# The Trend in ENGINEERING

UNIVERSITY OF WASHINGTON COLLEGE OF ENGINEERING NEWSLETTER FALL 2016

## Enabling smart care through smartphones

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# FROM THE DEAN

At the University of Washington, our students benefit from Seattle's international reputation as a hub for global innovation — from designing software and airplanes to advancing biotech and data-driven retail solutions. The companies that do business here routinely look to the College of Engineering for the fresh ideas and enthusiasm for innovation and problem-solving that our students and faculty offer.

In this issue, you'll read about our groundbreaking industry-academic partnerships that offer students unique educational experiences and position them well for successful engineering careers. For example, several years ago, Microsoft took notice of an experimental research program being run by electrical engineering and computer science and engineering faculty. The company committed funding and its own scientists to create the Molecular Information Systems Lab, where UW and Microsoft team members recently broke the world record for the amount of data that is able to be stored in — and retrieved from — synthetic DNA.

Our feature story focuses on the innovative work coming out of the UbiComp Lab where faculty and students are developing, testing and deploying mobile technologies to screen and track illness. These researchers see smartphones as more than just communications and entertainment devices; they are tools that can — and will — transform how we detect and manage disease across the world.

Our ties to industry and academia extend well beyond Seattle, and last spring I took my first trip to Taiwan where I had the opportunity to meet many UW engineering alumni. Our international alumni communities, partners and friends have made a significant impact in our global economy, and I look forward to expanding our many international collaborations.

The fall is filled with many events including our annual lecture series and "Together," a one-of-a-kind community celebration at which we'll kick-off the most ambitious campaign in UW history. We hope you will join us at this event on October 21, to explore how the UW is transforming Washington and the world, and how — together — we can make a difference.

Mike Bragg
*Frank & Julie Jungers*
*Dean of Engineering*

## Welcoming a new class of innovators

Several exceptional new faculty members will join the College this year. We highlight two below. Meet them all at engr.uw.edu/newfac2016.

### Michael Gomez

**Assistant Professor, Civil & Environmental Engineering**

Michael Gomez joins us from the University of California, Davis, where he completed his Ph.D. In his research, Michael investigates the use of chemical and biological processes in soils to develop new sustainable geotechnical technologies. As current soil improvement processes rely upon large amounts of energy and materials, Michael's work leverages existing natural processes to strengthen soils, which addresses global challenges related to population growth, climate change, and material and energy demands. His current research focuses on strengthening weak granular soils using native soil microorganisms.

### Lillian Ratliff

**Assistant Professor, Electrical Engineering**

Lillian Ratliff researches in the areas of game theory, optimization and statistical learning. She develops theoretical models of human decision-making in societal-scale cyber-physical systems, such as smart grids and urban spaces. Her algorithms consider fluctuating data such as waiting time, price and congestion to improve transportation efficiency and the user experience. She plans to continue this research to support intelligent design and sustainable growth in cities.

Previously Lillian was a UW electrical engineering affiliate professor and a post-doctoral researcher in electrical engineering and computer sciences at the University of California, Berkeley, where she also earned her doctorate.

## UW, Microsoft researchers store digital images in DNA, retrieve them perfectly, break record for data storage

A new technique developed by UW and Microsoft researchers could shrink the space needed to store digital data that today would fill a Walmart supercenter down to the size of a sugar cube.

The team of computer scientists and electrical engineers has detailed one of the first complete systems to encode, store and retrieve digital data using DNA molecules, which can store information millions of times more compactly than current archival technologies.

In one experiment, researchers successfully encoded digital data from four image files into the nucleotide sequences of synthetic DNA snippets. More significantly, they were also able to reverse that process — retrieving the correct sequences from a larger pool of DNA and reconstructing the images without losing a single byte of information.

In July, the team broke what it believes is the world record for the amount of digital data successfully stored and retrieved in DNA molecules. Researchers encoded and decoded a video of the band OK Go, the Universal Declaration of Human Rights in more than 100 languages, the top 100 books of Project Gutenberg and the Crop Trust's seed database — among other things — all on strands of DNA.

"Life has produced this fantastic molecule called DNA that efficiently stores all kinds of information about your genes and how a living system works — it's very, very compact and very durable," said Luis Ceze, Torode Family Career Development Professor of Computer Science & Engineering.

"We're essentially repurposing it to store digital data — pictures, videos, documents — in a manageable way for hundreds or thousands of years."

In addition to Ceze, other principal researchers include Georg Seelig, associate professor of electrical engineering and of computer science and engineering, and Microsoft researchers and computer science and engineering affiliate faculty Doug Carmean and Karin Strauss. The team also includes students and researchers from electrical engineering, bioengineering and computer science and engineering.

## UW-led research team wins $7.5M MURI grant to defend against advanced cyberattacks

A UW-led research team has won a $7.5 million, five-year Multidisciplinary University Research Initiative (MURI) grant from the Department of Defense to better model and mount defenses against stealthy, continuous computer hacking attacks known as "advanced persistent threats."

"Unlike conventional viruses, these threats exploit vulnerabilities and persist over a very long time and they're very difficult to detect," said lead researcher Radha Poovendran, chair of the Department of Electrical Engineering and director of the Network Security Lab, which he founded in 2001. "Right now, there is no good understanding of the interactions in these complex cyberattacks or how to mitigate them."

The winning proposal was one of 23 MURI awards totaling $162 million, which support a cross-disciplinary approach to accelerate research progress. The grants support basic research with significant potential to improve the nation's security or expand military capabilities.

The UW-led team will develop a new and comprehensive scientific framework to understand advanced persistent threats and mathematically represent adversarial cyber interactions. Using statistical modeling, adaptive game theory, machine learning and control and systems theory, they aim to model the strategic interactions between these stealthy malware attacks and cyber defense mechanisms to combat them.

# Enabling smart care through smartphones:

**For researchers in the UW's UbiComp Lab, a smartphone offers much more than access to email, Facebook and Pokémon Go: It has the power to detect disease and, ultimately, save lives.**

For faculty and engineering students in the UW's UbiComp Lab, smartphones are more than communications and entertainment devices; they are tools that can transform how we detect and manage disease.

The growing availability of smartphones with increasingly sophisticated sensors has opened new avenues for exploration and innovation — avenues that will lead to healthier communities in even the poorest regions of the globe. With partners across campus and worldwide, UbiComp researchers are developing and deploying mobile technologies that will transform health care as we know it.

Shwetak Patel, Washington Research Foundation Endowed Professor of Computer Science & Engineering and Electrical Engineering, leads the UbiComp Lab. The College of Engineering recently talked with him about this emerging body of work.

**COE: Your lab's early work focused on monitoring systems in the home. Why has your team's research expanded into mobile health?**

SP: In our previous sustainability research, we used the infrastructure of the home. Instead of creating sensors, we asked how we could use existing elements — electrical wiring, water systems and so on — to track power and water usage.

We're now applying the same concept to smartphones by leveraging the sensory capabilities of phones to provide on-the-go physiological sensing. Smartphones provide opportunities for remote monitoring and self-management of disease — both doctors and patients can track patients' health through data collection and assessment. Additionally, we can enable care in places where it hasn't been widely accessible before, particularly in low-resource communities.

**COE: Why mobile phones?**

SP: Mobile phones are ubiquitous — people take their phones everywhere, and they like to use them. Plus, these devices have ridiculous capabilities in terms of computation, networking and sensing. We want to introduce easy-to-use health management applications so that people can monitor their health via their phones. No extra devices or attachments needed. No special trips to drug stores or doctors' offices.

**COE: How available are smartphones across the globe?**

SP: Smartphone communication is quite prevalent worldwide, and it continues to grow. People don't always have the latest and best devices, and we are mindful of this when developing our apps. Phones don't

have to be on the cutting-edge to run our apps; they just need to be "smart enough."

And even if individuals in remote or low-resource areas don't have mobile phones, that's okay: A health care provider's phone can host multiple apps to screen many people for a number of diseases.

**COE: What's the biggest challenge facing your lab's research?**

SP: Our work is inherently integrative, and the U.S. health industry is not. It's a model built around one-on-one care with many specialized fields. The tools we're developing cut through many silos, and they allow for remote care and cloud-based data sharing. As remote mobile health emerges as its own field, the challenge — for all of us — will be figuring out how to make it work within the health care industry at large.

# Mobile health innovation for the greater good

*By Chelsea Yates*

**COE: You're currently pursuing FDA clearance for two mobile health apps, BiliCam and SpiroSmart. What's it been like to be involved in this process as it evolves to keep pace with technological advancements?**

SP: BiliCam and SpiroSmart are the first examples of projects for which the UW funded the FDA approval process. Universities usually aren't involved in pursuing FDA clearance, but thanks to CoMotion, the Wallace H. Coulter Foundation and the Life Sciences Discovery Fund, I've been able to lead it for our team. We haven't completed the process yet, and although it was challenging at first, it's been incredibly beneficial to go through it as an academic. It has certainly made our research better. With insight into the process, we can better inform our study designs, and we can help pave the way for future research.

Learn more at ubicomplab.cs.washington.edu.

*Images courtesy of the UbiComp Lab, University of Washington.*

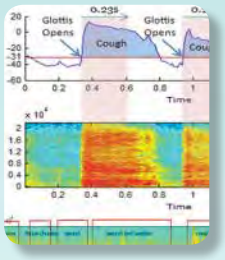
## Five smartphone apps with the power to transform global health

UbiComp researchers are developing and testing several low-cost, easy-to-use, non-invasive mobile health apps, including:

**BiliCam:** An alternative for detecting newborn jaundice — which can lead to brain damage and death — using a smartphone's camera. Instead of looking for "yellowness" in the skin, the camera and flash together measure the amount of bilirubin in the blood by examining wavelengths of light absorbed by the skin. In the U.S., this app will enable parents and general practitioners to screen before involving a specialist. In many parts of the world, midwives and traveling nurses more commonly deliver babies. Currently they have no screening tool for jaundice; this app will provide them with one.

**HemaApp:** A means of measuring hemoglobin in the blood using a smartphone's camera. Many health conditions — such as anemia, malnutrition and pulmonary illnesses — impact hemoglobin levels. This app is not only a disease screening tool but it can also help medical professionals assess the nutritional well-being of individuals and communities. Current monitoring requires blood samples or expensive equipment. By eliminating the need for blood draws, HemaApp alleviates concerns about sample contamination or infection.

**SpiroSmart/SpiroCall:** Hundreds of millions of people worldwide suffer from chronic respiratory diseases, and millions die each year. SpiroSmart measures lung function by having the patient blow into a phone's microphone, replacing an expensive dedicated spirometer for diagnosing and managing asthma, cystic fibrosis and other pulmonary diseases. SpiroCall is a related project that is particularly useful in low-resource settings where smartphone access is limited. It turns any phone into a spirometer through a toll-free calling service.




**CoughSense:** Coughing is the number one symptom individuals report when experiencing an illness. Currently, to assess coughing, patients are asked to self-monitor or wear specialized equipment. CoughSense uses the phone's microphone to monitor cough frequency for a single person or, when networked, to track trends across an entire population. In this way, it will be an important tool in monitoring the spread of diseases such as influenza or tuberculosis through pattern recognition in high-density areas.

**BPSense:** Measures blood pressure by Pulse Transit Time (PTT), the time taken by a pressure pulse to travel through the arterial tree. One method uses a phone's dual camera to measure a person's pulse at his/her fingertip and ear simultaneously. A second method uses a phone's microphone and camera to listen to the patient's heart beat and measure pulse at his/her fingertip. In addition to tracking, BPSense can also remind individuals to check their blood pressure at various times throughout the day.

## UW-led team wins $10M EPA grant for air pollution research

To help address the nation's pressing need for better air quality, the U.S. Environmental Protection Agency has awarded a UW-led research team a five-year, $10 million grant.

The grant will be used to create the Center for Air, Climate and Energy Solutions. Civil and environmental engineering professor Julian Marshall will co-lead the center in collaboration with researchers from Carnegie Mellon University, the University of Minnesota and several other universities.

The center's researchers will explore which pollutants are most damaging to people's health, as well as current levels and sources of pollution. The team will also provide guidance to the EPA on how air pollution emissions and concentrations are anticipated to change in the future and will evaluate strategies for reducing air pollution.

"A critical step for improving air pollution is understanding the contributions from specific sources, such as cars, ships, agriculture and power plants," Marshall said. "Our research will provide critical tools and information for understanding people's exposure to air pollution and what steps would reduce those exposures."

The researchers will use a new approach combining air pollution research with the related areas of climate change and energy usage. Since air pollution and climate change are largely caused by the combustion of fossil fuels, this integrated approach will address commonalities and encourage solutions that will positively impact all three areas.

## Nominate an exceptional engineer for a 2017 Diamond Award

The Diamond Awards honor outstanding alumni and friends who have made significant contributions to the field of engineering. If you know an engineer who deserves to be recognized among the distinguished ranks of Diamond Award honorees, please nominate him or her by October 17 at engr.uw.edu/da.


## Motorsports racing team takes second place at Formula SAE competition

The UW Formula Motorsports Team won second place out of more than 100 teams at this summer's Formula SAE competition stateside challenge in Lincoln, Nebraska. Competition was close: First and second place were separated by a mere .5 points in their final scores, out of 1,000 points total.

Formula SAE competitions challenge teams of undergraduate and graduate students to design and compete small, formula-style competition vehicles. Teams spend eight to twelve months designing, building and preparing their vehicles before the challenge.

The UW's team includes students from across the College of Engineering and is housed in the Department of Mechanical Engineering.

## Improving malaria detection through computer vision and machine learning

Electrical engineering doctoral students Charles Delahunt and Mayoore Jaiswal are applying their skills in computer vision and machine learning to the fight against malaria, a disease that affects over 200 million people each year and is one of the most severe public health problems globally. Working with a team at Intellectual Ventures (IV) Lab and with support from the Global Good Fund, they have developed Autoscope, a low-cost, portable and automated device for diagnosing malaria.

Though preventable and treatable, malaria can be difficult to detect. The current diagnosis method is microscopy, which requires highly-trained medical professionals to examine blood samples one at a time for parasites. The parasites tend to be very small and challenging to distinguish from distractor objects that also appear in blood slides. Additionally, in communities worldwide where malaria is most prominent, specialists are often in short supply.

Autoscope is alleviating these burdens by allowing for automated diagnosis. The device is small, measuring 15 inches tall by 7 inches wide, and easily transportable. Not only does it automate blood sample scanning and analysis, but it also creates a diagnosis report that includes both the quantity and type of parasites — information that can determine strains of the disease that may be drug-resistant. Autoscope processes samples faster and in batches, and its diagnosis results are more consistent than those yielded by current practice.

Both Jaiswal's and Delahunt's contributions to the project have involved researching detection algorithms and applying machine learning and computer vision techniques — processing and extracting information from images, pattern recognition and data analytics. The malaria detection algorithms currently achieve performance close to that of an expert malaria microscopist.

"Like all IV Lab projects, the Autoscope project combines the best of academia (creative research) and industry (specific, meaningful applications)," says Delahunt. "Plus, the detection algorithms involve lots of mathematical methods and machine learning, which are super fun."

For Jaiswal, who grew up in Sri Lanka where mosquito-transmitted diseases were and, in some cases, continue to be a serious threat, the project's social impact is key.

"In my studies, I've always been interested in applications that help others," she explains. "With Autoscope I get to work with a team to develop something that's going to make a real difference in people's lives — in many cases, it will save lives — and that is my motivation for doing this work."

Autoscope is currently being tested in malaria-endemic regions around the world. In the future, the team hopes to expand the device's diagnosis techniques to other diseases diagnosable by microscopy.

"As a parent, I feel for parents who must watch their children die of disease," Delahunt says. "If we succeed in the work we're pursuing, the winners will be kids and families in low-resource communities across the globe, and that's a very compelling mission."


## Human powered submarine team places third in European International Submarine Races

The UW Human Powered Submarine team traveled to Gosport, England, to compete in this year's European International Submarine Races. Twenty international teams registered, and twelve qualified to race in the finals. In addition to its third-place overall win, the UW placed first in the category of "top speed by a female pilot."

The European International Submarine Races challenge teams of university students to design, build and race human-powered submarines against the clock on an out-and-back course. The concept combines engineering design challenge with technical skill development. The overall prize is awarded based on a range of evaluations, including performance tests, production quality, design creativity and safety.

Housed in the Department of Mechanical Engineering, the team is made up of students from across the College of Engineering, as well as other disciplines.

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## 2016 Engineering Lecture Series — CITY SMARTS: ENGINEERING RESILIENT COMMUNITIES

### Engineering Solutions for a Seismically Resilient Seattle

**Jeffrey Berman,** *Thomas & Marilyn Nielsen Associate Professor, Civil & Environmental Engineering*
Wednesday, October 12
Compared to California, the Pacific Northwest remains largely unprepared for a major earthquake. Seattle's seismic hazard is unique, with earthquakes that occur less frequently and faults that are not as well understood. It will take innovation, research and planning to prepare for "the big one." At the UW, engineers are developing solutions to improve the resilience of buildings, bridges and other structures. Learn about our regional earthquake hazards, examine structural engineering technologies that enable faster and stronger post-event repair, and understand the risks and requirements involved.

### Delivering Sustainability: Transporting Goods in Urban Spaces

**Anne Goodchild,** *Allan & Inger Osberg Associate Professor, Civil & Environmental Engineering*
Wednesday, November 2
With greenhouse gas emissions threatening the health of the planet at an alarming rate, actions both big and small play an important role in addressing climate change. As the popularity of online shopping and grocery delivery rises, consumers have an opportunity to make more sustainable choices when it comes to transporting goods in urban spaces. From drones to delivery vans, discover which transportation methods are the most sustainable today and in the future. What you'll learn might surprise you.

### Understanding Our Chemical Fingerprints: Safer Water for Our Cities

**Edward Kolodziej,** *Associate Professor, Civil & Environmental Engineering*
Wednesday, November 16
Although more than 80,000 chemicals are in circulation and thousands more are introduced each year, only a handful are evaluated for safety by the Environmental Protection Agency. Through our daily actions, humans leave a distinctive chemical fingerprint on water, which can linger for years, impacting salmon populations and other fish, animals and plants, as well as people's health and safety. Learn about the paths chemicals take from homes, factories and offices into the waters around us, systems aimed at identifying and removing toxic chemicals, and links between our chemicals and the ecosystem.

**All lectures are at 7:30 p.m., Kane Hall, UW Campus - FREE! Registration required, online at UWalum.com/engineering.**
**Presented by the College of Engineering in partnership with UW Alumni Association.**