SPRING 2018

ELECTRICAL AND COMPUTER ENGINEERING

UNIVERSITY OF WISCONSIN-MADISON

SMART CITIES:

RESEARCH COULD MAKE STREETS SAFER FOR CYCLISTS

CHAIR'S MESSAGE

John Booske

Dear Alumni and Friends,

It is with mixed feelings that I write this final outgoing chair's message. This spring 2018 semester, I completed my ninth and final year as chair of this fantastic department. It has been a wonderful, exciting ride. I have met so many terrific, supportive, generous ECE Badgers, as well as employers around the world who love to hire our graduates. I have been blessed with the best department staff you can find in the entire country and two of the best, most visionary, College of Engineering deans in the country—Deans Paul Peercy and Ian Robertson. At the same time, I'm excited for the great future that will come with our chair-elect: Philip Dunham Reed Professor Susan Hagness, who will be leading the department for the next five years.

Looking back, there are so many things to be thankful for during the past nine years. We successfully recruited 17 new faculty members. Approximately half of them have already received at least one major national honor, such as an NSF CAREER award, a DOD Young Investigator Award, a Moore Foundation Inventor Fellowship, or a *Forbes* 30 under 30 recognition. Five of them have received more than one of these awards, and I know there will be many more deserved recognitions for this best-of-the-best faculty.

Our department remains one of the top academic departments in power engineering, signal processing, computer architecture, and applied electromagnetics (microwave engineering, photonics, and plasmas). What has been especially exciting is the way we have begun establishing a name for ourselves in several critical new areas. Those expertise areas include mobile computing systems, optimization and machine learning (a.k.a. artificial intelligence), sustainable energy with smart power grids, and nanophotonics.

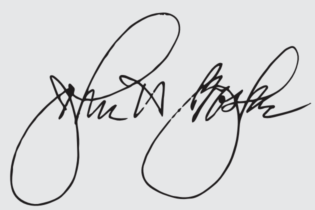
I was lucky to serve as chair during the opening of the college's new Grainger Institute of Engineering. During my time as chair I have been gratified to witness, and privileged to help lead, a commitment to improve our teaching methods with active learning and flipped classrooms. I have seen the impact it has had on our students' mastery of electrical and computer engineering fundamental knowledge and skills. I've felt pride in our great institution's values revealed in its commitment to innovate and invest in nation-leading active learning classrooms including WisCEL, the Plexus Collaboratory, the Qualcomm Design Lab, the Grainger Engineering Design Innovation Laboratory, and transformation of the entire third floor of the Wendt building into modern, interactive learning spaces. Our students' improved learning success in the classroom has been matched by their success in extramurual innovation experiences such as the Qualcomm/Transcend innovation competitions, the BadgerLoop team, and many more.

Finally, I've been gratified by the response of alumni and industry donors to sustain our nation's-best brand with generous gifts. Our department's total endowment has doubled during my time as chair, with a 40-percent growth in professorships, a 40-percent growth in graduate student fellowships, and a gratifying 170-percent increase in undergraduate scholarships support. Our annual discretionary fund has grown by 400 percent, due to a 300-percent growth in the number of annual donors. This is wonderful news, and crucial to ensuring that a degree—your degree—from UW-Madison's ECE department remains forever a top-valued brand. However, this is just an important start. We cannot allow any loss in the value of your degree, the quality of our students' education, or the impact of our research discoveries. Therefore, please consider making a gift to the department's annual fund or endowment by visiting **allwaysforward.org/giveto/ece**, or contacting our ECE Director of Development, Todd Hollister, todd.hollister@supportuw.org.

For the 2018-19 academic year, I'll be on sabbatical, and devoting more time to my research in microwaves and bioelectromagnetics as well as an exciting new education innovation project: applying new research on memory formation to teaching students effective study skills. However, you can always drop me a note just to say hi! at jhbooske@wisc.edu.

If you're in Madison or planning a visit to campus, please let us know that you'll be here. Susan would be happy to schedule a time to chat with you about the wonderful things happening in the department and around campus! You can reach her at susan.hagness@wisc.edu.

ON, WISCONSIN!



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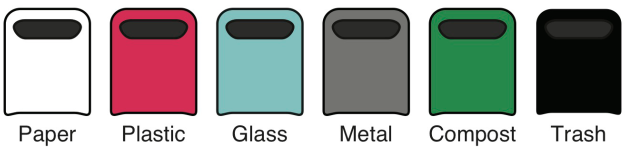
OPERATIONS RESEARCH HELPS SHOW THE WAY TO CLEARER COLOR COMMUNICATION

Communicating using color can be difficult, because the same hue can signal different meanings—and different colors can signal the same meaning. Red means stop to a driver approaching an intersection, and high temperatures on a weather map, and … discard your empty plastic bottle here?

UW-Madison researchers have developed a method for designing color-coding systems that are easy enough to interpret that no labels or other hints are necessary. ECE Assistant Professor Laurent Lessard and Psychology Professor Karen Schloss used recycling bins as a test case in a study published recently in the journal *Cognitive Research: Principles and Implications*.

"If you want to design bins for discarding paper, plastic, glass, metal, compost and trash, which colors should you use?" asks Schloss, who studies how we respond to and interpret color. "You might think that simply using labels would be enough. But, it is more difficult for people to get the right message when colors do not match people's expectations."

The researchers found that the best colors to use for recycling were shades of white for paper, red for plastic, pale blue-green for glass, dark grey for metal, dark green for compost, and black for trash.



They began by asking people which of 37 standardized colors they most strongly associated with each of the recyclables and trash. But overlapping color associations meant simply using the most strongly associated color for each bin would produce a confusing and ineffective design.

"For paper, plastic and glass, the top few colors are pretty similar for all three—white and gray," Lessard says. "And if you look at compost and trash, the top colors for those—brown, yellow and green—are pretty similar, too."

The challenge was to strike the right balance between picking colors that are strongly associated with the corresponding recyclables and picking colors that avoid confusion.

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Some of the results were unexpected results. For example, red was the best color to use for plastic even though the association was relatively weak.

Lessard likens the color-coding problem to a common class of problems in what is known as operations research.

"Similar trade-offs arise when solving scheduling and logistics problems in industry, such as getting packages to their destinations on time or scheduling flights at an airport in a way that minimizes delays," he says.

Although the present study—conducted with co-authors Charlotte Walmsley of Massachusetts General Hospital and UW–Madison psychology student Kathleen Foley—focused on recycling, Schloss describes a broader vision for their approach.

"Our goal is to expand and automate the process of creating easily interpretable color-coding systems," she says. "This understanding will not only lead to more effective uses of color in design but will also advance our understanding of how people infer meanings from colors."

The Early Career Development (CAREER) awards are among the National Science Foundation's most prestigious awards. NSF confers CAREER awards to promising young academic role models who perform innovative research at the frontiers of science and technology, as well as community service through education or community outreach.

STRATEGY FOR STRONGER STATISTICS

Assistant Professor Po-Ling Loh plans to improve statistical methods for modern computer science problems. The project could help self-driving cars avoid accidents or aid algorithms that make automatic diagnoses from medical images.

More and more technologies today rely on machine learning, or artificial brains known as neural networks, that parse out patterns from vast amounts of data in order to make decisions. When coping with messy information, classical statistical techniques sometimes come up short, which is why Loh plans to leverage an approach known as robust statistics.

"Deep learning is not robust," says Loh. "Machine learning algorithms might make the wrong decision if they see some carefully chosen noise."

The concept that an algorithm could be intentionally tricked by doctored data is called adversarial contamination—a growing concern as neural networks become commonplace.

Security experts worry that in the future, for example, that a few strategically altered pixels in an image could make the steering system in an autonomous vehicle go haywire.

Traditional statistical methods aren't equipped to deal with adversarial contamination. The classical theorems were developed to wrangle data sets that are, for the most part, well behaved.

"There's a big difference between average conditions and worst-case scenarios," says Loh.

Loh is developing new tools that could help neural networks outthink adversarial contamination. The methods will also be useful for scenarios where the data is inherently messy even without insidious outside influences, such as interpreting medical images. She's begun working with the UW-Madison Department of Radiology to apply robust statistics to diagnostic algorithms.

"Radiologists are very interested in the practical applications of machine learning," says Loh. "We're very good at the theoretical aspects in the electrical and computer engineering department, so it's a nice collaboration."

The grant provides $400,000 of support over five years.

APPLYING CONTROL THEORY TO ALGORITHM DESIGN

Assistant Professor Laurent Lessard plans to improve the algorithms and computer software that keep the modern world running smoothly.

His approach draws on control engineering principles to help design optimization algorithms.

"There's a fundamental difference in philosophy in designing an engineering system compared to the current state of machine learning," says Lessard. "I'm trying to approach algorithms from an engineering standpoint."

Machine learning algorithms are ingrained in many aspects of everyday life, and the simple bits of code that help computer programs make predictions based on patterns in large data sets usually perform remarkably well. When algorithms do make errors, oftentimes the consequences aren't catastrophic—for example, very little harm is done if a program fails to recommend relevant products on an online shopping website.

However, machine learning extends well beyond recommendation systems. "If you build a bad bridge, you are putting human lives at risk. Is the same true if you build a bad algorithm? It depends on what you're building an algorithm for," says Lessard.

Increasingly, algorithms drive systems that do have the potential to wreak havoc if designed incorrectly.

Already, for example, algorithms protect our financial information by helping banks identify

Story continues at the bottom of the next page.

REIMAGINING COMPUTERS FROM THE GROUND UP

Imagine if desktop computers contained the processing power of entire data centers.

That notion could become reality within the next five years, speculates Jing Li, Dugald C. Jackson Faculty Scholar. Li is working to make computers much more powerful by completely reimagining the basic principles and devices underlying the machines.

"We're rethinking computers from the ground up," says Li. "It's not about engineering. It's not about the components. It's about a new computing model."

Computers have relied on the same fundamental mathematical concepts since Alan Turing presented the notion of a universal machine in 1936. Although processing power has increased by leaps and bounds over recent decades, computers still struggle mightily with some types of complicated data—especially the broad class classified mathematically as graphs, which pop up in social networks, maps, or any other enormous collections of information that contain hidden relationships.

Computers have trouble tracing graphs, like the several degrees of separation that can link two individuals within a social network. Every hop from friend to friend (or node to node) represents an unknown, and the organizations of the electronic brains inside computers cannot efficiently handle such unpredictable random-access data patterns.

Graphs are so tricky that they represent one of the grand challenges for modern computing. To solve the graph problem, Li and her students are fundamentally rethinking how computers work.

"Previously we were doing computation in one dimension. From the very original computer with a single core to today's advanced multicore applications, we have been doing things better in a single dimension," says Li. "This is trying to explore higher dimensions."

Higher-dimensional computing needs more than new math. Li envisions machines running on entirely different architectures. Her project is subdivided into three pillars: hardware, software, and algorithms, with the goal of creating a vertically integrated computing ecosystem.

Importantly, however, Li plans to keep the top-level interfaces unchanged so that programmers won't have problems adapting to the new systems.

"It's not a strange, weird computer that you wouldn't want to use," says Li. "From a programmer perspective, it's a transparent speed-up; you won't even notice, except your program is running so much faster compared to traditional data centers."

Already, Li and her students have generated promising preliminary results. Additionally, through her close collaboration with colleagues at IBM, Li is already working on reducing potential barriers to commercialization and distribution.

"It's very hard, but it's very exciting," says Li. "We're connecting the science together with engineering to make bigger transformative innovations in the world."

fraudulent credit card charges. Self-driving cars rely on algorithms to recognize their surroundings and avoid crashes. The power grid uses machine learning algorithms to predict future electricity supply and demand, especially as home solar energy becomes more common.

Algorithms are indispensable for many critical infrastructure systems, yet the process for creating them is still more of an art than a science.

"Right now, machine learning is like a big bag of tricks," says Lessard. "When there's a new problem, I dig into my bag and try different things until something works."

Because individual coders might have their own distinct "bags of tricks" or apply different criteria to evaluate how effectively an algorithm performs its task, it's possible that the best tools aren't being used for some machine learning jobs.

Lessard wants to change that.

Using his background in control theory, the branch of engineering that deals with dynamical systems and feedback, Lessard intends to improve algorithms by leveraging the same design principles that underlie such products as thermostats and airplane autopilots.

"If we think about algorithms as control systems, we can use that engineering discipline for their analysis and synthesis," says Lessard.

Lessard plans to create new guides for practice to help implement more rigorous standards in algorithm analysis, creation, and tuning. Although bridging the gap between two traditionally disparate fields can be challenging, both control system engineers and computer programmers have, so far, been receptive to Lessard's ideas.

"I think everybody recognizes that we need to do something," said Lessard.

To help educate as many people as possible, Lessard make all of the materials for the courses he teaches freely available on his website and notes that thousands of people already have downloaded his lectures. He is also an active blogger, using his platform to promote engagement with science and mathematics by posting quirky puzzles with detailed solutions.

The grant provides $467,300 of support over five years.

COOL CUSTOM THERMAL EMISSION MATERIALS

Assistant Professor Mikhail Kats received the award for his efforts on tweaking the way substances emit light as they change temperatures. The work could someday offer a no-power means of heat regulation for satellite components and space-going vehicles or help to create camouflage materials that can hide from infrared cameras.

"The ability to thermally regulate with no power will be very important in space, for satellites or even interplanetary travel," says Kats.

All materials have the capacity to shed some heat energy as light when their temperatures increase. The property—which is called thermal emission—accounts for most of the light in the universe, from the incandescent glows of light bulb filaments to twinkling starlight.

One particular parameter called emissivity governs how brightly objects glow, and Kats is working to create new and interesting objects with custom thermal emission properties.

For example, boosting emissivity with increasing temperature could lead to substances that offload excess thermal energy as extra light. Such radiator coatings could help satellites keep their cool without requiring any power sources.

Alternatively, objects engineered to have emissivity that decreases with temperature could be harder to identify using infrared cameras—potentially shielding troops from the artificial eyes of unmanned aerial assault vehicles.

Key to Kats' efforts is an ability to measure thermal emission at relatively low temperatures. A lot of prior research on engineered thermal emitters has focused on the light given off by blisteringly warm objects as hot as 1,000 degrees Celsius, but Kats is trying to tune emissivities for substances at temperatures not far above room temperatures.

Performing such measurements at almost ambient temperatures, however, is technically challenging because of natural interference from objects surrounding the substance of interest. Kats and his students are working to develop new instruments and algorithms to ensure their calculations are accurate.

"We want to make sure we have the measurements down cold," says Kats, noting that the techniques they develop will be tremendously useful to other engineers.

Kats is committed to sharing his advances with the broader research community and will make his low-temperature thermal emission datasets freely available for others to use. Additionally, he plans to communicate broadly by launching a podcast about applied physics and engineering with a special focus on UW-Madison's contributions to the field.

The grant provides $500,000 of support over five years.

ENVISIONING CAMERAS OF THE FUTURE

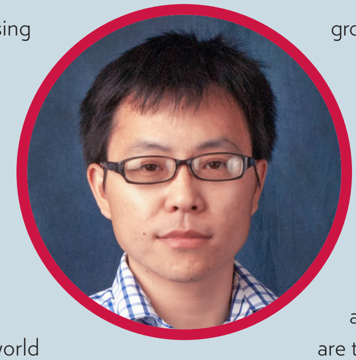
Zongfu Yu hopes to enhance machine vision by creating light detectors that process much more information than human eyes can comprehend.

"It's difficult to see now, but, down the road, we could have new ways to visualize the world," says Yu, Dugald C. Jackson assistant professor.

Such enhanced light detectors could greatly improve automated navigation systems or other applications where algorithms need to make decisions based on visual information. Boosting the vision of machine eyes, however, isn't as simple as modifying existing cameras.

Although cameras have improved substantially over the years, with innovative new lenses that can render images with breathtaking clarity, individual photographic pixels still only contain information about light intensity.

Cameras contain photodetectors that record the intensity of incoming light—and whether that information is captured on film or by a charge-coupled device, the systems were designed to create pleasing images for human eyes.



"Yet cameras today are more often used by machines than people," says Yu.

Human vision merely perceives color and brightness, whereas a computer algorithm could intuit information about the world based on other details of an incoming light beam that are imperceptible to human eyes.

For example, computers could use the angle at which light encounters a detector, or another property called the phase, to infer how far away an object is.

The researchers have already created nanoscale structures composed of pairs of tiny wires capable of detecting the angle of incoming light. In addition to the photodetectors, Yu's group now is building new computational tools to this unique image information.

"The information from these new photodetectors is rather unconventional, so you cannot use old algorithms," says Yu.

To develop their new algorithms, Yu and his students are training neural networks to work with the detectors. Developing new photodetector hardware and software at the same time represents a substantial shift from historical approaches.

"We're rethinking how the pixels of cameras should be built," says Yu.

The scientists are working with the Wisconsin Alumni Research Foundation to patent the new photodetectors. The grant provides $500,000 of support over five years.

AMY WENDT ENVISIONS A BRIGHT RENEWABLE ENERGY FUTURE FOR BURNING PLASMA

Amy Wendt

Imagine an abundant energy source that could power the world without harming the environment.

Fusion energy—the same powerful reactions that keep stars burning—could provide a completely renewable alternative to fossil fuels while being much more reliable than solar or wind. What's more, fusion power plants will not emit greenhouse gasses nor produce long-lived radioactive waste.

"Fusion energy as a clean and viable energy source will have a huge impact on our society," says Professor Amy Wendt.

Wendt is shaping the future of fusion energy research in the United States as one of 19 leaders of a National Academies of Science, Engineering and Medicine committee to develop a strategic plan for U.S. burning plasma research.

To eventually achieve fusion energy, scientists have set their sights on burning plasmas, similar to the hot ionized gasses found in stars. The most promising approach to harnessing burning plasmas is magnetic confinement fusion, where tremendously high temperatures combined with enormous amounts of compression causes atoms to start fusing, so that the energy released from those fusion reactions sustains the plasma without further inputs.

The easiest path to fusion makes use of isotopic forms of hydrogen as the fuel, with helium formed as the fusion product. Magnetic fields produced by currents in the plasma and external magnet coils contain and compress the plasma until fusion begins.

But containing and compressing those hot ionized gasses is anything but easy.

"It's like taking a lump of Jello and trying to compress it with your hands—it wants to squirt out between your fingers," says Wendt.

And that lump of Jello is at a temperature roughly 10 times hotter than the core of the sun.

The under-construction ITER facility in southern France. *Photo: ITER organization*

Even though plasma scientists have identified clear pathways to achieve magnetic confinement fusion, a cost-effective power plant requires better understanding of how burning plasmas behave, as well as further development and testing of new technologies.

Efforts are currently underway to build a burning plasma facility in the south of France, under the auspices of an international collaboration called the ITER organization. When completed in 2025, the ITER machine will weigh more than 23,000 tons, and the donut-shaped burning plasma confinement chamber will be more than six stories tall.

"It's hard to convey the enormity of this construction project. It's fantastically huge and complex and there's a lot of new technology," says Wendt. "When you're standing in the room where the plasma chamber will be located, it's like you're in a Roman coliseum."

The United States contributes machine components and financial support to the endeavor, and UW-Madison faculty, including engineering physics professors Ray Fonck, Paul Wilson and Oliver Schmitz, among others, have devoted their expertise to ITER over the decades.

The National Academies committee issued a preliminary report in December 2017, that identified burning plasma experiments as necessary steps toward fusion power. The preliminary report emphasized the potential benefits to the U.S. of combining expertise through international collaboration if it remains a full partner, and detailed recommendations will be released in a final report in September 2018.

Even after the ITER burning plasma facility switches on in 2025, advances in many disciplines will be necessary to build a full-fledged fusion power plant, which is another reason why Wendt and the committee were invited to make recommendations on a long-term strategic plan.

"Fusion power on the electric grid is something that I will not see in my lifetime, but the potential benefit to humanity is incalculable. I think there's a human drive to create these things that are bigger than ourselves, and in this case it is to meet a societal need," says Wendt.

While visiting the ITER construction site, Wendt took a side trip to Paris. While marveling at the beauty and history of the Notre Dame Cathedral, she was struck by connections between the labor of medieval artisans and that of present-day fusion researchers.

"The cathedrals were conceived by people with a vision powerful enough to sustain the construction over the lifetimes of many generations of contributors," says Wendt.

MATURE RFID TECHNOLOGY COULD DRIVE FLEDGLING SMART CITIES

A bicyclist speeds down the road toward a busy intersection, showing no signs of slowing down.

A toddler playing in the yard ambles out into a traffic-filled street.

Today, both scenarios would likely end in disaster. But in smart, interconnected cities of the future, radio frequency identification (RFID) tags in the cyclist's or child's clothing could trigger traffic signals, averting catastrophe.

Engineers at UW-Madison are working to bring tomorrow's smart cities closer to reality, and their work is earning national recognition. In April 2018, for example, Yuchen Gu, a junior double-majoring in electrical engineering and film, presented a smart city concept for traffic safety at the Institute of Electrical and Electronics Engineers (IEEE) International Conference on RFID in Orlando, Florida.

"The conference was amazing," says Gu. "I talked to a lot of people from industry and academia about the state-of-the-art RFID technology."

Gu traveled to Orlando to compete in the 2018 IEEE Educational Megachallenge, which asked teams to identify a specific city with a problem that could be amenable to smart city solutions, and then devise a means to improve conditions using RFID technology. Gu worked under the mentorship of Professor Dan van der Weide and Marcos Martinez, a postdoctoral scholar in van der Weide's lab.

Drawing on their own experiences bike-commuting in Madison—all three members of the team are endurance athletes who regularly participate in triathlons—Gu, Martinez, and van der Weide devised a system of RFID reflectors for cyclists and pedestrians to improve traffic safety.

"We started with that idea: What if I can trigger the traffic light with RFID?" Gu says.

Beyond making commutes safer and more convenient for cyclists, the concept could help prevent toddlers from wandering into traffic. By incorporating a lightweight, inexpensive RFID tag into a child's clothing, parents could set up sensor systems around their yards to help keep tabs on their kids

Yuchen Gu, an undergraduate mentored by Professor Dan van der Weide, presents his smart cities concept at the 2018 International Conference on RFID. *Photo: IEEE.*

Gu, Martinez and van der Weide created a prototype person-detection system with sensors and RFID tags. At the conference, Gu presented their work to a panel of seven judges, who then interrogated him about why RFID is the best tool for the task in a "Shark-Tank" style question-and-answer session.

RFID is a relatively inexpensive technology, with each tag currently costing no more than 10 cents. The small tags don't require a power source, and they function akin to supermarket barcodes: Each has a unique identity that can be recognized by a reader. Unlike a barcode, however, RFID readers can detect tags from afar without a direct line of sight.

"That's the cool part of RFID tags," says Gu. "You don't have to carry a battery or a microchip. It's a passive device, you don't need to take care of it. I think that's a lot easier for many daily life applications."

Already, RFID technology is being implemented in corporate warehouses for inventory control; for example, at the conference, a representative from Boeing described how a tagging system saved the company several million dollars' worth of lost parts over the course of a year. Other companies, like the clothing retailer H&M, are developing strategies to weave RFID into textiles so that clothing can come with built-in tags.

"It's great for them because they can track their inventory, and it is great for us because that's a lot of data," says Gu.

Smart cities need vast amounts of data to function. The concept envisions urban areas that collect data from citizens, devices and infrastructure to optimally manage resources like transportation systems or utilities. Collecting and processing all that information is no easy task, but RFIDs could help make substantial strides.

"RFID is a mature technology, it's fast, it's robust, it's cheap, and the computing complexity is much less than image processing," says Gu.

Gu hopes to keep working on RFID after his graduation in 2019. He also hopes to leverage his talents as a filmmaker to help encourage more widespread adoption of RFID.

"A scientist encouraging people to use new technology is similar to a director making a film. It's storytelling, says Gu. "As engineers, we are not only the pioneers and trailblazers for technology, we are also the bridge to bring new technology to the public."

STUDENT ENERGY HACKATHON YIELDS SMART REAL-LIFE SOLUTIONS

One team at EnerHack 2018, Madison's first-ever energy hackathon, developed a betting marketplace to encourage people to conserve electricity.

Today's technology can control any number of devices at the push of a button—yet for many people, conserving energy hasn't gotten any easier.

Imagine being able to ask your smart speaker for real-time information about your home electricity usage and to offer suggestions about how to conserve power. Or, picture an app that identifies the best locations for solar panels on your roof, and then provides detailed data about potential power bill savings.

Those were just two of the many sustainability innovations that took the leap from idea to reality during a jam-packed weekend of programming, prototyping, and debugging at EnerHack, the first-ever UW-Madison energy hackathon.

"It's amazing to see what the teams accomplished in so short a time," says Professor Giri Venkataramanan, who organized the event with his PhD students Ashray Manur and David Sehloff.

Some of the teams at EnerHack had never worked on sustainable power before the hackathon—but that didn't stop the eight groups of undergraduate and graduate students from coming together in the College of Engineering makerspace to build creative hardware and software solutions.

"We have a great blend of students from electrical engineering, some from computer science, and even from business," says Manur. "I think that mix helps them be more creative because they look at problems differently."

The weekend-long hackathon kicked off at 5 p.m. on Friday, April 13, 2018, and by the final pitches at 3 p.m. on Sunday, the participants had built everything from point-based smartphone apps for making conservation a fun "Fitbit-esque" challenge to home sensor networks that automatically reduce wasteful power consumption.

EnerHack put a unique spin on traditional hackathons (which are sprint-like intensive collaborative coding events that usually have an open-ended end-goal of creating useable software) by providing all the teams with an energy research and education platform called EnerGyan that Manur and Sehloff developed. Using EnerGyan, functionally an "energy grid in a box," as a scaffold and starting point gave the students unprecedented chances to tinker with real-world hardware.

EnerHack was also the first hackathon in Madison with a strict focus on one problem: sustainable energy.

"When we work together, we really can solve important problems for our community and the world," says Sehloff.

Teams competed for top prize in one of three categories—hardware, innovation, and social impact. The winning groups took home up to $1,000, but every participant left the event with at least a little bit of new knowledge and fresh perspectives. Some groups taught themselves the programming language Python on the fly, while others gained first-time experience working with real home hardware thanks to the components in the EnerGyan kit.

"I love hackathons because you always learn something," says Namrata Kogalur, an ECE graduate student who helped create a betting marketplace app with challenges designed to encourage more sustainable energy use.

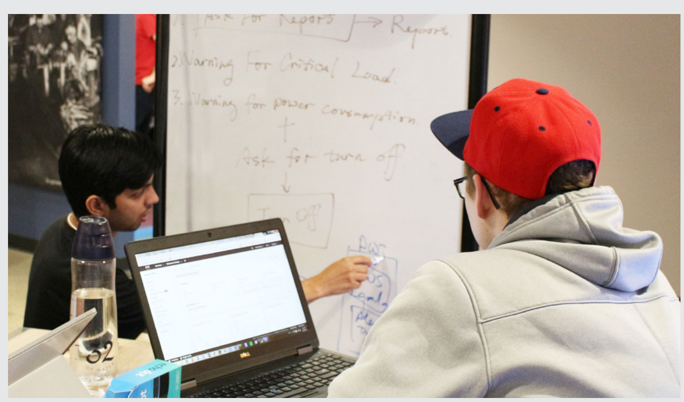
Holding an energy hackathon in Madison has been a longtime dream for Venkataramanan, yet, until recently, logistical hurdles prevented such an event from seeing the light of day.

"Having the makerspace was so important," says Venkataramanan. "We needed a place where the students could work all weekend and be able to rapid-prototype."

Venkataramanan also noted that the tireless efforts of Manur and Selhoff, other student volunteers, and substantial help from Wisconsin Electric Machines and Power Electronics Consortium administrative director Helene Demont were also crucial to the event's success.

That work—whether helping troubleshoot a buggy piece of code in person at 10 p.m. or ordering mountains of tortilla chips and guacamole to fuel late-night coding—did not go unappreciated.

"We've been to several hackathons, and this was by far the most seamless and one of the most fun," says Sukanya Venkataraman, a graduate student in computer science.



Ashray Manur, a graduate student and one of the co-organizers of EnerHack, helps a student with his project during the hackathon.

Photos: Sam Million-Weaver

JOSHUA SAN MIGUEL TEACHES COMPUTERS TO READ BETWEEN THE BITS

Sometimes, perfection can be the enemy of the good—especially for computers.

"A computer only needs to be as perfect as the person using it," says Joshua San Miguel, who joined the faculty in spring 2018.

San Miguel, who completed his PhD at the University of Toronto in 2017, is highly regarded in the fast-growing field of approximate computing, which gives programs a little leeway to sometimes return inaccurate results in return for huge gains in efficiency and energy savings.

Approximate computing is based on the premise that not every calculation needs to be absolutely perfect. Instead, depending on the context in which a device is meant to be used, occasional mistakes might not only be tolerable, but could, in fact, improve the entire system.

For situations where many answers to a question might be equally acceptable—for example, identifying the best restaurant in a city—approximation lightens the computational load while still steering humans toward a satisfying meal.

Another application where users might not mind a little bit of imperfection is streaming video. Most people's senses aren't acute enough to notice an occasional dropped frame. What's more, depending on who's watching and on what type of screen, super-crisp images could be more desirable than immersive sound experiences, or vice versa.

"If the user doesn't need something perfect, they're not going to ask for something perfect, and we shouldn't build them something that works that way," says San Miguel.

Identifying where there's wiggle room for inaccuracies, however, is a major challenge for approximate computing. Right now, computers cannot tell the difference between the bits of information that code for crucial bank account details and those that represent more trivial content like GPS coordinates or social media posts.

"Computers have been built in a digital world that is blind to the user and blind to the underlying circuitry. Computers process a string of bits, but don't know what the bits represent," says San Miguel.

One of San Miguel's main goals is to give computers some context along with the strings of ones and zeros that encode digital information. He calls the concept "reading between the bits."

Teaching computers to read between the bits and occasionally return inaccurate answers represents a substantial departure from traditional programming. However, as computers become integrated into more and more everyday objects, people are beginning to value battery life and portability almost as much as processing power.

> **One of San Miguel's main goals is to give computers some context along with the strings of ones and zeros that encode digital information.**

"A lot of what we were doing before—building super-fancy giant computers that can do incredibly sophisticated calculations—is excessive and wasteful," says San Miguel.

He predicts that programmers will need to relearn some old habits and stop striving for perfection in all situations for approximate computing to become widespread. Additionally, San Miguel envisions that computer users should play a more active role—giving their devices feedback to identify situations where imprecision is acceptable.

Users are used to turning a device on and having its processes run to completion, but San Miguel would prefer a scenario where people only keep programs going for as long as the results are satisfactory. He dubbed the notion "hold-the-power-button" computing.

Such a concept could be folded into digital photography applications by gradually increasing image quality and resolution for as long as users hold down the shutter button.

Both "hold-the-power-button" and "reading between the bits" have garnered accolades from the computer architecture community. San Miguel's conference publications were recognized multiple times as top picks, and he's becoming an increasingly in-demand reviewer for research articles as approximate computing comes to the forefront.

"Even people who are skeptical of the notion of imperfect computers are starting to realize it's an important area," says San Miguel.

The vibrant computer architecture community at UW-Madison was one of the major factors that attracted San Miguel to UW-Madison. Already, the new faculty member is initiating collaborations across campus to apply his expertise to problems ranging from quantum computing to computer security.

In addition to familiarizing himself with the campus and establishing his lab, San Miguel taught the advanced graduate course ECE 757 during spring 2018. In the class, students evaluated, critiqued and improved upon commercially available programs. He reports that the participants were enthusiastic and highly motivated.

CHAT TOOL SIMPLIFIES TRICKY ONLINE PRIVACY POLICIES


Kassem Fawaz

Register for an account on just about any website or download an app to your smartphone and you likely will encounter that pesky, "I certify that I've read and understand the privacy policy," check box.

Many of us scroll quickly through and click the box without a second thought.

"Typically drafted by lawyers, these documents tell you, 'This the information we're collecting, this is how we're processing it, this is who we're sharing it with, this is how we're storing it, and these are your options regarding the collection and processing of it,'" says Assistant Professor Kassem Fawaz. "The problem is that almost nobody reads those documents."

Motivated by a desire to help users comprehend the important privacy and security implications of such documents, Fawaz and collaborators from the University of Michigan and École Polytechnique Fédérale de Lausanne (EPFL) in Switzerland have developed a unique online chatbot that can answer, in simple language, questions about specific privacy policies—without requiring users themselves to weed through all of the fine print.

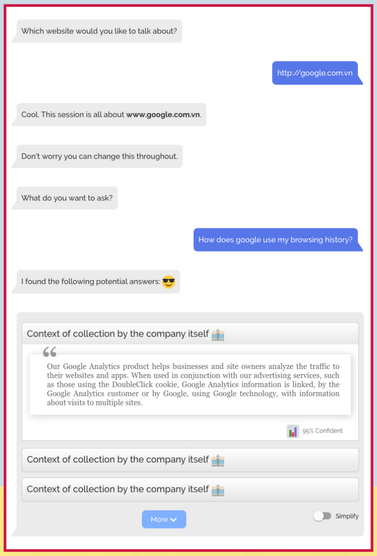
In other words, it's perfect for people who might be having second thoughts about the implications of hurriedly clicking the privacy policy check box. "We believe people really do care about privacy and we want to help them take active steps to protect it," says Fawaz.

Located at pribot.org, the chatbot looks and functions like a text-messaging conversation with a good friend—complete with blue and gray speech bubbles and fun emojis. Ask it, for example, how a specific popular online shopping website uses an individual's browsing history, and the chatbot displays small, relevant portions of the site's privacy policy. If the chatbot can't find the website users are asking about, it volunteers to search for and add it. Currently, the site's database includes more than 14,000 privacy policies.

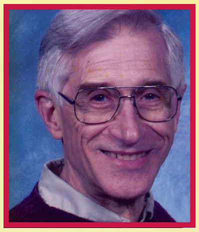
As a companion to the chatbot, the researchers also created a tool called Polisis. It shows users, in an engaging, colorful, easy-to-comprehend graphical format, what types of data companies collect, how and why they share it, how they keep that information secure, what data they store, how data from children (think toys) is treated, an overview of users' options for controlling the use of their information, and more. Polisis is available through pribot.org and also as an add-on or extension to some internet browsers.

Under the hood, Pribot and Polisis draw heavily on an aspect of artificial intelligence called natural language processing. And, by way of full disclosure, the researchers also are collecting data from user interactions with Pribot and Polisis with the goal of improving their performance.

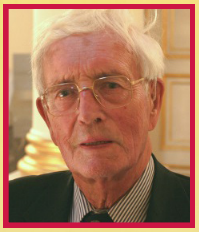
In addition to Fawaz, other collaborators include Florian Schaub and Kang Shin of the University of Michigan, and Rémi Lebret, Hamaz Harkouz and Karl Aberer of EPFL.



IN MEMORIAM


James Nordman

Professor Emeritus **James Nordman** died peacefully on Nov. 21, 2017. Nordman received his PhD in electrical engineering from the University of Wisconsin in 1962. He then joined the ECE faculty, teaching and mentoring scores of students. He was a soft-spoken teacher, talented musician, and creative engineer, known for his sense of humor, patience while teaching, and ready smile. He and his graduate students contributed to many research advances in both low-temperature and high-temperature superconductivity. He continued to pass on his love of learning and sense of curiosity at UW-Madison until his retirement in 1996.


Jean Van Bladel

Jean Van Bladel, who received his MS and PhD degrees in electrical engineering from UW-Madison in 1949 and 1950 before serving on the faculty from 1956 to 1964, has passed away at the age of 86. After his time at UW-Madison, Van Bledel founded the electromagnetics research group at Ghent University in Belgium. During his almost seven-decade-long career, Van Bladel made seminal advancements in the field of fundamental electromagnetic theory and its applications in electrical engineering. Even after retiring in 1987, Van Bledel continued to contribute to the research community. He authored multiple textbooks, he was awarded the Henrich Hertz Medal of the IEEE, and he presided as secretary general of the International Union of Radio Science for 14 years.

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ENTREPRENEURIAL STUDENTS TAKE TOP HONORS

Entrepreneurial students took home first place at the Wisconsin Energy & Sustainability Challenge. Graduate students **Ashray Manur** and **David Sehloff** won the $5,000 Dvorak Energy Prize for "EnerGyan." EnerGyan is a modular and intuitive hardware and software platform to educate students in high school and college programs in the next generation of energy systems. EnerGyan's "electricity grid-in-a-box" is the first of its kind, enabling users to learn about energy from writing simple programs to control and manage their own energy system. Manur and Sehloff are members of Professor Giri Venkataramanan's research group.