE) will lead this effort, which will also include faculty from agricultural and biological engineering, aerospace engineering, computer science, and electrical and computer engineering, among other departments.

In addition, you will read about CSL's new \$8.3 million collaboration, led by Prof. Naresch Shanbhag (ECE), with DARPA to develop foundational computing technologies for next-generation autonomous systems for defense and commercial applications. Prof. Olgica Milenkovic (ECE) is heading numerous projects related to using DNA for data storage, including a \$1.5 million project that aims to produce new DNA-based storage nanoscale devices using chimeric DNA.

And finally, please take a moment to check out all the many accolades and awards received by our researchers in the latter part of 2018. I am so proud of all that our people have accomplished, and look forward to more highlights in 2019.



# CSL Achievements



## **Bashir named 2018-2019 Centennial Scholar**

CSL Assistant Professor Masooda Bashir has been named

the iSchool's Centennial Scholar for 2018-2019. Endowed by alumni and friends of the School, the Centennial Scholar award recognizes outstanding accomplishments and/or professional promise in the field of library and information science.

Innovations in computing and the advance of electronic communication technologies have led to the exponential growth of digital data. The privacy, security, and trust of such data have become a top national and global priority. Bashir explores these critical concerns from a human-centered perspective, investigating users' attitudes, knowledge, behavior, and preferences related to digital privacy, cybersecurity, and automation.

In addition to her CSL appointment, Bashir is the director of Social Sciences in Engineering Research in the College of Engineering and holds appointments in the Information Trust Institute, Department of Industrial and Enterprise Systems Engineering, and Beckman Institute.



## **High-risk research results in reward for former CSL student**

Former CSL student Mingu Kang received

the 2018 CSL Ph.D. Thesis award for his dissertation "Deep In-memory Computing" on realizing energy- and latency-efficient machine learning systems in silicon.

In his research, Kang conceived of the deep in-memory architecture, or DIMA, for reducing the energy consumption of machine learning systems used in battery-powered electronics.

"DIMA is a radical shift away from von Neumann architecture since it eliminates the standard memory-processor interface," said Naresh Shanbhag, Kang's adviser and CSL and electrical and computer engineering (ECE) professor. "Mingu was extremely bold in not only formulating DIMA but also working hard to make it real by designing multiple prototypes."

After graduating with an ECE degree in 2017, Kang joined the IBM T.J. Watson Research Center as a research staff member. His current work is an extension of his Ph.D. research; he optimizes the data processing and movement in large-scale machine learning processors.

# CSL Achievements



## **Kamalabadi receives award to help NASA improve telescope resolution**

NASA has recently put a strong emphasis

on developing smaller technology that can be launched into space at lower cost. CSL's Farzad Kamalabadi, who is the Kung Chie and Margaret Yeh Endowed Professor in ECE, is leading a team to develop imaging systems to improve telescope resolution on smaller spacecraft.

Kamalabadi's project will focus on the development and demonstration of novel computational diffractive optical sensing and advanced image processing that make use of a small satellite formation's flight to enable an extremely high-resolution imaging capability that would otherwise be unattainable with conventional approaches.

"The current generation of NASA space telescopes are limited in the resolution they can attain for looking at very detailed phenomena," Kamalabadi said.

Current telescopes rely on technology that uses reflective optics, i.e., concave or convex lenses or mirrors, which have manufacturing constraints, he explained. Those constraints result in limitations in spatial and spectral resolutions. Kamalabadi is working to beat those limitations with a completely different approach to imaging that uses diffractive imaging elements and computational processing of the measured data.



## **Sanders named interim director of DPI**

CSL Professor William H. Sanders has been named interim director of the Discovery Partners Institute (DPI), a new world-class

innovation center led by the U of I System.

Sanders joined the university's faculty in 1994, and has a long history of academic leadership in Urbana-Champaign. He served as director of CSL for a number of years. While there he (with other faculty members) created the Advanced Digital Sciences Center, a research facility in Singapore.

In addition, Sanders was the founding director of the Information Trust Institute (ITI). At ITI, he built the institute from the ground up, growing it to about 100 faculty members from 28 departments, and enabling ITI to create interdisciplinary research teams to address important societal-scale problems related to cybersecurity and trust. Sanders has also served as head of the Electrical and Computer Engineering Department.

# CSL Achievements



## CSL Professor Awarded Honorary Degree

CSL Professor Narendra Ahuja was awarded the honorary Doctor of the University honoris

causa by the University of York in the United Kingdom. According to the university, the research professor of electrical and computer engineering was given this award for making “outstanding contributions to society.”

Specific accomplishments highlighted by York included Ahuja’s role as the founding director of the Information Technology Research Academy in New Delhi and the International Institute of Information Technology (IIIT) in Hyderabad. The research conducted by Ahuja, also a member of the Beckman Institute, has received four patents, resulted in more than 450 journal and conference papers, and been used across the electrical industry by companies such as General Electric, Westinghouse, Lockheed Martin, and Honeywell.

Currently, Ahuja’s research focuses on extraction and representation of spatial structure in images and video.



## Hwu named acting head of ECE Department

In August, the University of Illinois at Urbana-Champaign’s College of Engineering

announced CSL Professor Wen-mei W. Hwu will serve as acting head of its top-ranked Department of Electrical and Computer Engineering.

Hwu is currently the AMD Jerry Sanders Chair of Electrical and Computer Engineering. He leads the IBM-Illinois Center for Cognitive Computing Systems Research (C3SR) and is a PI on the Blue Waters supercomputing project. He is also a fellow of the Institute of Electrical and Electronics Engineers (IEEE) and the Association for Computing Machinery (ACM).

“Wen-mei is the epitome of an Illinois Engineering faculty member—gracious, collaborative, innovative, and incisive. I am certain he will serve ECE extremely well,” said Tamer Başar, former interim dean of the College of Engineering.

Hwu will be acting department head while Prof. Bill Sanders serves as interim director of the Discovery Partners Institute.

# CSL Achievements



## Srikant recognized with IEEE Koji Kobayashi Computers and Communications Award

Fredric G. and Elizabeth H. Nearing Endowed

Professor of Electrical and Computer Engineering Professor R. Srikant, who conducts research in the Coordinated Science Lab, was recently awarded the IEEE Koji Kobayashi Computers and Communications Award “for contributions to congestion control and scheduling in computer communication networks.”

The award was established by the IEEE Board in 1986 to recognize outstanding contributions to the integration of computers and communications. It is named in honor of Dr. Koji Kobayashi, a global leader in the advancement of the integrated use of computers and communications.

Srikant’s research has contributed to congestion control protocols in communication networks, beginning with more traditional networks and reaching into wireless, cloud computing, and machine learning. His projects and publications have focused on designing efficient architectures and algorithms for networks with heavy traffic queues, developing distributed algorithms with low-complexity implementation, and protecting wireless infrastructures against terrorist attacks.



## President’s Executive Leadership Program Fellow

Out of more than 60 nominations from across the three universities in the University of Illinois

system, CSL professor Jennifer Bernhard has been announced as one of the 2018-19 President’s Executive Leadership Program (PELP) Fellows.

PELP Fellows investigate broadly pressing issues in public higher education, specifically for land-grant institutions. Some other goals for fellows include increasing knowledge and awareness of issues that may challenge higher education and the university, enhancing management and decision-making skills, and studying various participatory methods and approaches in university governance and management.

Bernhard came to the University of Illinois in 1999 as a faculty member and became the Associate Dean for Research of the College of Engineering in 2012. Bernhard also serves as the Interim Director for the Applied Research Institute and is a Donald Biggar Willett Professor in Electrical and Computer Engineering.



# Allerton Conference

## Allerton by the numbers

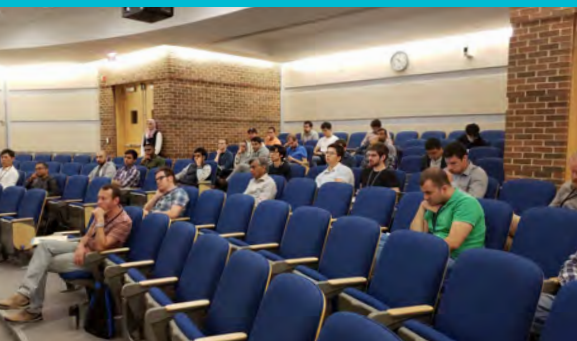
In October, researchers from the University of Illinois at Urbana-Champaign and around the globe attended the 56th Annual Allerton Conference on Communication, Control, and Computing. One of the longest-running circuits conferences, it was started in 1963 by Mac Van Valkenburg and was originally called the Allerton Conference on Circuits and Systems.

The Allerton Conference has a reputation as a gathering place for the brightest minds in the fields of communication, control, and computing, and this year was no exception.

More than 450 researchers attended 150 sessions that offered nearly 100 hours of presentations.

The presenters came from 80 universities, 22 countries and 25 states.

The 2019 conference will be held on September 24-27 at the beautiful Allerton Park and Retreat Center in Monticello, Illinois.





## Illinois researchers pursue top performance and high programmability under new DARPA project

CSL Professors Wen-mei Hwu and Deming Chen are on the Dynamic Data-Aware Reconfiguration, Integration and Generation (DDARING) team, brought together to improve how computers handle information.

Currently, many computing platforms have the flexibility to work with many applications and a variety of operating systems, but they aren't as high-performing as computing platforms that use ASIC ("application-specific integrated circuit") chips. The DDARING team is pursuing the goal of approaching the high processing capability of an ASIC chip, without losing the programming flexibility of standard computing platforms.

## Illinois team looks to robots, not chemicals, for weed-free crops in the future

Scientists at the University of Illinois at Urbana-Champaign are working to remove farmer reliance on chemicals to destroy weeds. Their goal is to create collaborative and autonomous robots that would weed fields in lieu of chemical formulas.

CSL's Girish Chowdhary and his group of scientists hope their research will result in farmers' having a team of reliable, proficient, and cost-effective robots as a sustainable weed management option.

Researchers from a wide variety of disciplines are coming together to build AgBots that are capable of meeting this goal. Fellow CSL Professor R. Srikant's machine learning and deep learning expertise is being used to apply fundamental principles that will allow the robots to acclimate to real-world uncertainties experienced in the field. The group also includes weed expert Adam Davis, head of the U of I Department of Crop Sciences, and Chinmay Soman, a natural resources expert and CEO of the company EarthSense.

The group has succeeded in developing a robot that can traverse fields and differentiate between crops and weeds. The next step is to build an arm that would be responsible for the weeding action of the robot.

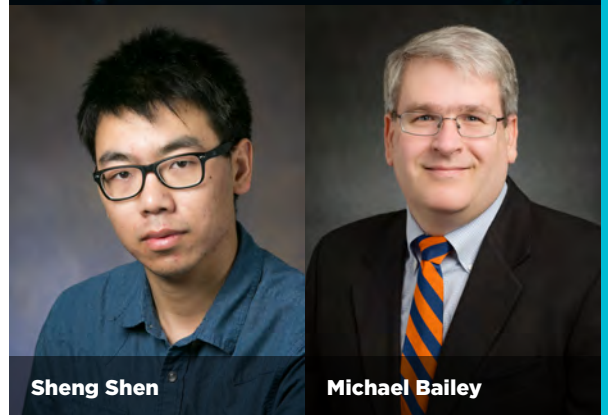


## University of Illinois researchers develop method to cancel noise without ear-blocking headphones

Research being conducted at CSL is looking to improve noise cancellation without blocking the ear canal. Current noise-cancelling technology blocks noise by emitting an anti-noise signal to contrast with the objectionable sounds. It is not very effective, which is why such devices must cover the entire ear with noise-canceling material. Wearing such devices for long periods of time is not comfortable, and can even be harmful.

The main idea behind this research, led by Sheng Shen, a Ph.D. candidate in CSL and the Dept. of Electrical and Computer Engineering (ECE), involves combining wireless IoT networks with noise cancellation. A microphone is placed in the environment; it senses sounds and sends them via wireless signals to an earpiece. Since wireless signals travel a million times faster than sound, the earphone can receive the sound information much faster than the actual sound itself.

CSL Professor Romit Roy Choudhury and Assistant Professor Haitham Hassanieh, along with Ph.D. students Nirupam Roy and Junfeng Guan, all of ECE, collaborated on the research.



## Researchers discover “skill squatting” can hijack Amazon Alexa

CSL Associate Professor Michael Bailey and Adam Bates, an assistant professor in computer science, have helped identify homophones and mistakes in voice processing that could be used to phish Amazon Alexa users. The researchers identified an attack method they call “skill squatting.”

There have been several recent demonstrations of attacks that leverage voice interfaces. Voice-recognition-enabled Internet of Things (IoT) devices have been shown to be “vulnerable to commands from radio or television ads, YouTube videos, and small children.” Skill squatting poses a more immediate risk due to homophones in the names of applications.

For example, “Fish Facts” would return random facts about fish, while “Phish Facts” would return facts about “Phish,” the Vermont-based rock band.

Several potential exploits by malicious developers could include skills that “intercept requests for legitimate skills in order to drive user interactions that steal personal and financial information.” Illinois researchers demonstrated how a skill called “Am Express” could “hijack initial requests for American Express’s Amex skill” and steal users’ credentials.





## SENSELET provides sensory-driven IoT network for scientific instruments



When fabricating new semiconductors, the external environment — such as the humidity, temperature, or vibration from nearby machines — can make or break the experiment. That holds true for many types of research involving scientific instruments, including the discovery of new materials or biomedical processes.

A team of researchers at the University of Illinois, led by Klara Nahrstedt, director of the Coordinated Science Lab and the Ralph and Catherine Fisher Professor of Computer Science, is building a wireless and scalable sensory infrastructure that will help scientists better understand the conditions under which their experiments succeed or fail, with the idea of accelerating scientific discovery and the introduction of new technology to the

marketplace. The National Science Foundation (NSF) is funding the two-year, \$500,000 project, titled “SENSELET: Sensory Network Infrastructure for Scientific Laboratory Environments.”

The team’s goal is to deploy a diverse wireless and sensory infrastructure that collects data and sends it to the cloud, where it will be correlated and synched with instrument data in real-time and on demand.

The research team also includes CSL’s Roy Campbell, the Sohaib and Sara Abbasi Professor of Computer Science.





## Center for Autonomy launched to develop research, education in emerging field

From self-driving cars to intelligent robotic assistants to remote surgical systems, autonomous technology will revolutionize the way we live, work, and play. In order to enable this revolution, however, advancements in foundational research and workforce development must first take place to provide assured and certified-safe performance.

The University of Illinois at Urbana-Champaign has allocated \$2.1 million in funds to create a new Center for Autonomy that will enable high-impact research and develop new educational programs for students and professionals. The Center will play an important role in designing innovative systems that can function autonomously, or without human intervention, in a safe and reliable way. In addition, the College of Engineering is providing a \$2.1 million match to recruit new faculty in robotics to continue growing expertise at Illinois.

“We have achieved some measure of autonomy already,” said CSL’s Geir Dullerud, the W. Grafton and Lillian B. Wilkins Professor of Mechanical Science and Engineering, who is the Director of the new center. “However, there’s a difference between a self-driving car that works most of the time and a self-driving car that works all of the time. When it comes to safety-critical activities, we need to be assured that autonomous systems will function in the intended way.”

Experimental space for autonomy and robotics research is set to increase fourfold with the creation of the Center, with the goal of applying fundamental theoretical advances to applications of the future.

The Center for Autonomy’s researchers are already pursuing distributed autonomous and robotic trustworthy systems (DARTS) for applications that are important to humanity

and our economy, such as the farms of the future, information-rich IoT-driven autonomous manufacturing floors, and defensive systems that bring humans and robots together in operational teams that will be unparalleled in their capacity to defend our nation. As part of this process, researchers will advance knowledge in artificial intelligence, robotics, digital hardware, and communications.

The Center will also galvanize thinking on many critical issues associated with autonomous systems, such as:

- Exploring the ethical considerations of using autonomous systems and the value judgments that these machines will make, potentially without human intervention;
- Expanding and modifying the law, business, and labor models to deal with such systems in the public domain and workplace; and
- Understanding the psychological impact of these developments on humanity.

In addition to research, the Center will develop new degree programs in autonomy and robotics, which will help prepare the next generation of students to tackle critical problems in this field. The first effort will be a Master's degree that will help students develop a holistic view of the issues pertinent to autonomous systems. There will also be opportunities for individuals to further focus on business, societal, and ethical dimensions. In addition, Dullerud and his colleagues plan to develop specialization certificates that would tackle similar issues.

The Center for Autonomy will continue the excellence that Illinois has claimed in this area for years. For example, the University was recently named No. 1 in Automation & Control by the Shanghai Ranking Consultancy's Academic Ranking of World Universities.

The Center is being funded through the competitive Investment for Growth program, which is sponsored by the Provost's office.



**“We have many top researchers in this field and the many related fields. I believe that Illinois with its breadth and excellence has all the right resources to dramatically impact this field for the benefit of humanity and society in the coming decades.”**

Provost Andreas Cangellaris



# Illinois receives \$1.5 million to lower cost, improve viability of DNA data storage

As the global datasphere expands, so does the need for more data storage. Enter DNA, the carrier of life's genetic information, which offers a potential storage medium of unprecedented density, durability, and efficiency.



By 2025, the world will generate 163 zettabytes (163 trillion gigabytes) of data a year, in part due to emerging technologies such as the Internet of Things, predicts research group IDC. While not all of that data will be stored, the demand for storage may outpace traditional storage capabilities.

DNA is an attractive solution because one gram of DNA can store up to 455 exabytes of data.

The University of Illinois at Urbana-Champaign is undertaking a \$1.5 million effort to produce new DNA-based storage nanoscale devices using chimeric DNA, a hybrid molecule made

from two different sources. The research team will design and synthesize hybrid DNA molecules that contain non-natural chemical modifications. The goal is to expand the storage capacity enabled by DNA coding methods, essentially increasing the number of equivalent bits.

The Illinois collaborators include Olgica Milenkovic, CSL researcher and professor of electrical and computer engineering (ECE); CSL professor Jean-Pierre Leburton, the Gregory E. Stillman Professor of ECE and Physics; Xiuling Li, Professor of ECE; and Charles Schroeder, Professor and the Ray and Beverly Mentzer Faculty Scholar in Chemical and Biomolecular Engineering. Leburton is also a researcher in the Beckman Institute, while Li is part of the Micro and Nanotechnology Lab.





# Illinois to lead \$8.3 million initiative to design energy-efficient computing for autonomous platforms

The University of Illinois has received an \$8.3 million grant to collaborate in the development of foundational computing technologies for next-generation autonomous systems for defense and commercial applications.

The team will develop novel computing technologies that address the needs of autonomous sensory platforms that make mission-critical decisions in real-time, within strict thermal limits, and while withstanding high-radiation space environments. The program is being funded through the Defense Advanced Research Projects Agency (DARPA)'s Foundations Required for Novel Compute (FRANC) research program.

"These are sensor-rich platforms that acquire multi-modal data continuously," said Naresh Shanbhag, Jack S. Kilby Professor of Electrical and Computer Engineering at Illinois and CSL researcher. "Such large data volumes need to be processed in real-time using modern machine learning and artificial intelligence (AI) methods."

The team's approach is to use a silicon-compatible technology called "magnetoresistive random access memory" (MRAM). Compared to the commonly used static RAM (SRAM), MRAM is dense, non-volatile (meaning that it retains data even when the power source is turned off), and immune to radiation effects.

FRANC is one of six programs under DARPA's recently established Electronic Resurgence Initiative (ERI), whose goal is to "more constructively enmesh the technology needs and capabilities of the defense enterprise with the commercial and manufacturing realities of the electronics industry." In addition to Shanbhag, Illinois Professor Pavan Hanumolu is also part of the FRANC research team.



## Shanbhag honored for excellence in semiconductor research

The Semiconductor Industry Association announced CSL Professor Naresh R. Shanbhag as one of two winners of its 2018 University Research Awards. Shanbhag is receiving the award for pioneering an information-theoretic approach for computing by fusing Claude Shannon's theory for communications with Turing machines to enable the design of energy-efficient information processing systems in advanced semiconductor process technologies.

**I ILLINOIS**

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