ELECTRICAL ENGINEERING KALEIDOSCOPE

ANNUAL RESEARCH REVIEW

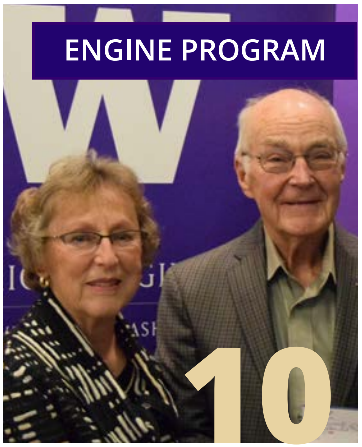
EEK 2017 **HIGHLIGHTS:**

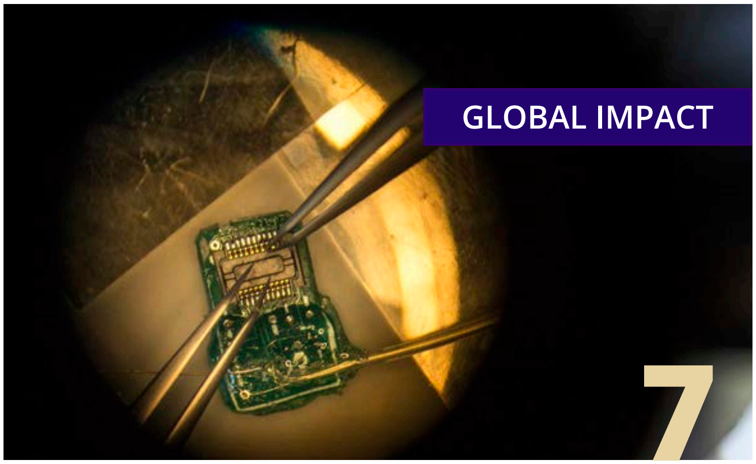
LEADERSHIP IN REHABILITATION NEURAL ENGINEERING

DEVICES FOR BIOELECTRONIC MEDICINE

ENGINEERING ENTREPRENEURSHIP PROGRAMS

TABLE OF CONTENTS





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MESSAGE FROM THE CHAIR

DEAR SUPPORTERS AND ALUMS OF UW EE

The past year has given UW EE a lot to be proud of. We have made several significant research advancements, recruited exceptional new talent, received a new endowment for entrepreneurship and witnessed numerous faculty, student and alums receive honors through national and international recognition.

UW EE is very focused on strengthening our robust research in rehabilitation technologies. In the coming year, UW EE will add two star faculty in neural engineering. Assistant Professors Amy Orsborn and Azadeh Yazdan-Shahmorad bring expertise in brain-machine interfaces (BMIs) and stimulation-based neurorehabilitation. Professor Orsborn's research uses BMIs to restore motor functions in people with disabilities. This past fall, she was named a L'Oréal Women in Science Fellow and visited the White House. Professor Yazdan-Shahmorad, who is now at the University of California San Francisco, researches stimulation-based therapies that focus on restoring function and mobility in people with neurological disorders. Amy and Azadeh will hold professorships from the Claire Booth Luce Foundation and the Washington Research Foundation, respectively. These star faculty will further advance UW EE's goal of building device-driven rehabilitation technologies.

Our faculty and students continue to lead in entrepreneurial efforts at UW. At the University of Washington, UW EE has launched the most engineering startups since 2010. Vibrant research that is taking place in the EE department is a key contributor to this success. Our faculty are mentoring students at the forefront of research in their chosen fields. This year, Professor Georg Seelig and his students achieved the world record in synthetic DNA (with no biological components) data storage. Professor Eve Riskin is leading an academic engineering "redshirt" program. This program offers underserved students an extra year to prep for college engineering courses, providing these students an opportunity to excel. In this effort, Professor Riskin leads a consortium of six universities. Professor Shwetak Patel has transformed mobile phones to help with mobile health, creating a series of apps that help monitor a user's health, including lung function, osteoporosis and hemoglobin levels.

I am very pleased to announce that our recently started Engineering Entrepreneurial Capstone program received a generous endowment by EE alum Milton Zeutschel (BSEE '60) and his wife Delia Zeutschel. This program enables students to work on teams on industry-sponsored projects to develop skills in innovation, systems engineering and project management. Milton and Delia Zeutschel's gift will enable more students to enter the advanced course and build the program, offering more opportunities to all students. We anticipate this program will be scaled beyond the EE department.

Our faculty have achieved national and international recognition and prominence from their outstanding achievements. Professor Sreeram Kannan received the NSF Early CAREER Award for his work in developing new methods to solve inference problems arising in RNA sequence analytics. Professor Linda Bushnell was just named an IEEE Fellow for her significant contributions to networked control systems. Professor Bushnell is the 26th faculty member from UW EE to receive this honor. Professor Shwetak Patel was named an ACM Fellow for his contributions to sustainability sensing, low-power wireless sensing and mobile health. In addition, Shwetak Patel and Georg Seelig received Microsoft's prestigious 2016 Outstanding Collaborator Award.

I am also pleased to report that Professor Karl Böhringer was selected as the Director of the Nano Engineering and Sciences Institute (NanoES). NanoES leads and acts as a national magnet for design, processing and integration of scalable nano-engineered devices and systems. Karl is expected to shape the NanoES as a top-tier research institute in the country.

UW EE will continue to pioneer research in electrical and computer engineering and provide students and collaborators with the tools to achieve entrepreneurial excellence. **I invite you to join UW EE's entrepreneurial mission — come join us and build the much needed innovation ecosystem that is unique to the UW and the Pacific Northwest!**

Best to all,

Radha Poovendran
Professor and Chair

A NEURO-ENGINEERING POWERHOUSE

VISIONARY ALUMS

CHERNG JIA AND ELIZABETH HWANG — CREATE TRANSFORMATIVE ENDOWMENT TO SUPPORT REHABILITATION RESEARCH

In 2015, Cherng Jia and Elizabeth Yun Hwang endowed the creation of new professorships to advance rehabilitation technologies for spinal cord injury and stroke. Cherng Jia "CJ" Hwang received his Ph.D. from EE in 1966 and Elizabeth Hwang received her MLIS in 1965. Their daughter, Karen, is the inspiration and commitment behind the Hwang family's vision to establish a program in device-driven new rehabilitation technologies for spinal cord injury and stroke.

NEW FACULTY

AMY ORSBORN

Clare Boothe Luce
Assistant Professor

BOUNDLESS BRAINS

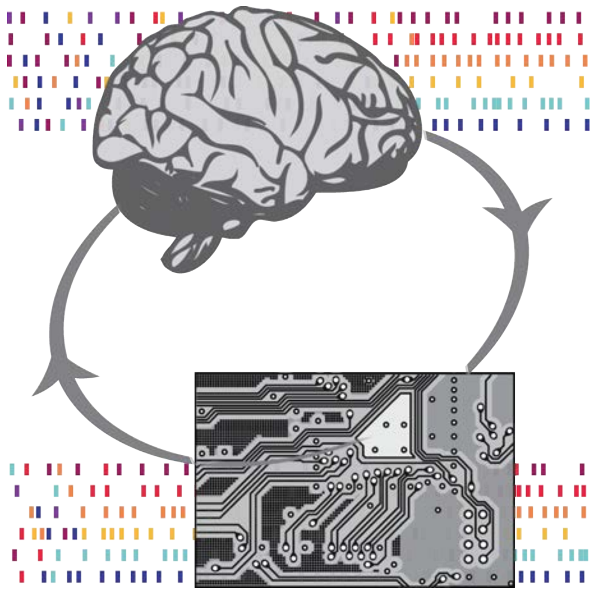
Using Brain-Machine Interfaces to Restore Motor Functions

Amy Orsborn is a neural engineer focused on harnessing the brain's ability to learn to treat patients suffering from neural damage and disease. Orsborn's work primarily focuses on how brain-machine interfaces (BMIs) can be used to restore motor function to persons with motor disabilities. Motor BMIs map recorded neural activity into a control signal for an actuator via an algorithm (the "decoder"). Feedback of the actuator movement creates a closed-loop control system. BMIs give the brain a new motor task to learn—controlling a prosthetic device rather than the body. Because our brains constantly learn new skills, we can learn to control the prosthetic much like we learn to play a new sport. Orsborn is interested in understanding both how the brain learns this task and how to engineer neural interfaces to maximally harness learning to repair and restore function.

BMI performance is shaped by both the decoder and the brain. Both components can adapt, via neural plasticity or adaptive decoding. Such adaptation may be particularly useful for creating neuroprostheses with robust, natural-feeling control. Orsborn studies this "two-learner" control system. She develops adaptive decoding methods, studies neural plasticity in BMIs and probes brain-decoder interactions. More generally, Orsborn wants to understand how the design of BMI systems—from the actuator being controlled to the neural activity used for control—influences control and learning. These studies will not only lead to better neuroprostheses, but may also reveal basic principles of how our brains learn to control our movements.

Orsborn also develops technology platforms to measure and probe neural circuits. These tools allow her to investigate neural changes during learning and to understand how the structure of neural circuits influences learning in BMIs. She is developing systems to simultaneously, chronically record and stimulate neural activity across multiple spatial scales (ECoG, LFP and spikes). These tools have applications for basic neuroscience and will help identify the best scale for interfacing with the nervous system. She's actively exploring how the choice of neural signals influences BMI control and learning.

BMIs create novel functional circuits that engage learning, an essential function of the central nervous system. Orsborn's research at UW will integrate neuroscience and engineering to gain deeper insights into how we learn, and how neural interfaces can shape neural function. Beyond her current focus on the motor system, her work has potential applications for treating neurological disorders such as stroke and psychiatric disorders.



BMIs record neural activity into a control signal for an actuator via the "decoder," or algorithm. Feedback of the actuator movement creates a closed-loop system. BMI performance is shaped by both the decoder and the brain.

ABOUT

Amy Orsborn will join UW in January 2018 as the Clare Boothe Luce Assistant Professor in Electrical Engineering and in Bioengineering, researching motor learning to improve brain-machine interfaces (BMI) to restore motor function to people with disabilities.

EDUCATION

Postdoc	Ph.D.	B.S.
NYU	UC Berkeley	Case Western
2014-2018	2013	2007

NEW FACULTY

AZADEH YAZDAN-SHAHMORAD

Washington Research Foundation Innovation Assistant Professor

BUILDING NEURAL THERAPIES

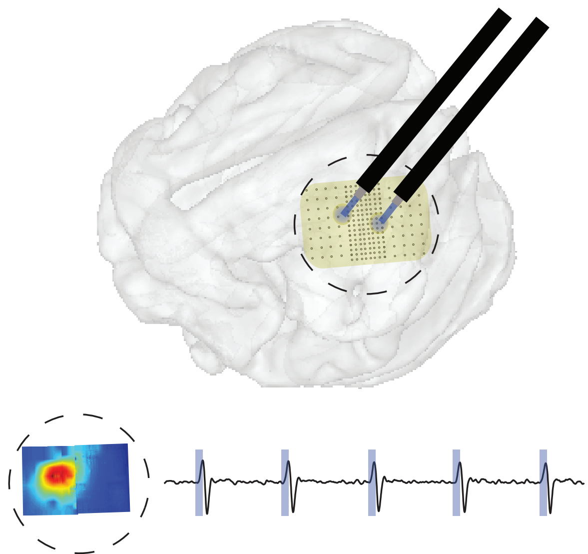
Novel Tools and Techniques for Implementing Stimulation-Based Neurorehabilitation

Azadeh Yazdan-Shahmorad investigates novel tools and techniques for implementing optogenetics in non-human primates (NHPs) and rats. Using these tools she studies targeted plasticity in sensorimotor cortex via patterned optogenetic stimulation. Her long-term goal is to utilize novel neural technologies to develop stimulation-based therapies for neurological disorders such as stroke.

Optogenetics is a powerful tool for relating brain function to behavior, as it enables cell-type specific manipulation of neurons with millisecond temporal precision and artifact-free neural recordings. Although optogenetics have been used successfully in NHPs, reliable techniques had not been developed for large-scale, bidirectional study of neural circuits in these animals. Yazdan-Shahmorad has developed a stable interface for stimulation and recording of large-scale cortical circuits.

To obtain optogenetic expression across a broad region, spanning primary somatosensory and motor cortices, Yazdan-Shahmorad has used convection-enhanced delivery of the viral vector, with online guidance from magnetic resonance imaging. To record neural activity across this region, she used a custom micro-electrocorticographic (μECoG) array designed to minimally attenuate optical stimuli. Lastly, she demonstrated the use of this interface to induce targeted sensorimotor cortical plasticity using spatial and temporal patterns of optical stimulation. This interface offers a powerful tool for studying circuit dynamics and connectivity across cortical areas, for long-term studies of neuromodulation and for linking these to behavior.

Yazdan-Shahmorad's research seeks to identify and employ stable interfaces for the development of stimulation-based therapies. These novel therapies will be utilized to treat conditions that affect the nervous systems, like stroke.



Schematic of the novel optogenetic interface for NHPs that enables stable, large-scale stimulation and recording across cortical areas (top). Examples of spatial (bottom left) and temporal (bottom right). The blue rectangles represent the duration of light stimulation, light-evoked neural responses. This interface offers a powerful tool for studying stimulation-based neurorehabilitation.

ABOUT

Azadeh Yazdan-Shahmorad will join UW in Fall 2017 as the Washington Research Foundation Innovation Assistant Professor in Electrical Engineering and in Bioengineering, researching stimulation-based therapies to help restore function and mobility in people with neurological disorders.

EDUCATION

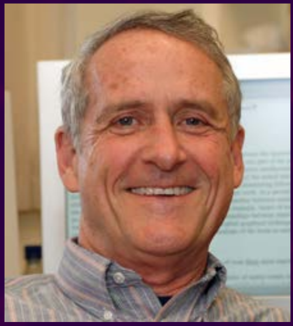
Postdoc	Ph.D.	M.S.	B.S.
UCSF	U. of Michigan	U. of Tehran	Tehran Poly
2012-2017	2011	2003	2001

LEADERS IN NEURAL REHABILITATION ENGINEERING

With a focus on device-driven rehabilitation technologies, UW EE is uniquely positioned at the forefront of neural engineering. With diverse expertise among faculty, UW EE and the NSF Center for Sensorimotor Neural Engineering (CSNE) are driving the development of implantable devices that can restore movement, and improve the overall quality of life, for people with spinal cord injury or stroke. Researchers are also working to improve current devices on the market, such as deep brain stimulators that are used to treat Parkinson's disease.

RAJESH RAO
DIRECTOR, CSNE
NEUROSCIENCE, BCI

CHET MORITZ
DEPUTY DIRECTOR, CSNE
NEUROPROSTHESIS, REHAB



EBERHARD FETZ
NEUROSCIENCE

JEFF OJEMANN
NEUROSCIENCE, BCI

HOWARD CHIZECK
DEEP BRAIN STIMULATION, HAPTICS

MATT REYNOLDS
NOVEL LOW-POWER WIRELESS DEVICES

JOSH SMITH
NOVEL LOW-POWER WIRELESS DEVICES

BLAKE HANNAFORD
TELESURGERY, HAPTICS

CHRIS RUDELL
ANALOG DEVICE ENGINEERING

VISVESH SATHE
DIGITAL DEVICE ENGINEERING

AMY ORSBORN
ADAPTIVE BMI

AZADEH YAZDAN-SHAHMORAD
REHABILITATION

NEW FACULTY

MICHAEL TAYLOR

Associate Professor

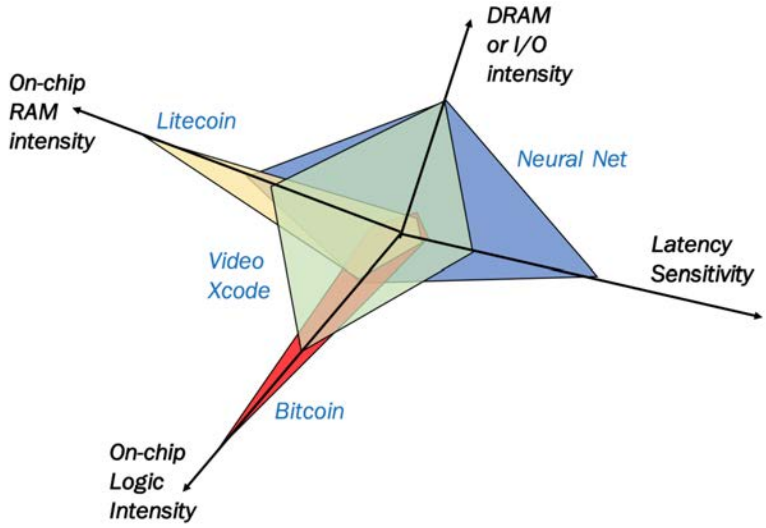
CREATING CUSTOM CHIPS

New Approaches to Hardware Design for Energy-Efficient Chips

As a true applications-to-circuits researcher capable of prototyping both hardware and software, Michael Taylor brings deep expertise in the design of specialized custom chips — for example, for crypto-currency mining — and the development of novel approaches to hardware design and prototyping. His work has been particularly influential within the computer architecture community and has also generated a significant amount of press coverage and publications.

Performance and efficiency are consistent themes in Taylor's research. He is a leading expert on extreme hardware specialization to deal with dark silicon — the portion of a chip that is switched off at any given time due to power constraints. One of his ongoing projects is GreenDroid, an energy-efficient chip for Android phones that is 10 times more efficient than industrial mobile application processors in use today. Taylor is known for actively pushing new ideas, methods and open source designs that reduce the effort required to build silicon and hardware prototypes. For example, he created the open-source framework Basejump to support more efficient ASIC prototyping, from base designs, to packaging, to boards.

Taylor produced the first academic paper on bitcoin mining chips, which attracted nationwide attention and established Taylor as an authority on mining hardware innovation. His team recently published the first paper on ASIC Clouds, which are purpose-built datacenters comprised of large arrays of ASIC accelerators. Their purpose is to optimize the total cost of ownership of large, high-volume chronic computations that are emerging in datacenters today. Taylor also has turned his attention to developing architectures and benchmarks for machine learning applications, with a focus on computer vision. He contributed to the creation of the first comprehensive computer vision benchmark suite, SD-VBS, used by over 1,000 institutions and companies. He later developed CortexSuite, an extension of SD-VBS to include machine learning and artificial intelligence — the largest, most comprehensive such benchmark suite to have been created.



Taylor's prototypical ASIC Cloud Architecture explores applications with varying accelerator properties.

ABOUT

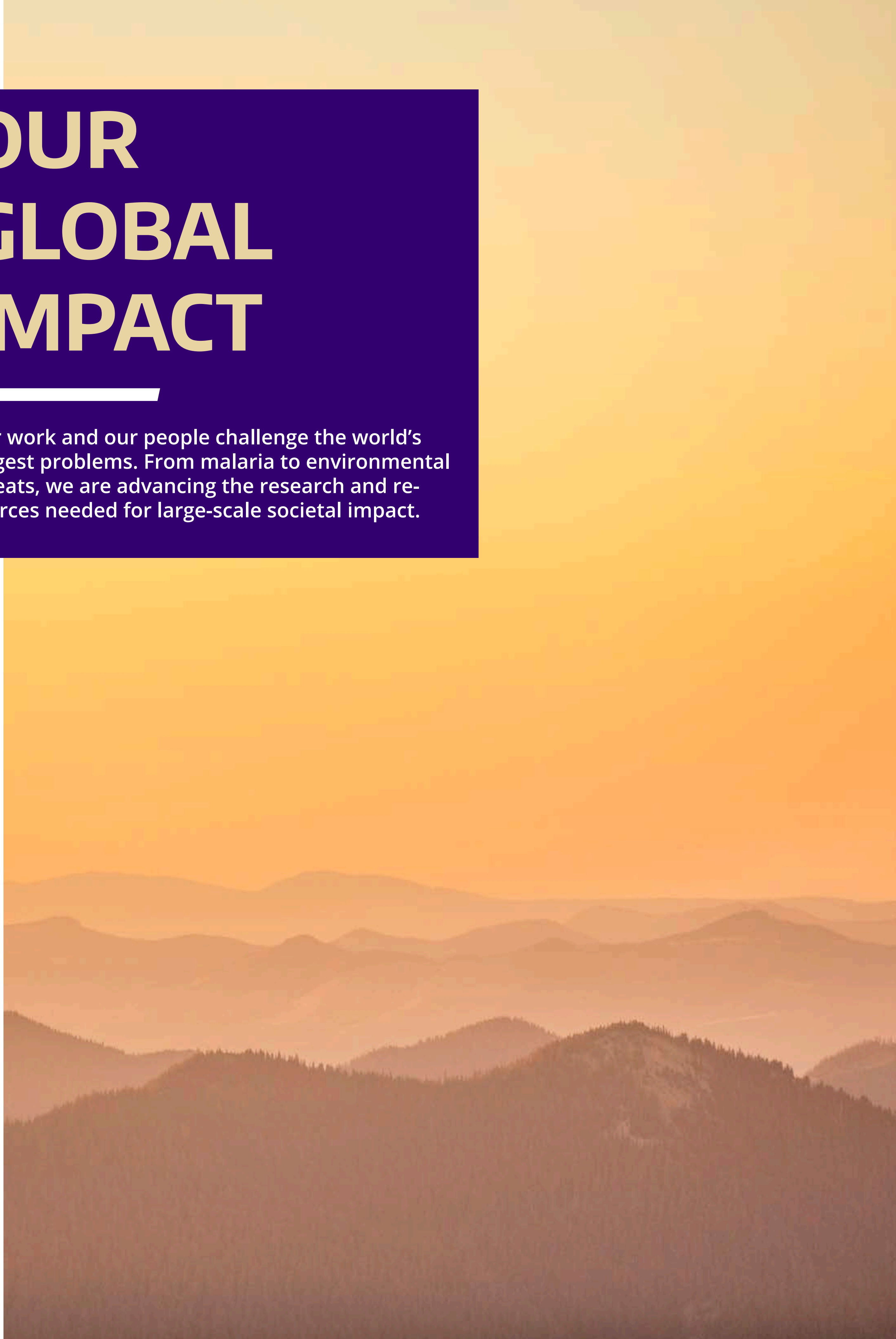
Michael Taylor will join UW in September 2017 with a joint appointment in Electrical Engineering and Computer Science and Engineering, bringing expertise in leading-edge hardware design and prototyping.

EDUCATION

Ph.D.	M.S.	B.A.
MIT	MIT	Dartmouth
2007	2000	1996

OUR GLOBAL IMPACT

Our work and our people challenge the world's biggest problems. From malaria to environmental threats, we are advancing the research and resources needed for large-scale societal impact.



SAVING DATA WITH **DNA**

Associate Professor Georg Seelig and additional researchers at the UW and at Microsoft Research have achieved the world record (200MB) in DNA storage. Because current methods will not maintain future data storage needs, the researchers developed a new tool to preserve the data — DNA. Because of this process, researchers were able to shrink the space needed to store digital data that today would fill a Walmart Supercenter down to the size of a sugar cube.

GEORG SEELIG
ASSOCIATE PROFESSOR

MAYOORE JAISWAL
GRADUATE STUDENT

CHALLENGING **MALARIA** WITH A SINGLE TEST

Ph.D. student Mayoore Jaiswal and collaborators at Intellectual Ventures have developed Autoscope, a low-cost, automated device for malaria diagnosis and drug resistance studies. Last year, over 200 million people were affected by malaria. Because the disease is endemic in some of the poorest areas of the world, efficient, portable and inexpensive methods are needed — that's where Autoscope comes in.

RAHIL JAIN
GRADUATE STUDENT

IMPROVING **HEALTH** WITH SMART-PHONES

Ph.D. student Rahil Jain seeks to improve rapid diagnostic tests by attaching contextual information, such as recent travel, to the interpretation of a physical test — all on a mobile app.

ENGINEERING FOR IMPACT

HOW INNOVATION DRIVES GLOBAL GOOD

REHABILITATION
FOR SPINAL INJURIES

Associate Professor Josh Smith and other UW collaborators received a $1 million GlaxoSmithKline (GSK) Grant to develop an implantable wireless device that can assess, stimulate and block the activity of nerves that control organs. The researchers are working on a device that can help restore bladder function for people with spinal cord injuries or millions of others who suffer from incontinence. The device also has the potential to "read" how the organs are functioning and decide whether any treatment action is necessary at that moment.

JOSH SMITH

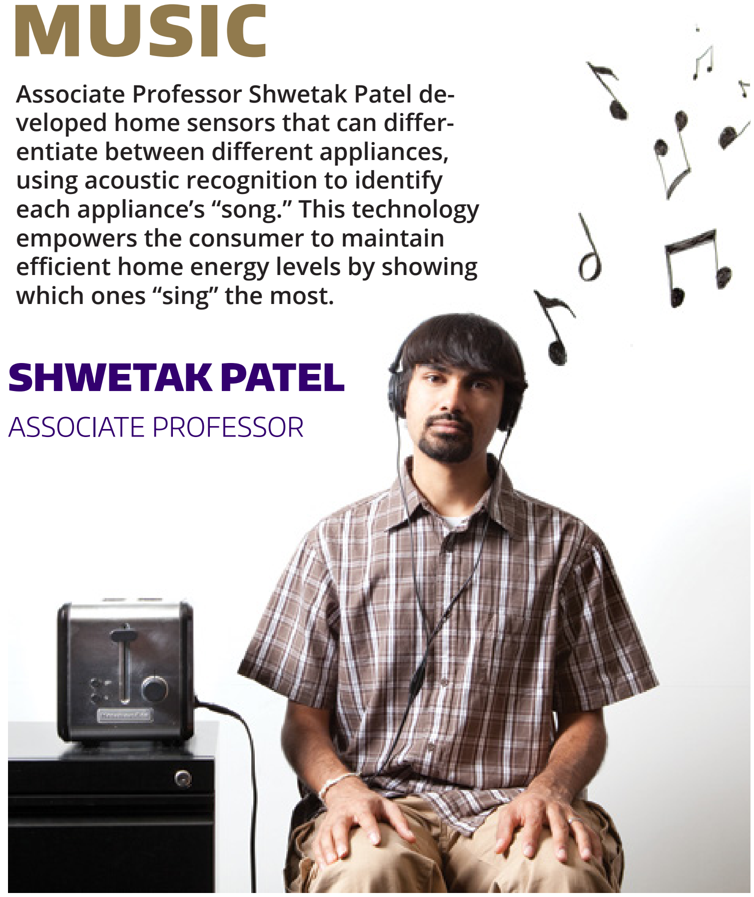
ASSOCIATE PROFESSOR

ENERGIZING MUSIC

Associate Professor Shwetak Patel developed home sensors that can differentiate between different appliances, using acoustic recognition to identify each appliance's "song." This technology empowers the consumer to maintain efficient home energy levels by showing which ones "sing" the most.

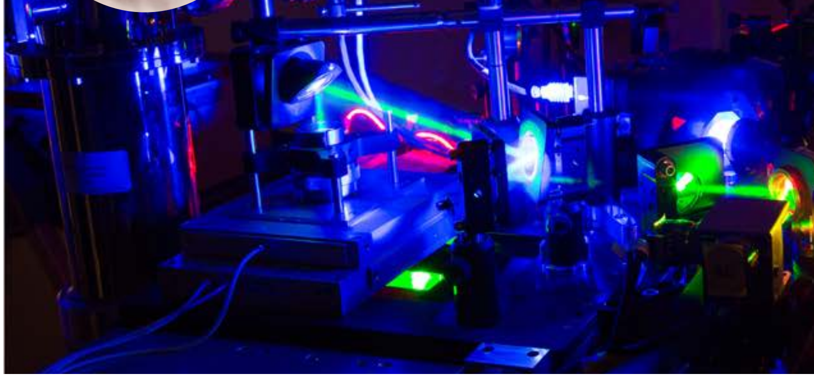
SHWETAK PATEL

ASSOCIATE PROFESSOR



KAI-MEI FU

ASSISTANT PROFESSOR



SECURE COMMUNICATIONS

Assistant Professor Kai-Mei Fu is exploring how to make communications more secure through quantum mechanics after receiving a four-year, $2 million Emerging Frontiers in Research and Innovation grant from the National Science Foundation. The research focuses on photons — minute particles of light — that can carry information through fiber-optic cables. These photons are linked to a counterpart on the other end, a link called quantum entanglement. Encrypted data follows behind each encoded photon, which means that those who eavesdrop will trigger an alert.

THE UW EE ENGINEERING ENTREPRENEURIAL CAPSTONE

Rolled out in 2016, the Engineering Entrepreneurial Capstone Program enables students to work in teams on industry sponsored projects, under faculty and industry mentorship. The first entrepreneurial system design course of its kind in the department, it develops students' skills in innovation and entrepreneurship, systems engineering, project management and product development. This new initiative offers select companies an opportunity to benefit from the vibrant innovation culture at the University of Washington's Department of Electrical Engineering.

VISIONARY ALUM

THE MILTON ZEUTSCHEL & DELIA ZEUTSCHEL ENDOWMENT

UW EE Alum Milton "Milt" Zeutschel (BSEE '60) and his wife, Delia Zeutschel, are dedicated to promoting and building entrepreneurship in Washington State. For the Zeutschels, this begins at the University of Washington. After graduating from UW EE, Milton Zeutschel forged a career of entrepreneurship, founding five companies. He wanted to instill that same spirit of innovation and opportunity by investing in the Engineering Entrepreneurial Capstone Program, which allows students to use their bold ideas to advance technologies in several different engineering fields under faculty and industry mentorship.

FACULTY FOUNDERS

PROFESSORS PAYMAN ARABSHAHI & JOHN SAHR

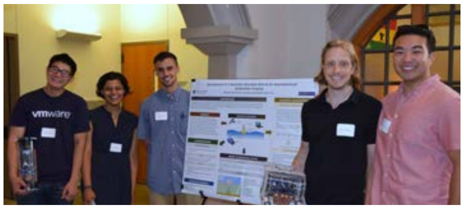
The Capstone Program was a major initiative of UW EE Chair Radha Poovendran. Professor Poovendran enlisted Professor Payman Arabshahi (left) and John Sahr (right) to lead the efforts to build the Engineering Entrepreneurial Capstone Program. Under their leadership, the Capstone program has grown significantly since its launch in 2016. Arabshahi teaches the course and works with Sahr to engage with industry leaders around Seattle to provide sponsorship on projects. The professors and industry partners offer mentorship to students as they build a product prototype within six months.

A YEARlONG COURSE

Teams of 3-5 students work on hardware and software system design challenges that emphasize depth of analysis and synthesis in all areas of electrical engineering.

1,500 HOURS

During the course of a full academic year, students spend around 1,500 hours per team on a project supervised by industry and faculty mentors.



PROJECT LEADERSHIP

Students present their final projects in the spring to faculty, industry leaders, peers and researchers at the annual Capstone showcase.

GROWING FAST: 2016-2017 NUMBERS

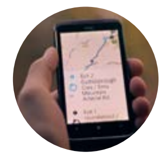
15	22	69	5x	6x
COMPANIES	PROJECTS	STUDENTS	MORE STUDENTS THAN 2015	MORE PROJECTS THAN 2015

COMPANIES INCLUDE

FLUKE
dTOOR
NVIDIA
BLUE ORIGIN
TUPL
WALLY LABS
ECHODYNE
UW MEDICINE
FIZIKL
VOICEBOX
BOOZ ALLEN HAMILTON
SEATTLE DEPT. OF TRANSPORTATION
SEATTLE MOUNTAIN RESCUE
MILLENNIUM SPACE SYSTEMS
PLUGABLE TECHNOLOGIES

PROJECT EXAMPLES

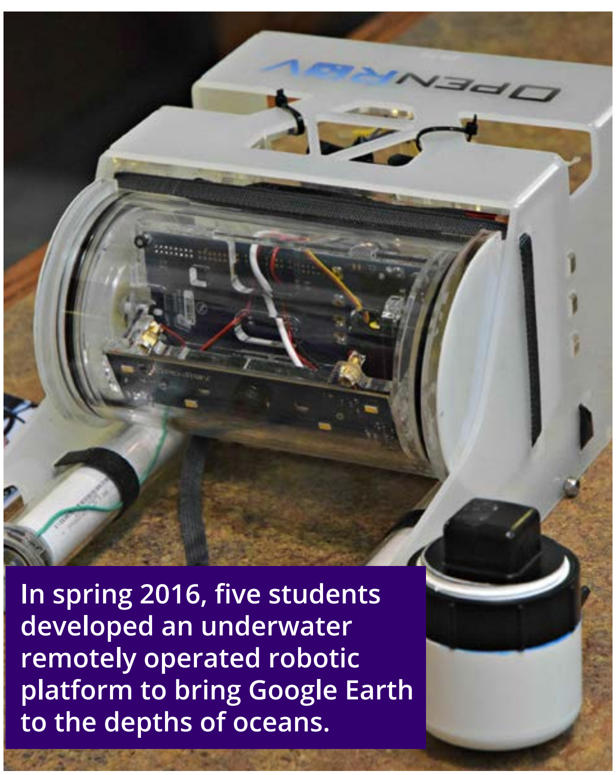
DRONE RADAR



TRANSIT APPS

SPACE COMMS

CLEAN ENERGY



In spring 2016, five students developed an underwater remotely operated robotic platform to bring Google Earth to the depths of oceans.

At the 2016-2017 project pitch, 40 percent of the 2017 graduating class listened to 15 companies present on products like clean energy and medical devices.

NOTABLE NUMBERS

OUR UNDERGRADUATE STUDENTS

242
STUDENTS ADMITTED IN 2015-2016

530
CURRENT ENROLLMENT IN 2016-2017

20%
WOMEN

25%
INTERNATIONAL STUDENTS

11%
UNDER-REPRESENTED MINORITIES

OUR GRADUATE STUDENTS

193
STUDENTS ADMITTED IN 2015-2016

359
CURRENT ENROLLMENT IN 2016-2017

23%
WOMEN

44%
INTERNATIONAL STUDENTS

4%
UNDER-REPRESENTED MINORITIES

ENTREPRENEURIAL HUB

#6 UW EE IS SIXTH IN THE NATION FOR NUMBER OF BACHELOR'S DEGREES AWARDED IN 2015.

#19 BEST GRADUATE SCHOOL FOR 2017 *U.S. News & World Report*

#1 UW EE HAS MORE STARTUPS THAN ANY OTHER DEPARTMENT ON CAMPUS SINCE 2010

3 NEW STARTUPS | **23** PATENTS ISSUED | **83** PATENT APPLICATIONS | **45** REPORTED INNOVATIONS

In 2016

2016: **$18,975,000**

2015: **$12,555,638**

2014: **$12,059,801**

2013: **$10,719,631**

2012: **$10,127,659**

66% OF UW EE GRANTS ARE FEDERALLY FUNDED

#1 THE UW RECEIVES MORE FEDERAL FUNDING THAN ANY OTHER U.S. PUBLIC UNIVERSITY.

FACULTY HONORS

27 IEEE & ACM FELLOWS

2 PECASE AWARDS

5 NAE MEMBERS

3 OSA FELLOWS

1 MACARTHUR FELLOW

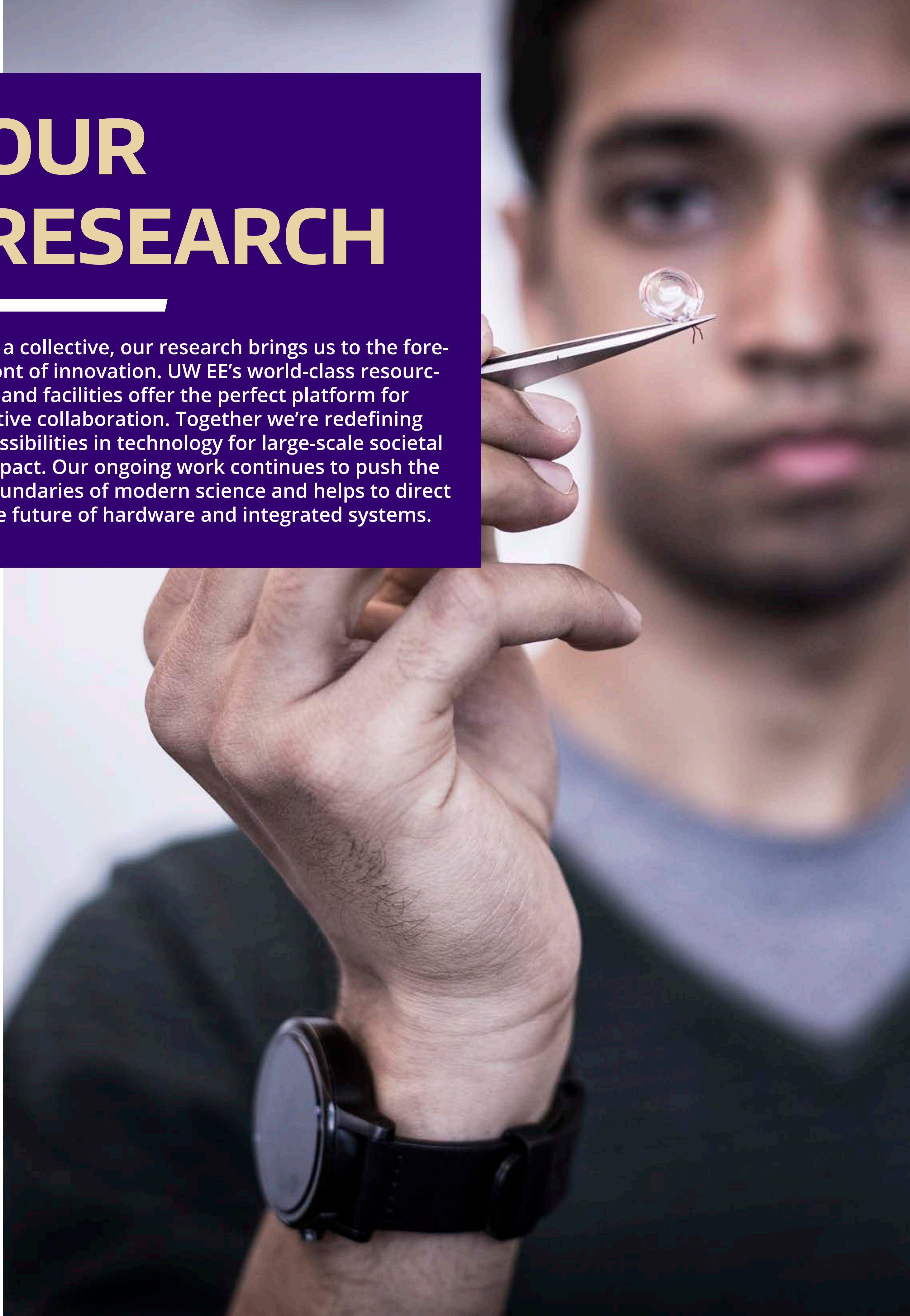
4 ASA FELLOWS

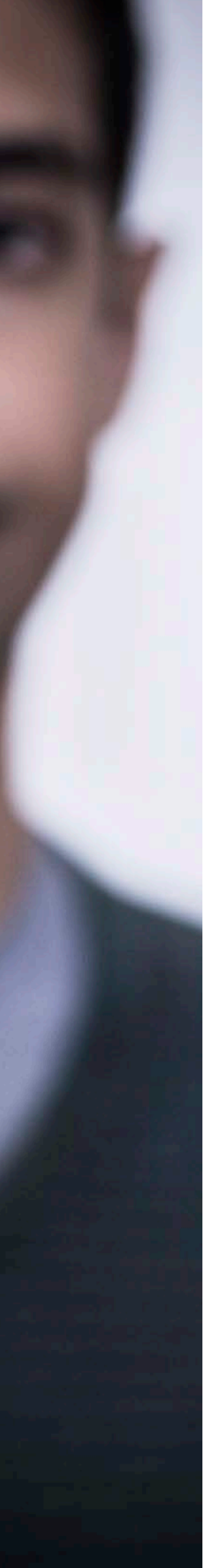
24 NSF EARLY CAREER AWARDS

4 SLOAN RESEARCH FELLOWS

OUR RESEARCH

As a collective, our research brings us to the forefront of innovation. UW EE's world-class resources and facilities offer the perfect platform for active collaboration. Together we're redefining possibilities in technology for large-scale societal impact. Our ongoing work continues to push the boundaries of modern science and helps to direct the future of hardware and integrated systems.





DATA SCIENCES

Data sciences are fundamentally transforming nearly every area of engineering, science and society. The UW EE faculty are making fundamental contributions to many different areas of data sciences, including machine learning, AI, optimization, information theory, computer vision and speech and natural language processing.

POWER & ENERGY SYSTEMS

Power and energy systems research at UW EE includes interdisciplinary work at all energy scales, ranging from nanowatts to gigawatts. Our faculty are active in smart grid, integration of renewable energy sources, grid security, energy economics and solar and electromagnetic energy harvesting. EE faculty are leaders in the Clean Energy Institute and work with local utilities and grid systems operators.

BIOSYSTEMS

Biosystems research in UW EE is a highly collaborative endeavor. Our faculty focus on four areas of biosystems research: synthetic and systems biology, neural engineering, biomedical devices and mobile health. Many of our faculty work closely with collaborators from other departments across the university.

COMPUTING & NETWORKING

UW EE's computing and networking research includes computer architecture and computer system engineering, VLSI, embedded computing, wireless networks and wireless communication research. This research traverses a wide range of applications, from government security to developing country infrastructure.

PHOTONICS & NANO DEVICES

Photonics and nano devices research at UW EE includes quantum electronics, nanoscale optics, novel photon sources and optical metamaterials, with applications in quantum science, imaging, biomedical sensing and other areas. UW EE is the host for the Washington Nanofabrication Facility and the leading member of the National Nanotechnology Coordinated Infrastructure.

ROBOTICS & CONTROLS

UW EE's robotics and controls researchers are leaders in the areas of surgical and biorobotics, haptics, smart cities and network control systems. They collaborate with other departments, hospitals and medical centers around the Seattle area. In addition, UW EE's research on Smart Cities has developed partnerships with cities around the country.

DATA SCIENCE

Data sciences are fundamentally transforming nearly every area of engineering, science and society. UW EE uses the field to develop cutting-edge devices and applications and to propel research in the areas of artificial intelligence, signal processing, machine learning, speech recognition, natural language processing and computer vision.

SCENT SIGNATURES

Following Mosquitoes to Reveal Human Odor Fingerprints

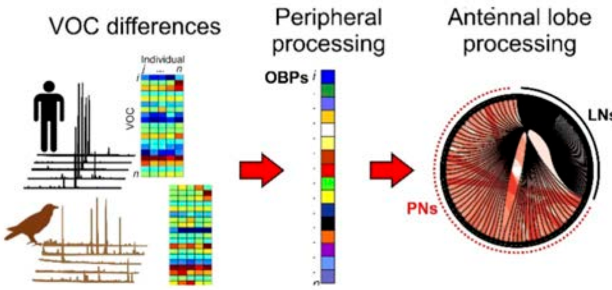
Eli Shlizerman, Assistant Professor

We often look to unique identifiers such as fingerprints or DNA to distinguish individuals. Could it also be possible to track a person by their individual odor signature? To explore this question, Assistant Professor Eli Shlizerman is developing methods to decipher the activity of the nervous system of one of humans' most irritating adversaries — mosquitoes.

Human odor signatures, known as chemical biomarkers, are extremely complex, containing over 350 aroma elements. Tracking these odor signatures using chemi-sensors can be challenging because the concentration of the aroma elements, technically called volatiles, in the air is constantly changing. Mosquitoes, however, always seem to know exactly where humans are — remarkably, their olfactory system appears to be able to process the volatiles, encode them into a profile of "human scent" and then track them.

Shlizerman, who holds a joint appointment in Applied Mathematics, is collaborating with Jeffrey Riffell, associate professor of biology, to investigate the mosquito olfactory system — a complex structure that is critically important, but not well understood. The researchers will employ a three-pronged approach to resolve the neural responses of the olfactory system. The first step is defining and cataloging human scent volatiles. Once the volatiles have been fully characterized, the researchers will explore the mosquito olfactory system to identify the components that provide detection and discrimination of human scent.

The second stage of the research is key to the ultimate goals of the project. Armed with an understanding of how the mosquito nervous system processes scent volatiles, the researchers will model the specific neural coding that identifies humans and distinguishes them from other animals.



The mosquito olfactory system.

Finally, in the third stage of the project, the researchers will aim to apply their understanding of both the human scent profile and the neural coding that identifies these profiles to building an artificial antennae lobe that can detect volatiles at trace levels.

The ability to detect the chemical biomarkers of human scents has an intriguing range of applications. One possible use, of course, is the development of more effective mosquito repellents. More compelling, however, is the possibility of detecting anomalies, which could correspond to diseases, by classifying chemical biomarker abnormalities and developing devices to identify them.

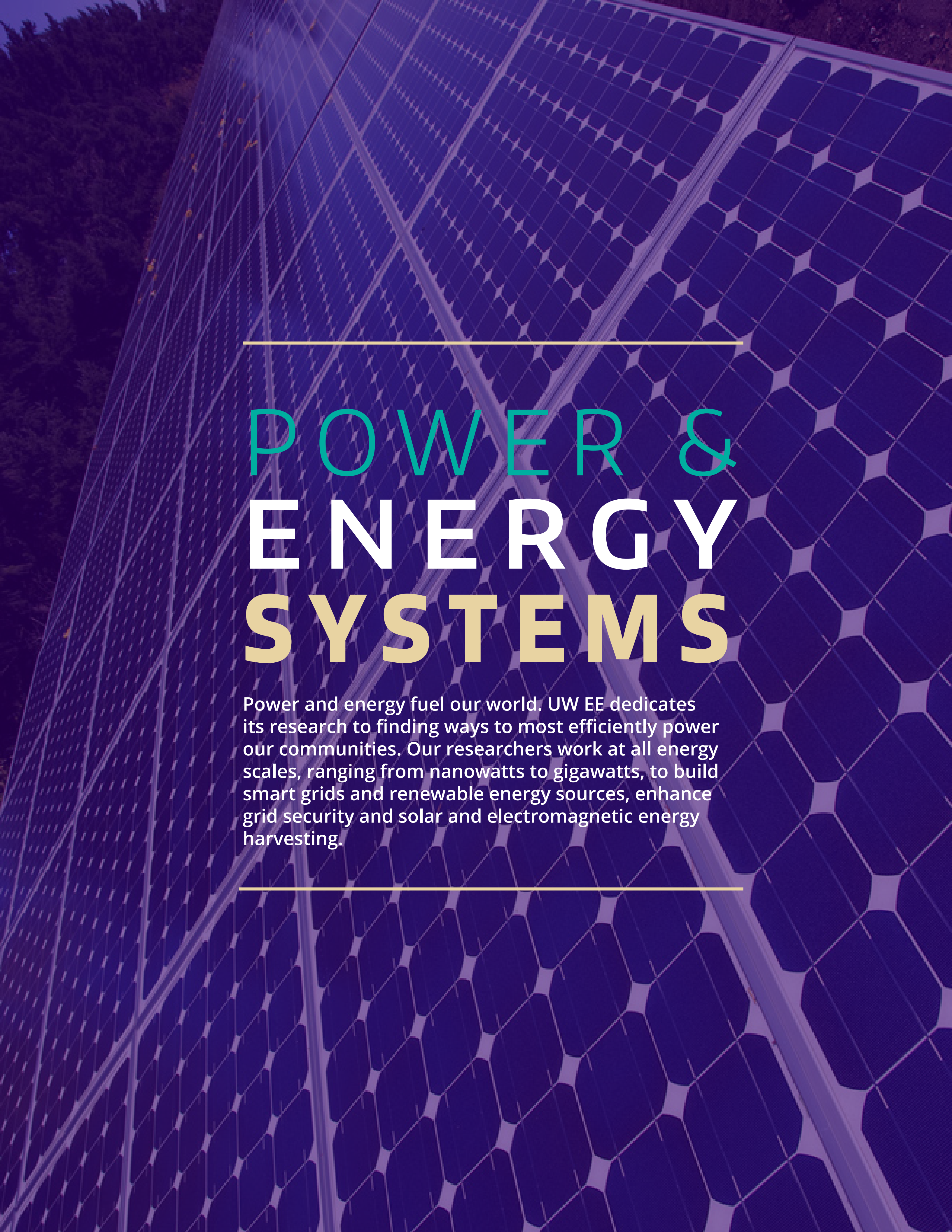
ADDITIONAL INFORMATION

COLLABORATORS:

Jeff Riffell, Associate Professor, Biology

GRANT/FUNDING SOURCE:

Air Force of Scientific Research (AFOSR)



POWER & ENERGY SYSTEMS

Power and energy fuel our world. UW EE dedicates its research to finding ways to most efficiently power our communities. Our researchers work at all energy scales, ranging from nanowatts to gigawatts, to build smart grids and renewable energy sources, enhance grid security and solar and electromagnetic energy harvesting.

POWERING UP

Powering the Next Billion Devices with Wi-Fi

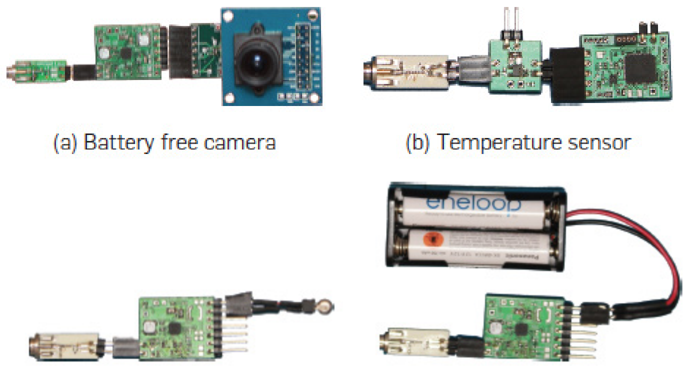
Josh Smith, Associate Professor

In the 21st century, wireless communication is everywhere — billions of people rely on it every day. Wireless power, however, has not been as successful. In recent years, near-field, short-range schemes have gained traction for certain range-limited applications, like powering implanted medical devices and recharging cars and phones. Researchers have recently demonstrated the feasibility of powering sensors and devices in the far field using radio frequency signals (RF) from TV and cellular base stations. In addition to enabling power delivery at further distances, RF signals can simultaneously charge multiple sensors and devices because of their long-range coverage.

Such an RF device is ubiquitous in modern homes, offices and even coffee shops — the Wi-Fi router. Work by Associate Professor Josh Smith and his collaborators has shown that Wi-Fi routers can be used to provide far-field wireless power without significantly compromising network performance. Smith's team has developed PoWiFi — the first power over Wi-Fi system that delivers power to low-power sensors and devices and works with existing Wi-Fi chipsets. PoWiFi combines two elements: (1) a Wi-Fi transmission strategy that delivers power on multiple Wi-Fi channels and (2) energy-harvesting hardware that can efficiently harvest from multiple Wi-Fi channels simultaneously.

Building on their PoWiFi work, Smith and his team have prototyped battery-free temperature and camera sensors that can be powered by Wi-Fi at ranges of 20 and 17 feet respectively. The team has also demonstrated the ability to wirelessly trickle-charge nickel-metal hydride and lithium-ion coin-cell batteries at distances of up to 28 feet. Their system has been deployed in six homes in a metropolitan area, which has successfully shown that it can deliver power via Wi-Fi under real-world network conditions without significantly degrading network performance.

The PoWiFi system has clear potential to impact the Internet of Things (IoT) — small computing sensors and mobile devices that are embedded in everyday objects and environments. A key issue with IoT is how to power these devices as they become smaller and more numerous; plugging them in to provide power is inconvenient and is difficult at large scale. PoWiFi's novel far-field power delivery system uses existing Wi-Fi chipsets while minimizing the impact on Wi-Fi network performance. This is a first step toward using Wi-Fi as a power delivery system. Smith and his collaborators are confident that with subsequent iterations of the harvester they can significantly increase the capabilities of the system.



(a) Battery free camera (b) Temperature sensor (c) Li-ion battery charger (d) NiMH battery charger

Prototype hardware demonstrating PoWiFi's potential. The prototypes harvest energy from Wi-Fi signals through a standard 2 dBi Wi-Fi antenna (not shown). The low gain antenna ensures that the device is agnostic to the antenna orientation and placement. We developed (a) a battery-free camera to capture images, (b) a temperature sensor to measure temperature, (c) a Li-ion battery charger and (d) a NiMH battery charger.

ADDITIONAL INFORMATION

COLLABORATORS:

Shyam Gollakota, Assistant Professor, Computer Science and Engineering and Adjunct Professor, Electrical Engineering

GRANT/FUNDING SOURCES:

National Science Foundation Grants
Qualcomm Innovation Fellowship
Intel Fellowship

BRIGHT SOLUTIONS

Self-Cleaning Surfaces for Solar Panels

Di Sun, Graduate Student

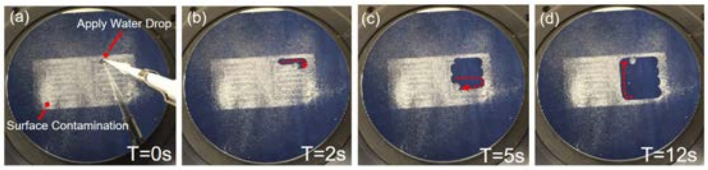
Karl Böhringer, Professor

Solar panels work best, of course, in areas where there's consistent sunshine. This means that most large-scale installations of solar panels are in remote, arid areas — the downside of which is that locally there are very high levels of sand and dust. When a system designed for sensitivity to something as infinitesimal as a light particle is combined with much larger particles like sand or dust, you get a vastly less efficient system. A project developed by graduate student Di Sun and Professor Karl Böhringer offers a solution.

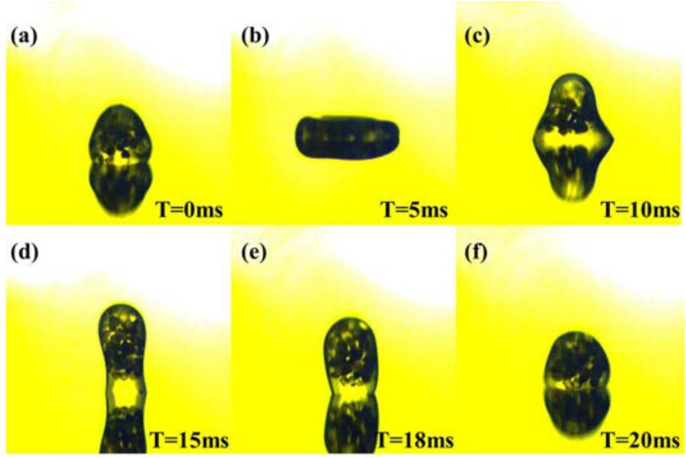
The problem is simple: dust and sand accumulate on the solar panel and prevent light from getting to the solar cells. Dust can reduce the solar panel efficiency by about 35% — up to 60% after a powerful storm. In remote areas such as deserts, cleaning large deployments of solar panels involves human-less systems such as automated water-spraying systems or robots, which are too expensive to be practical.

To reduce dust accumulation and maintenance cost, and to improve the overall efficiency of solar panels, Sun and Böhringer developed a unique self-cleaning coating technology. Using micropatterning techniques, the team created a surface that can guide water along defined routes. The background of the coating is hydrophobic, which means that water is naturally repelled away from it. On top of that coating are patterns that are hydrophilic, which means they attract water. This combination of simultaneously repelling water away from one aspect of the coating while another attracts it is what forces the water to follow specific routes across the surface. As the water follows the defined paths across the solar panel, contaminants such as dust and sand are cleaned away. What's more, the coating has a near-invisible thickness of nanometers or less, which means the coating does not reduce the efficiency of the solar panel.

Currently, Sun and Böhringer are focusing on the scalable design and fabrication of the textured surface for industrial applications. They also have a prototype of a solar panel cover made using their coating technology and are exploring commercialization opportunities.



Water droplet cleaning surface contaminants with zig-zag layout of ARC surface

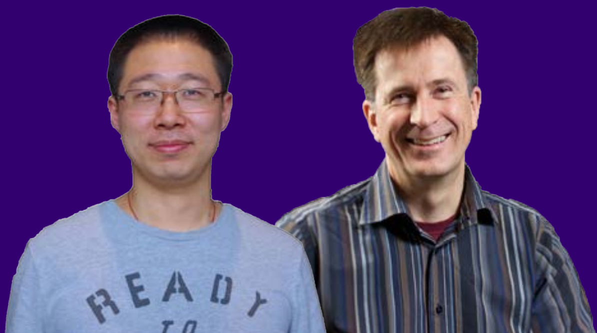


2 9μL water droplet carrying 2mg sand particles while moving along ARC surface

ADDITIONAL INFORMATION

GRANT/FUNDING SOURCES:

National Science Foundation Grants
Qualcomm Innovation Fellowship
Intel Fellowship



BIOSYSTEMS

UW EE's biosystems research integrates technology and applied biology and environmental sciences. Our faculty focus on four areas of biosystems research: synthetic and systems biology, neural engineering, biomedical devices, and mobile health. The applications for this research are diverse — from global health diagnostic tests to rehabilitation technologies for stroke and spinal cord injuries.

GLOBAL

Lilian de Greef, Graduate Student, CSE
Elliott Saba, Graduate Student
Edward Wang, Graduate Student
Shwetak Patel, Associate Professor

Millions of people, from the developing world to impoverished communities in developed countries, lack proper access to critical health devices. This means patients may not be able to monitor chronic diseases. Parents may not be able to identify a common newborn disease. There is, however, an increasingly ubiquitous device that puts low-cost sensing and communication into the hands of individuals: mobile phones. The work of Professor Shwetak Patel and his graduate students in the UbiComp Lab is specifically aimed at providing technology for managing and tracking health to care providers and individuals who could otherwise not afford or access health devices.

SpiroCall

Chronic diseases associated with the lungs account for over 10% of all deaths worldwide. It's important for individuals with lung conditions to be able to monitor the disease on a regular basis using a test called spirometry, which measures both the amount of air a patient can expel from their lungs and how quickly. SpiroCall makes spirometry available over any phone from modern smartphones to traditional landlines. All a patient has to do is call a phone number and exhale as hard as they can. The phone's microphone senses sound and pressure, then feeds that information through machine learning models to determine lung function using the same diagnostic measures as traditional spirometry devices.

In testing SpiroSmart in clinics in India and Bangladesh, UW CSE doctoral student Mayank Goel (front row, center) and collaborators learned that many patients did not have access to a smartphone, so they adapted SpiroSmart to work from any cellular or landline phone. Credit: University of Washington

BiliCam

Newborn jaundice occurs when bilirubin, a naturally occurring waste compound in the blood, is not quickly expelled from a baby's system and begins to build up — which can ultimately lead to brain damage or even death. In the U.S. alone, 1 in 14 newborns receives treatment for jaundice. To screen for jaundice without having to travel to a hospital or clinic, BiliCam uses a smartphone's camera and flash in conjunction with a standardized color calibration card. The user places the card on the baby's belly and snaps a picture

ADDITIONAL INFORMATION

COLLABORATORS:

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Seattle Children's Hospital

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Division of Pediatrics
University of Washington

COLLABORATORS, CONT.:

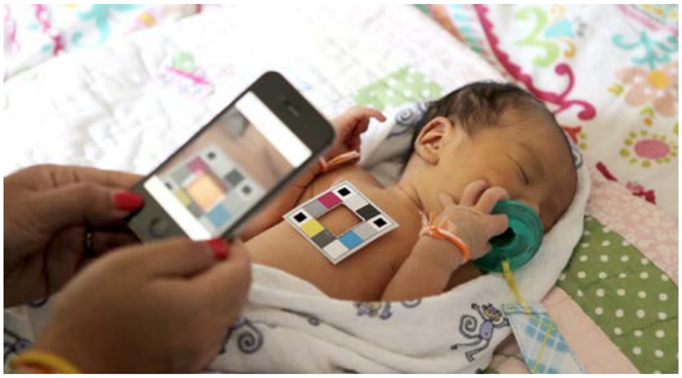
Jim Taylor, MD
Division of Pediatrics
University of Washington

GRANT/FUNDING SOURCES:

Coulter Foundation
The Bill and Melinda Gates Foundation
Washington Research Foundation
National Institute of Health

Applications

which is sent to a cloud service. The cloud service uses the smart phone's computer vision to analyze the wavelengths of light being absorbed by the skin and machine learning to estimate bilirubin levels. The user receives an analysis on the baby's bilirubin levels almost instantly.

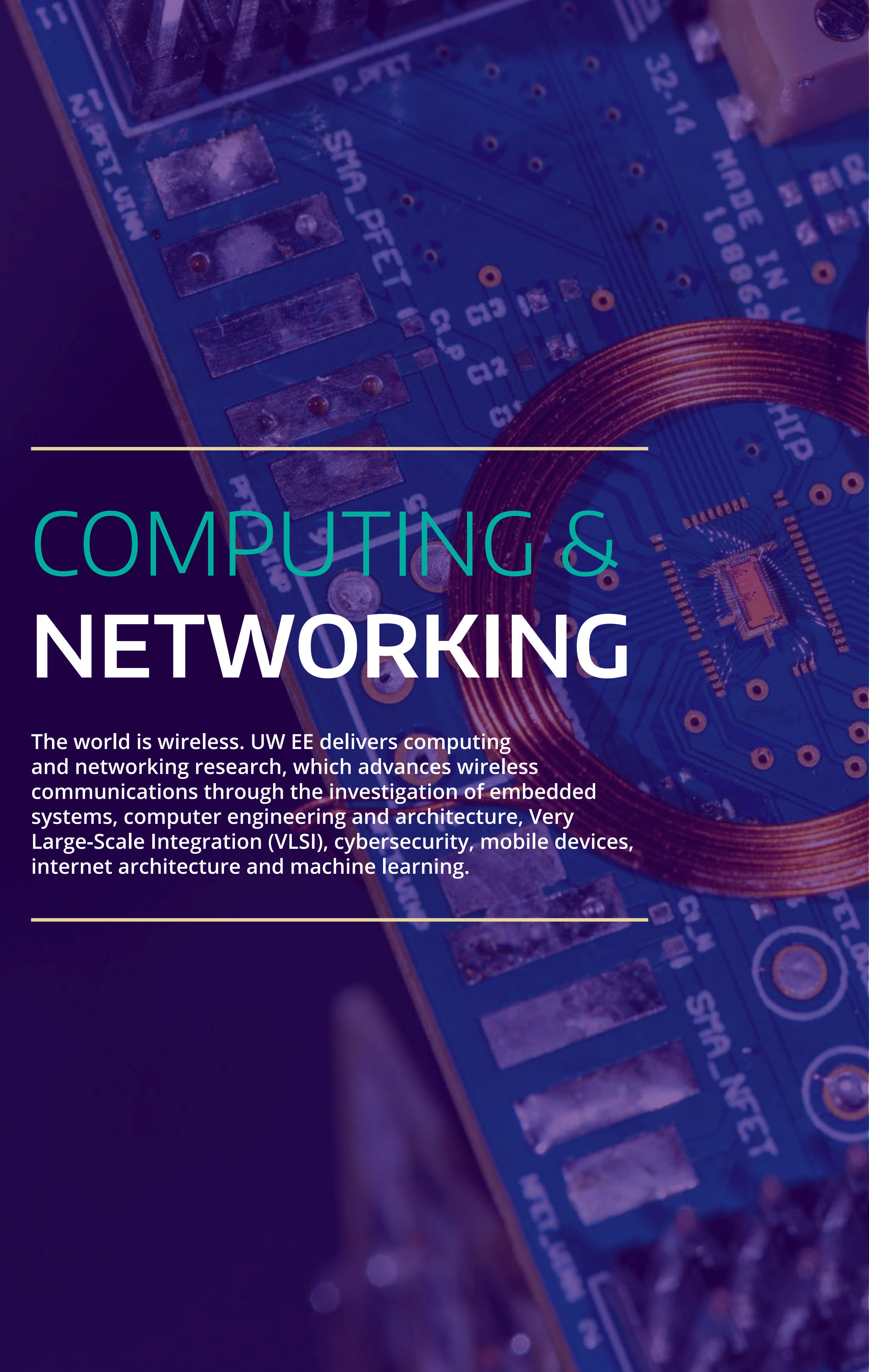


BiliCam uses a smartphone's camera and flash in conjunction with a standardized color calibration card. The bilirubin levels are analyzed through the wavelengths of light being absorbed by the skin.

HemaApp

Women and children are populations at high risk for anemia, a chronic disease which occurs when red blood cells have insufficient hemoglobin to carry oxygen. The most common effect of anemia is fatigue, but it can also lead to neural and behavioral development delay in children and can increase the chances of preterm labor for mothers. The current clinical standard to test hemoglobin levels are blood draws in a clinic — which can be a difficult trip to make regularly for patients whose primary symptom is fatigue. Anemia is also common in impoverished communities where it's not unusual that there are no clinics at all or clinics with limited resources. UbiComp Lab's HemaApp solution allows individuals with chronic anemia to test their own hemoglobin levels comfortably in their own home. HemaApp uses a smartphone's built-in camera and flash to illuminate a patient's finger and then analyze the color of the blood to estimate hemoglobin concentrations. The HemaApp test is also noninvasive, which means that patients are spared from repeated tests that require being stuck with a needle.

All of the UbiComp Lab's health testing solutions perform in the same range as — or even on par with — standard medical tests for lung function, jaundice and hemoglobin levels. The portability, low-cost and sensing capabilities of mobile phones mean that the ability to catch and monitor disease could be expanded to millions more worldwide who currently lack regular care. The group is currently working to increase the sample sizes for all three projects so that SpiroCall, BiliCam and HemaApp are effective for as wide a variety of patients as possible. They are also improving their prototypes and systems, and partnering with NGOs to deploy these solutions to external clinics around the world.



COMPUTING & NETWORKING

The world is wireless. UW EE delivers computing and networking research, which advances wireless communications through the investigation of embedded systems, computer engineering and architecture, Very Large-Scale Integration (VLSI), cybersecurity, mobile devices, internet architecture and machine learning.

ONR MURI

ADAPT — Actionable Defense Against Persistent Threats

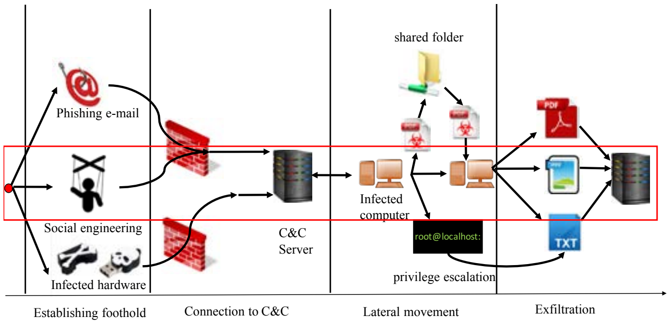
Radha Poovendran, Professor and Chair

In our increasingly connected world, cyber-attacks are ever more frequent and dangerous. A particular type of attack that's especially dangerous because of its stealthiness and ability to infiltrate systems using previously unknown vulnerabilities is known as an advanced persistent threat (APT). The most well-known example of an APT is Stuxnet, which caused significant damage to nuclear power facilities in 2010. Identifying and defending against these threats is crucially important, and is the work of a research team led by Professor and Chair Radha Poovendran.

Generally speaking, APTs vary as to what vulnerabilities they exploit and the techniques they use to infiltrate systems. But the similarities among APTs is that the progression of their attacks is almost always identical — initial compromise of components, establishing connections to command and control servers, compromise of system components using stolen information and then exfiltration of stolen data. However, although the attack progression is standard among APTs, modeling or mitigating such multi-stage attacks nevertheless is not well understood.

What is understood is that each one of these attack stages is inherently a game, played between the attacker and the defender, where each player is continuously interacting with the other trying to thwart the other player's goal. A game theory approach to understanding APTs might seem logical, but existing game theory based on economics is founded on the notions of equilibrium. Such notions don't apply well in cyber environments, where abrupt changes due to inherent randomness are the norm. Furthermore, the attacker may force changes in the environment if the foreseeable outcome of the game is not favorable. Such disruptive changes would result in abrupt transition to a completely different game before any equilibrium is reached, making traditional game theory inapplicable.

Poovendran and a research team consisting of leading experts in security, machine learning, game and control theory and optimization are exploring a novel game theory underpinning the adversarial cyber interaction against APTs. Funded by a $7.5 million Department of Defense Multidisciplinary University Research Initiative (MURI) grant, the research effort will develop a game-of-games framework where the outcome of one game determines the transition to another game and will ultimately develop actionable defenses against APTs. The developed models and defenses will be verified using real-world data gathered from log traces of APTs.



The ADAPT effort approaches the multistages of cyber attacks.

ADDITIONAL INFORMATION

COLLABORATORS:

Maryam Fazel, Assistant Professor

Linda Bushnell, Research Associate Professor

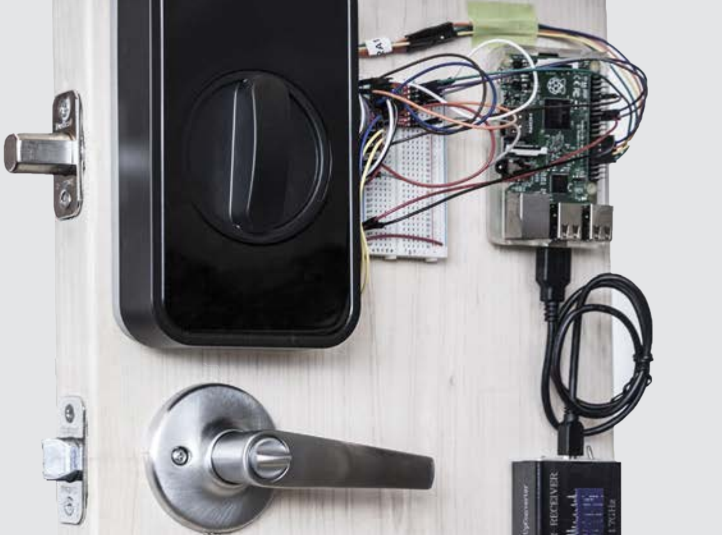
University of Washington

University of Berkeley

GRANT/FUNDING SOURCES:

Office of Naval Research
Multidisciplinary University Research Initiatives (MURI) Grant

SELF-PROTECTION



Enabling On-Body Transmissions with Commodity Devices

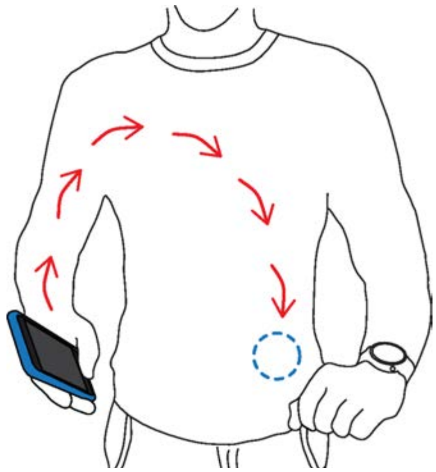
Mehrdad Hessar, Graduate Student
Vikram Iyer, Graduate Student

Sending data over a wireless network, whether it's Wi-Fi or Bluetooth, opens the data to potential eavesdropping by malicious hackers. Even for networks that encrypt their transmissions, the threat of eavesdropping is still worrisome when you're transmitting authentication information, such as a password or the secret key to encrypt the data. Fortunately, electrical engineering and computer science researchers at the UW are developing an intriguing solution for secure transmissions: sending authentications wirelessly via the user's own body.

The work of Mehrdad Hessar and Vikram Iyer, both electrical engineering Ph.D. candidates, and Shyam Gollakota, adjunct assistant professor, began by looking at commercial devices with touch-based inputs. Touchpads and fingerprint sensors, for example, are increasingly common on smartphones, which makes them attractive for experimentation. The researchers were also interested in these devices specifically because they produce low frequency signals that couple well to the body but don't travel well over air where they can be intercepted.

Results so far have been extremely promising. First, the researchers have been able to show that using touch sensors lowers the entrance barriers to being able to send signals across the body. Furthermore, signals can still be reliably decoded when users are moving, such as while walking or moving their arms. The results are also consistent when tested across diverse body types with various heights and weights. As a proof of concept, the researchers have successfully demonstrated sending an authentication code from a fingerprint sensor, through the body and to a locked door. Placing one hand on the smartphone's sensor and the other hand on the doorknob creates a complete circuit which the passcode travels to successfully unlock the door — quickly and securely.

As smartphones with touch sensors grow more and more common, applications for secure on-body communication also grow. Perhaps most importantly, the researchers highlight that secure communication, immune to hacking, has the great potential to be applied to a highly critical area — personal medical devices such as insulin pumps and pacemakers.



Example application: Secret keys for wearables.

ADDITIONAL INFORMATION

ADVISOR:

Shyam Gollakota, Assistant Professor, Computer Science and Engineering and Adjunct Professor, Electrical Engineering

GRANT/FUNDING SOURCES:

Intel Science and Technology Center for Pervasive Computing

Google Faculty Award

National Science Foundation Grants

PHOTONICS & NANO DEVICES

UW EE works at the edge of what is possible. Our research in photonics and nano devices utilizes multidisciplinary approaches to distribute technology into everyday life. UW EE research includes quantum electronics, nanoscale optics, novel photon sources and optical metamaterials, with applications in quantum science, imaging, biomedical sensing and other areas.

VISUAL IDENTITIES

New Approaches for Millimeter Wave Imaging

Matt Reynolds, Associate Professor

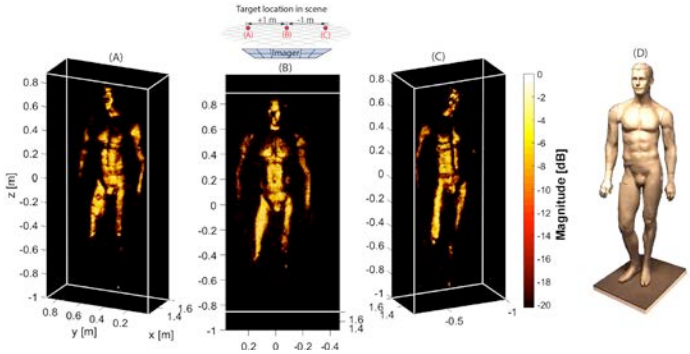
When you need to know if you've broken your wrist or just sprained it, or when airport security needs to quickly see what's in your luggage, the answer is usually the same: take an X-ray. Many other applications would benefit from an X-ray-like technology that can see beneath the surface, without the potential health hazards that can come from over-exposure to X-rays. An alternative lies in Associate Professor Matt Reynolds' work in millimeter wave imaging.

The millimeter wave spectrum refers to radio frequencies much higher than the frequencies commonly used for cellular, Bluetooth and Wi-Fi communications. For example, most Wi-Fi devices operate at 2.4 GHz, while the millimeter wave spectrum is over 10X higher in frequency, ranging from approximately 30 GHz to 100 GHz or more. These much higher frequencies have unique properties, enabling exciting new applications, such as high resolution 2D and 3D imaging in both indoor and outdoor environments.

Millimeter waves are attractive for imaging for several reasons. Millimeter waves have much longer wavelengths than visible light, so millimeter waves pass right through many materials that visible light cannot penetrate. For example, millimeter waves can make images of objects hidden behind walls made of wood, drywall or concrete. Also, unlike X-rays, millimeter waves used in imaging are human-safe. And millimeter waves can produce an image resolution of 1mm or better, enough to resolve even tiny details such as nails or screws in the wall.

One of the first uses for millimeter wave imaging is a new generation of airport security technology that eliminates the slow-moving, mechanically scanned antennas used in today's security checkpoints. Reynolds' group and collaborators at Duke University have combined two exciting emerging technologies — Duke's contribution is a low-cost metasurface antenna array; the UW technology is a Massive-MIMO (multi-input, multi-output) transmitter-receiver array. The new images are capable of 3D, video-rate imaging that is safe for humans.

In addition to its importance in defense and security applications, millimeter wave imaging has tremendous potential in industrial and commercial markets. For example, millimeter wave imaging sensors could soon guide autonomous systems such as robots and self-driving cars, and they can be used to identify product-quality defects such as foreign objects inadvertently making their way into food. Reynolds and his postdoctoral researchers are testing the waters with a new company, ThruWave, to commercialize the UW EE team's innovations, with an initial focus on the construction market.



3D millimeter wave image of a statue.

ADDITIONAL INFORMATION

COLLABORATORS:

David R. Smith, Professor at Duke University

Daniel Arnitz, Researcher at Intellectual Ventures and former EE postdoc

STUDENTS INVOLVED:

Claire Watts, postdoc

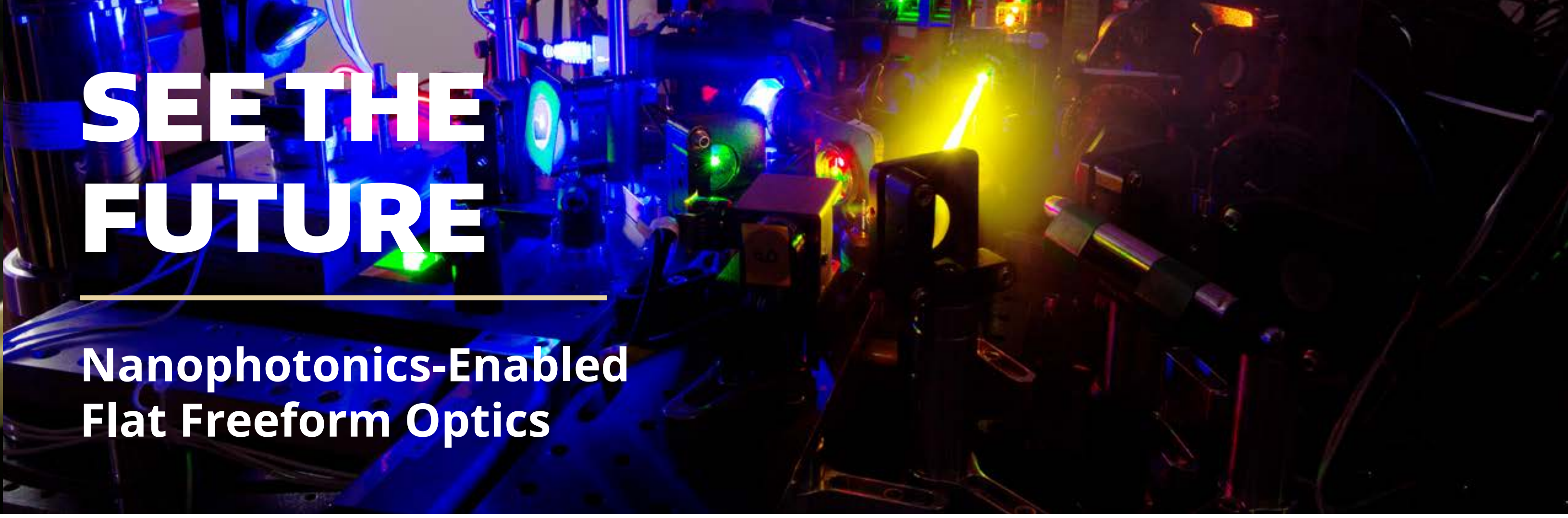
Andreas Pedross-Engel, postdoc

Xiaojie Fu , graduate student

Sandamali Devadithya, graduate student

GRANT/FUNDING SOURCES:

Department of Homeland Security and other government agencies



SEE THE FUTURE

Nanophotonics-Enabled Flat Freeform Optics

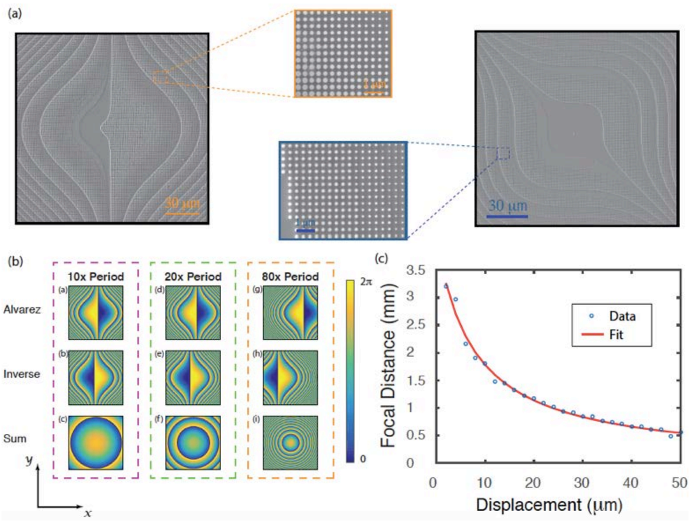
Arka Majumdar, Assistant Professor

A near-eye display is a device that brings a visual display as close to you as headphones bring sound. A well-known recent example is Google's smart glasses, Google Glass. A small, lightweight near-eye display would be of great use for mobile devices or in industries such as medicine and aerospace, where there are stringent size and weight constraints. These potential applications of compact optical systems have driven interest in freeform optics — which is where Assistant Professor Arka Majumdar, graduate student Shane Colburn and Alan Zhan, graduate student in physics, come in.

The problem with the high curvatures and complex forms inherent in freeform optics is that they are often difficult to manufacture with existing technologies, especially at the micron scale. To solve this problem, Majumdar's group developed visible frequency freeform optical elements by leveraging nano-patterned surfaces, known as metasurfaces. The resulting surfaces can induce spatially variant changes in phase with an ultrathin and flat form factor, enabling cheap and simple fabrication of freeform elements.

The technology developed by Majumdar's group is inspired by earlier work on diffractive optics, where spatial phase shifts are achieved by varying the thickness of the device. Majumdar's group took a slightly different approach — they use sub-wavelength structures, which allow for multiple phase-shifts by only changing the lateral geometry with the same thickness. This enables a flat component which is easier to fabricate. Not only does this reduce the need for multiple-stages of lithography, the sub-wavelength nature means that spatial profiles with large phase gradients can be fabricated. Realizing large phase gradients opens the possibility of building monolithic optical systems, akin to electronic integrated circuits.

These metasurface freeform elements being developed by Majumdar, Colburn and Zhan could enable optical systems, encompassing uses from vision-correcting eyewear to multi-focal augmented reality visors to implantable microscopes, all while maintaining an ultra-compact form-factor. The group's current research efforts focus on integrating these elements in existing systems. By incorporating them with optical systems they'll be able to demonstrate imaging. And by integrating them with solid-state mirrors they'll be able to develop monolithic optical systems.



Dielectric metasurface freeform optics: (a) SEM of the fabricated cubic phase-plates, which together can form a composite Alvarez lens. (b) By laterally displacing these two cubic phase-plates we can realize lens-like (quadratic) phase profile with varying curvature, and hence different focal lengths. (c) Experimentally measured focal length as a function of the lateral displacement, showing the nonlinear change in the focal length.

ADDITIONAL INFORMATION

STUDENTS INVOLVED:

Alan Zhan, graduate student, Physics

Shane Colburn, graduate student

GRANT/FUNDING SOURCES:

Intel Early Career Award

Amazon Catalyst Funding

CHARGING HUB

Long-Range Wireless Charging

Matt Reynolds, Associate Professor

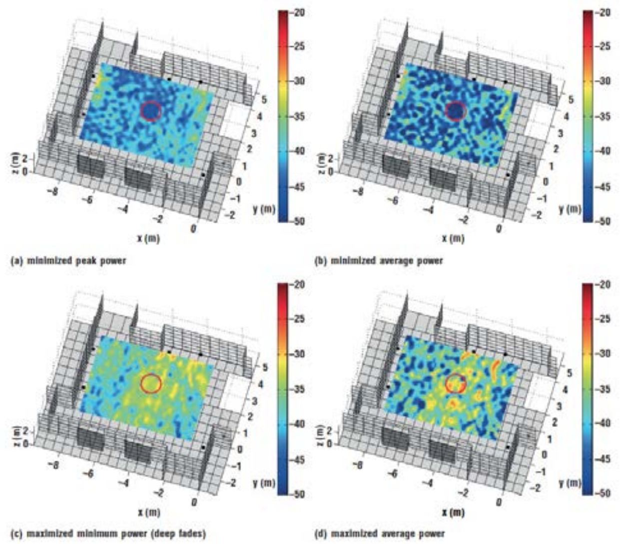
Wireless devices offer mobility and flexibility by freeing us from tethers. Phone cords are becoming a thing of the past as we use mobile phones that connect to cellular networks. Computers are no longer desktop-only devices tied to Ethernet cables thanks to the proliferation of Wi-Fi. But one cable remains: eventually, our wireless devices need to be plugged in to charge.

Associate Professor Matt Reynolds has been working on the problem of efficient, long-range wireless power transfer. Although wireless charging using magnetic induction is currently in wide use in ordinary household devices such as electric toothbrushes and many smartphones, it's limited to extremely short range. Magnetic induction requires the device being charged to be in close proximity to — often physically touching — a charging pad or docking station.

The limiting factor in magnetic induction is the low frequencies used. To achieve charging distances of room-scale or longer, much higher frequencies over 1 GHz are needed. The difficulty with such high frequency signals is that they tend to bounce around the environment in a phenomenon called multipath reflection. These unwanted reflections reduce the efficiency of power transfer by deflecting power away from the receiving device.

Reynolds' work has tackled the problem of multipath reflection by leveraging two emerging technologies: multi-input, multi-output (MIMO) beam forming and Fresnel-zone focusing with metasurface antennas. The MIMO techniques can be used to form a focused region of wireless power even in a home or office environment with lots of metal and other reflecting objects. To build such a system for delivering wireless power, Reynolds has been looking at using emerging low-cost metasurface antennas. Ultimately this work could lead to power access points that provide wireless power in a building, similar to the way communication access points provide network access today.

Practical long-range wireless power transfer technology would be transformative both for keeping your smartphone or your tablet charged and ready to move and for enabling entirely new applications like in-flight recharging of small drones. Reynolds' group has been collaborating with researchers at Duke University, and separately with Intellectual Ventures in Bellevue, Washington, toward pilot scale demonstrations of these new technologies.



Power distribution is optimized for a single (circled) 100 cm region, 902–928 MHz band.

ADDITIONAL INFORMATION

COLLABORATORS:

David R. Smith, Professor at Duke University

Guy Lipworth, Researcher at Intellectual Ventures

Yaroslav Urzhumov, Researcher at Intellectual Ventures

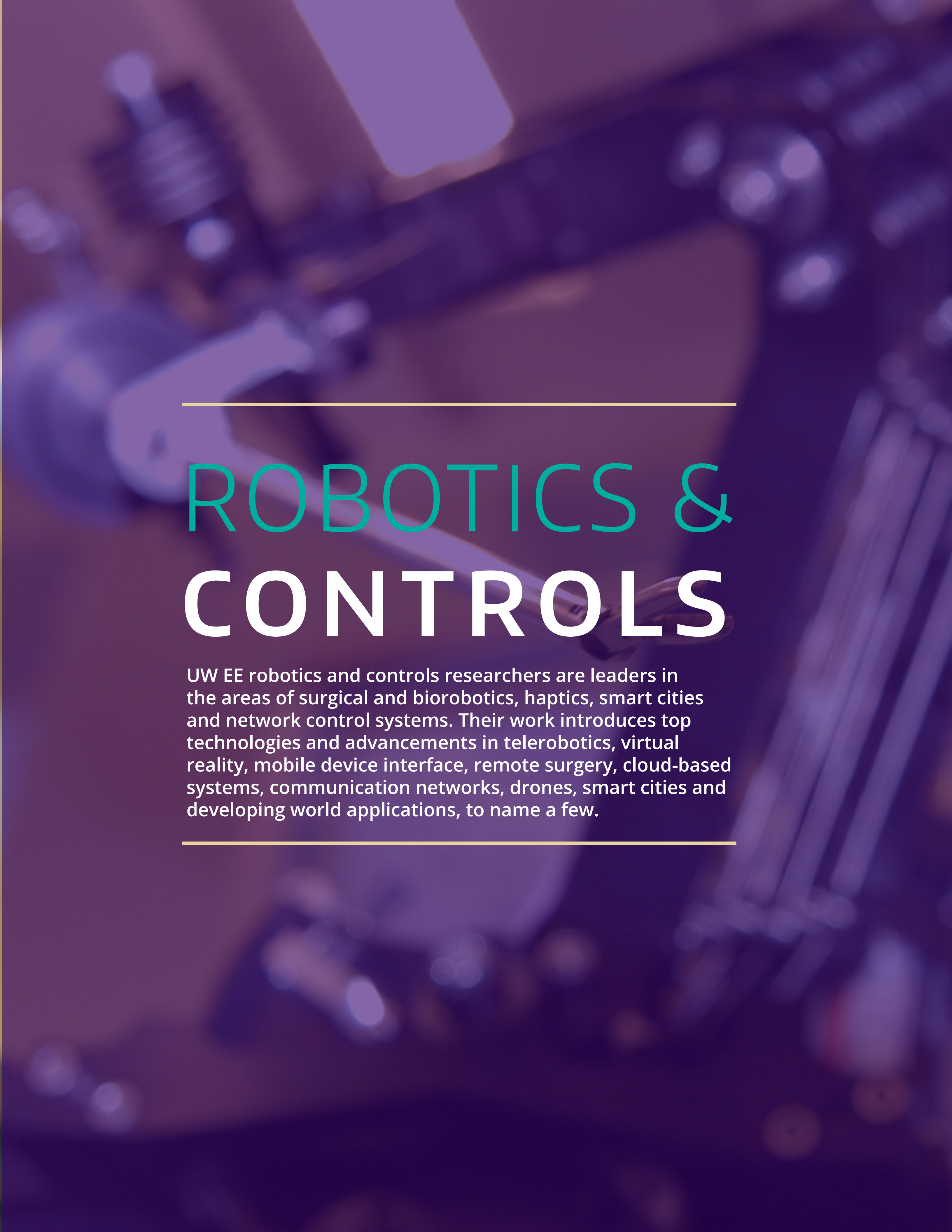
Daniel Arnitz, Researcher at Intellectual Ventures and former EE postdoc

STUDENT INVOLVED:

Josh Ensworth, Ph.D. '16

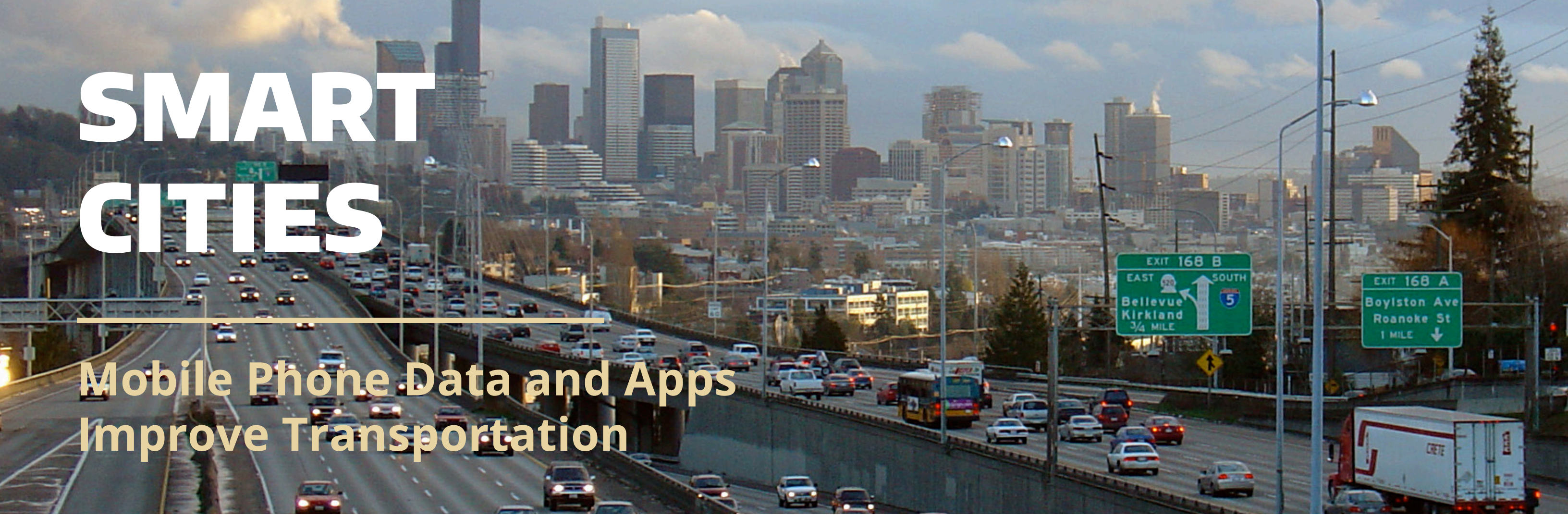
GRANT/FUNDING SOURCE:

Ricoh Innovations Inc. and various government agencies



ROBOTICS & CONTROLS

UW EE robotics and controls researchers are leaders in the areas of surgical and biorobotics, haptics, smart cities and network control systems. Their work introduces top technologies and advancements in telerobotics, virtual reality, mobile device interface, remote surgery, cloud-based systems, communication networks, drones, smart cities and developing world applications, to name a few.



SMART CITIES

Mobile Phone Data and Apps Improve Transportation

Baosen Zhang, Assistant Professor

Lillian Ratliff, Assistant Professor

Smart Transportation

As cities continue to develop and populations surge, the need for smart, available traffic solutions increases. In this three-year, proof-of-concept project, the consumer becomes a key player in urban transportation initiatives. Individual users are engaged through the use of smart devices. The platform serves as a virtual commons. Individual citizens can directly communicate with service providers.

The project utilizes smart devices due to their proliferation in the urban commuter space. The commuters, therefore, become active agents in a shared economy. Currently available applications for multimodal transport solutions focus on individual users and their local perspectives. This current application does not accurately represent an overall solution. Although there is large-scale data being collected by both municipalities and users, neither group has the resources to develop real-time analytics and controls.

Assistant Professors Baosen Zhang and Lillian Ratliff have collaborated with Vanderbilt University and the Cities of Nashville and Seattle to test the research. The range in size between the two cities offers a diverse testing bed for multimodal transport analysis.

The project will develop an architecture and framework to perform on a distributed platform and utilize multiple routes. The researchers will also develop the software to host a social platform capable of delivering relevant data and analytics. The cities offer real-world use for testing and implementation.

Smart Parking

Traffic congestion is increasingly becoming a bottleneck to sustainable urban growth as infrastructures are being stretched to their limits. Up to 40 percent of all surface level traffic in urban areas stems from drivers looking for parking. This project will develop new parking management tools using algorithms for cities and apps for drivers that allow municipalities to achieve better congestion control and enable drivers to act more efficiently.

Zhang and Ratliff address a host of environmental and infrastructure concerns, such as health, the environment and urban development. The project supports the development of a parking management tool, including algorithms for cities and apps for drivers. The information gathered will provide parking and congestion models to municipalities, allowing the city to achieve better congestion control and enable drivers to act more efficiently.

This project will result in fundamental advances in queuing theory and mechanism design. Specifically, the models study circulating traffic at block level resolution and the role information plays in driver decisions. The research develops a queue-flow network model of traffic informed by real data that captures network topology and spatio-temporal behavior; imposes a game theoretic structure on the queue-flow network that captures the strategic nature of heterogeneous users; and creates a living lab experimental platform in collaboration with the city of Seattle and industry partners for validation of Zhang and Ratliff's theories.

If this pilot is successful, this will inform how the city can engage the citizens more, not just with traffic congestion, but with other transportation and urban initiatives.

The heat map shows parking availability in a Seattle neighborhood. The red clustering illustrates limited parking availability, while the green depicts higher availability. Researchers are using this map to construct parking and congestion models.

ADDITIONAL INFORMATION

COLLABORATORS:

City of Seattle

City of Nashville

Vanderbilt University

GRANT/FUNDING SOURCES:

NSF U.S. Ignite Grant (Smart Transportation)

NSF EAGER Grant (Smart Parking)

BUILDING A FUTURE

THE REDSHIRT CONSORTIUM PREPARES LOW-INCOME STUDENTS FOR ACADEMIC SUCCESS IN ENGINEERING

LAYING THE FOUNDATION

EVE RISKIN
Professor and
Associate Dean of Diversity & Access

Professor Eve Riskin received a National Science Foundation Grant to support incoming first-year students who are interested in pursuing an engineering degree and who are from economically and educationally underserved backgrounds. The consortium is an extension of the STARS (Washington STate Academic RedShirt) program, and it will be a collaboration between six universities throughout the United States.

Research has found that increasing first- and second-year retention enhances the ability of academically talented low-income students to successfully graduate with engineering degrees. Riskin's "redshirt" model focuses on priming first-year college students for a future of academic success through an extra year of preparation. It consists of intensive academic advising, an innovative first-year academic curriculum, community building and career exploration and professional development activities.

University of Washington Department of Electrical Engineering Assistant Professor Sam Burden is co-PI on the grant and is leading the faculty-student mentoring program.

BY THE NUMBERS

800
SCHOLARSHIPS

BETWEEN THE SIX PARTNERING INSTITUTIONS, THERE WILL BE 800 SCHOLARSHIPS AWARDED.

$2.2
MILLION

A WASHINGTON STATE OPPORTUNITIES GRANT WAS AWARDED IN 2016 TO SUPPORT STUDENTS.

TAPPING INTO TALENT *RESULTS AFTER THREE YEARS*

80%

OF STARS STUDENTS HAVE ENTERED ENGINEERING DEPARTMENTS

STARS STUDENTS HAVE SIGNIFICANTLY IMPROVED IN MATH 124/125 AND CHEM 142

MULTI-COLLABORATIVE

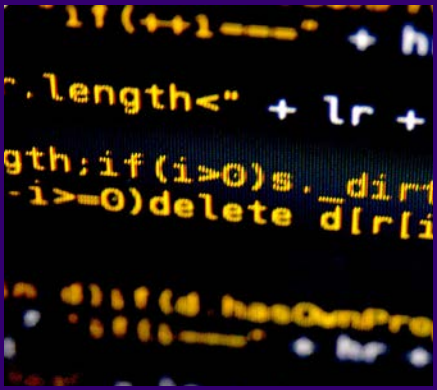
PARTNERING UNIVERSITIES INCLUDE:

THE UNIVERSITY OF WASHINGTON (LEAD)
THE UNIVERSITY OF COLORADO, BOULDER
THE UNIVERSITY OF ILLINOIS, URBANA-CHAMPAIGN
THE UNIVERSITY OF CALIFORNIA, SAN DIEGO
WASHINGTON STATE UNIVERSITY
BOISE STATE UNIVERSITY

STARTUP CENTRAL

ENTREPRENEURSHIP BEGINS AT UW EE

1

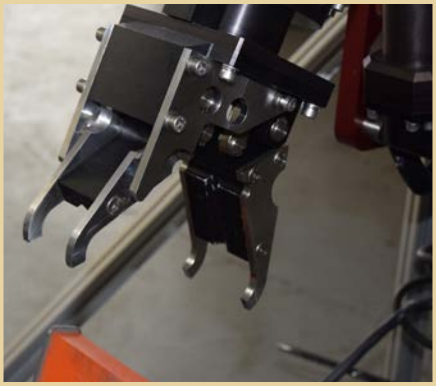


AQUARIUM

ERIC KLAVINS, PROFESSOR

Record-keeping in lab research has remained largely the same for generations — lab notebooks and lab reports have been the universal method for collecting data and detailing procedures, including instructions for replicating studies. This means that any inconsistencies in data recording methods make duplicating experiments unpredictable. Professor Eric Klavins' new startup, Aquarium LLC., aims to solve that with three components for the various needs of a biotechnology lab. The cloud-based Aquarium Operating System allows researchers to quickly and easily develop and execute experiments that are highly reliable to reproduce. Aquarium Analytics leverages the data generated to provide users with highly accurate predictions for any given experiment, including costs, the time it will take to complete and the probability of success. And with Aquarium Exchange users can share experiment workflows and protocols. Klavins and his co-founders were able to take the Aquarium project to market thanks to an award from the CoMotion Innovation Fund.

2



BLUHAPTICS

HOWARD CHIZECK, PROFESSOR

FREDRIK RYDÉN, PH.D. '13

There are two contradictory desires when managing tasks that are dangerous for humans — to keep the human at a safe distance and yet to have the dexterity of human hands. Meeting this need for precise control of remote operations is BluHaptics, a startup founded by UW Electrical Engineering faculty and students. The company grew out of work Professor Howard Chizeck and alum Fredrik Rydén were conducting on haptic interaction, which relays forces, vibrations and motion to operators of robotic systems. To enable precise control of robotic systems in underwater environments, BluHaptics developed software that applies haptic feedback together with 2D and 3D video in real-time. In 2016, BluHaptics was awarded a Phase II Small Business Innovative Research grant from the National Science Foundation. The $747,179 grant will be used to develop the company's remotely operated vehicle piloting software.

3

WIBOTIC

JOSHUA SMITH, ASSOCIATE PROFESSOR

BEN WATERS, PH.D. '15

Rechargeable robots generally need to be plugged in or to connect to a docking station. This is significantly less than optimal for robots that operate underwater or in the air. The start-up WiBotic, founded by EE alum Ben Waters (Ph.D. '15) and Associate Professor Joshua Smith, has developed a wireless charging system that requires robots to simply be in close proximity to a charging station to charge their battery. The WiBotic system automatically detects the robot and turns on. The robot then charges until either the battery is full or the robot is called away to another task. In 2016, WiBotic unveiled a system specifically designed for drones, industrial and aquatic robots. The system includes a wireless battery management system, which can significantly increase the lifetime of robot's battery, and fleet-level power management software, which dynamically monitors how an entire fleet of robots operates and uses the data to help create a custom operational plan to optimize the life of the entire collection of batteries in that specific fleet.

4

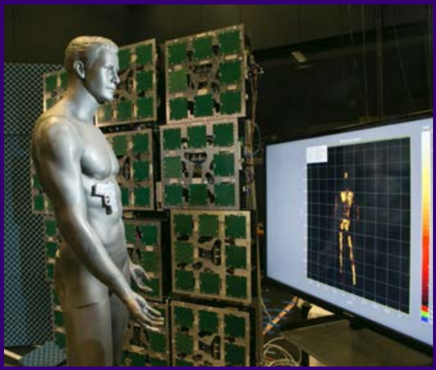
JEEVA WIRELESS

JOSHUA SMITH, ASSOCIATE PROFESSOR

SHYAM GOLLAKOTA, ADJUNCT PROFESSOR

Jeeva Wireless seeks to revolutionize the way devices communicate by enabling breakthrough transmission efficiency. The company has launched the Passive Wi-Fi system that can generate Wi-Fi transmissions using 10,000 times less power than conventional methods. Low-power options, such as Bluetooth Low Energy and Zigbee, cannot match the system's energy efficiency. Because of this, the project has landed the UW team in MIT Technology Review's top-ten list of breakthrough technologies in 2016. In 2017, the company raised $1.2 million to develop the revolutionary Passive Wi-Fi system. In addition to Associate Professor Josh Smith and Adjunct Professor Shyam Gollakota, other founding members are EE alums Vamsi Talla (Ph.D. '16) and Aaron Parks (M.S. '15) and graduate student Bryce Kellogg.

5



THRUWAVE

MATT REYNOLDS, ASSOCIATE PROFESSOR

An emerging startup from UW Electrical Engineering is developing imaging technology that can penetrate opaque objects or inclement weather, from wallboard, wood or concrete to fog, rain or sandstorms. ThruWave, led by Associate Professor Matt Reynolds, is leveraging several years of development funded by the Department of Homeland Security and other agencies to develop a new type of low-cost image sensor using millimeter-wave technology. Millimeter waves are high-frequency radio signals that, unlike more commonly known X-rays, are human-safe. ThruWave is focused on commercial and industrial applications of millimeter-wave imaging, such as quality control, security, robotics and construction. In addition to Reynolds, the founding team consists of UW EE postdoctoral associates Andreas Pedross-Engel and Claire Watts. UW's CoMotion is providing support for ThruWave via an Innovation Fund grant.

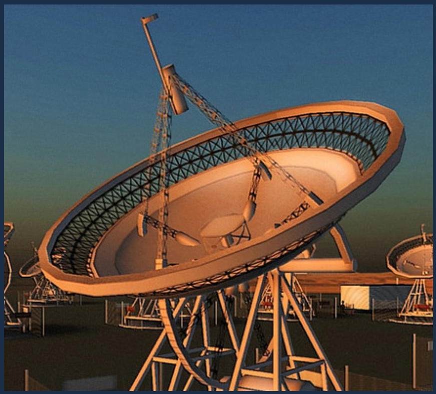
6

POTAVIDA

CHARLES MATLACK, PH.D. '14

Water-disinfecting systems for use by individuals have been around for years, but it's often not easy to tell when the water has become safe to drink. This may be irritating on a short camping trip, but it's life-threatening for the millions of people around the world who don't have access to clean drinking water. Alum Charles Matlack (Ph.D. '14) and his startup, PotaVida, have an answer — the Smart Solar Purifier. Designed by Matlack, the purification system consists of a reusable 10-liter hydration bag, with an electronic indicator that not only shows when the water is safe to drink but also records data. Users simply fill the bag with water, place it in the sun, press the start button and wait for the green light to indicate the disinfecting cycle has been completed. The PotaVida system is designed especially for disaster areas, where its data tracking is critically important for relief agencies that need to see if the purification systems are being successfully used. In 2016, PotaVida Smart Solar Purifiers were deployed in Somaliland and Haiti.

7



ONERADIO

JOHN SAHR, PROFESSOR

TONY GOODSON, AFFILIATE PROFESSOR

Modern radios have a one-track mind: no matter how high-tech they are, they're still bound by the same 100-year-old analog design that limits them to one frequency channel at a time. A universal radio capable of performing multiple functions simultaneously would be able to replace complex radio systems — such as on airplanes — with a single device. The OneRadio start-up aims to achieve just that. Developed by Professor John Sahr and Affiliate Professor Tony Goodson, the basic concept behind OneRadio is to create a single radio that is capable of performing multiple functions simultaneously. The technology combines hardware advances with software applications to allow users to perform many functions at once via software applications. In 2016, OneRadio participated in the Summer MBA Fellowship program with the Institute of Translational Health Sciences and the Washington Research Foundation. OneRadio was paired with a fellow to continue exploring commercialization opportunities.

FACULTY AWARDS

JEFFREY BILMES

The Best Paper Award went to Professor Jeffrey Bilmes and his co-authors at the Association for Computing Machinery Conference on Bioinformatics, Computational Biology, and Health Informatics in October 2016.

SAM BURDEN

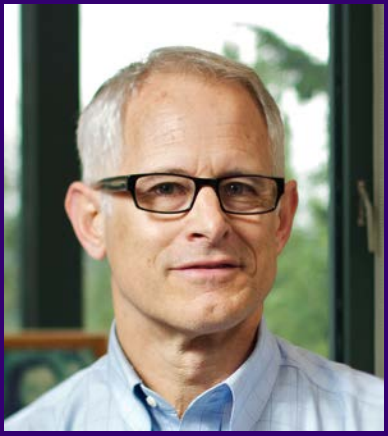
Assistant Professor Sam Burden was honored with an **Army Research Office (ARO) Young Investigator Program (YIP) Award**, one of the most prestigious awards the Army grants to early career researchers and scientists.

LINDA BUSHNELL

Research Associate Professor Linda Bushnell was the 26th UW EE faculty member to be elected an **Institute for Electrical and Electronics Engineers (IEEE) Fellow.** Bushnell was recognized for her significant contributions to networked control systems.

JAY GIRI

Affiliate Professor Jay Giri was named a **National Academy of Engineering member** for contributions to utility control center technologies to enhance grid situational awareness and reliability. Election to National Academy of Engineering membership is one of the highest professional honors accorded an engineer.



BLAKE HANNAFORD

Professor Blake Hannaford received the **Amazon Catalyst Award** for his proposal on the Intelligent Robotic Assistant. The fellowship supports solutions that address world challenges.

SREERAM KANNAN

Assistant Professor Sreeram Kannan received a **National Science Foundation Early Career Award**. As one of the NSF's most prestigious awards, it supports early-career faculty who have the potential to serve as academic role models in research and education and to lead advances in the mission of their department.

ERIC KLAVINS

Professor Eric Klavins received the **Amazon Catalyst Award** for his proposal on the UW BIOFAB Cloud Laboratory for Genetic Engineering. The fellowship supports solutions that address world challenges.

SHWETAK PATEL

Associate Professor Shwetak Patel was named an **Association for Computing Machinery (ACM) Fellow**. Patel's ACM peers chose to recognize him for his "contributions to sustainability sensing, low-power wireless sensing and mobile health."

RADHA POOVENDRAN

Professor and Chair Radha Poovendran was awarded a **2016 ECE Distinguished Alumni Award** from the University of Maryland. Poovendran was honored for his major influence to the science and engineering field of cyber security.

SHWETAK PATEL & GEORG SEELIG

Associate Professors Georg Seelig and Shwetak Patel received the **Microsoft Research 2016 Outstanding Collaborator Award**. The award highlights and celebrates the amazing academics who have worked with the company on research initiatives.

FOUR FACULTY RECEIVE GOOGLE RESEARCH AWARDS

Faculty members Chris Rudell, Joshua Smith, Hannaneh Hajishirzi and Shyam Gollakota received Google Research Awards in 2016. The funding covers tuition for one graduate student and allows faculty and students to work with Google engineers and researchers. A total of 151 projects were funded from 950 proposals.

SHYAM GOLLAKOTA

HANNANEH HAJISHIRZI

CHRIS RUDELL

JOSHUA SMITH

FACULTY AWARDS

GEORG SEELIG

Associate Professor Georg Seelig and collaborators in Computer Science & Engineering, where Seelig holds a joint appointment, and at Microsoft received the **"Best of What's New" Award** from Popular Science for their work on DNA storage.

ELI SHLIZERMAN

Assistant Professor Eli Shlizerman received **the 2016 Applied Math Teaching Award for outstanding teaching** by a member of the faculty. He specializes in teaching courses in the field of scientific computing for both undergraduate and graduate students.

JOSHUA SMITH

Associate Professor Joshua Smith is a co-PI on groundbreaking Passive Wi-Fi research. The paper received **the 2016 Best Paper Award** at the 13th USENIX Symposium on Networked Systems Design and Implementation.

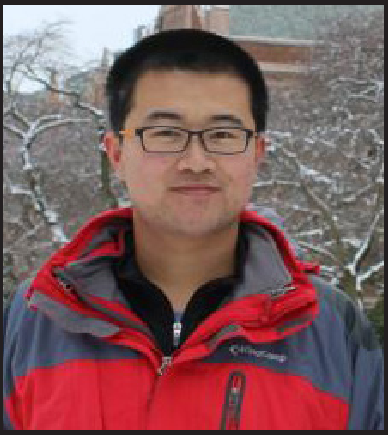
DENISE WILSON

Professor Denise Wilson and co-authors were awarded **the Best Paper Award** for the 2016 ASEE Annual Conference for the New Engineering Educators Division. The paper investigated student perceptions of faculty support.

STUDENT AWARDS

LAURA ADAM

Postdoctoral researcher Laura Adam in Professor Eric Klavins' lab was awarded a **2016 CoMotion Innovation Fund grant** for her ebioHUB project. Adam developed ebioHUB — a toolbox to integrate and manage the numerous sources of information that accompanies experiments.



WENRUO BAI

The Best Paper Award went to graduate student Wenruo Bai and his co-authors at the Association for Computing Machinery Conference on Bioinformatics, Computational Biology, and Health Informatics in October 2016. The paper discussed the algorithm to improve spectra identification when analyzing peptides.

DAVID DOLENGEWICZ

Undergraduate student David Dolengewicz was awarded a **Mary Gates Research Scholarship**. Dolengewicz's research, conducted with Professor Les Atlas, looks at how humans hear pitch, which is critical for hearing tonal languages, distinguishing between voices in noisy settings and enjoying music.

RAHIL JAIN

Graduate student Rahil Jain and his team were awarded a **Third Prize at the inaugural GIX Innovation Competition** for their SmartDx project. The annual Innovation Competition for university students was created to spur solutions to global challenges. SmartDx addresses the accuracy of existing infectious disease rapid tests.

PEIFENG JING

Graduate student Peifeng Jing received a **UW Clean Energy Institute Graduate Fellowship** for academic year 2015-2016. Jing's research focuses on using photonic crystal structures as highly efficient solar energy concentrators for thin-film perovskite solar cells.

WILLIAM LI

Undergraduate student William Li and co-authors earned a **Best Paper Award** at the 2016 International Joint Conference on Pervasive & Ubiquitous Computing. The paper was "HemaApp: Noninvasive blood screening of hemoglobin using smartphone cameras."

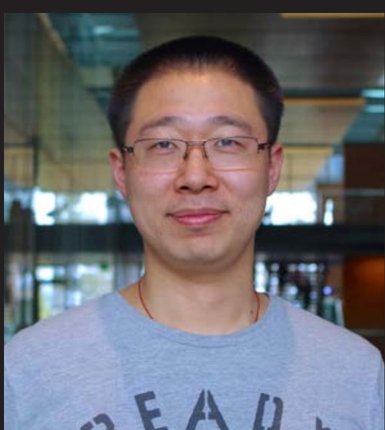
STUDENT AWARDS

KATHERINE PRATT

Graduate student Katherine Pratt was named to the inaugural class of **Husky 100** recipients. Pratt, who joined the United States Air Force after graduating from MIT, is studying neuroengineering and works in the BioRobotics Lab with Professor Howard Chizeck.

BRYAN BEDNARSKI & JACLYN WILSON

Undergraduates Bryan Bednarski and Jaclyn Wilson were chosen as **2016-2017 IEEE Power & Energy Society Scholars**. The prestigious award is awarded to the highest-achieving electrical engineering students, with a focus in the power and energy sector, across the U.S.

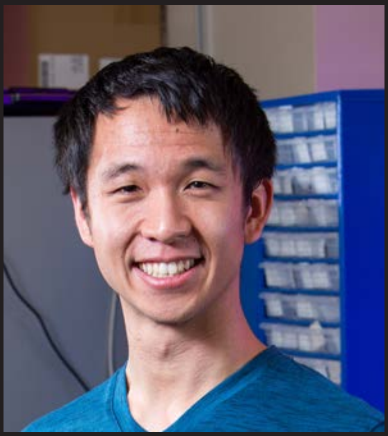


DI SUN

Graduate student Di Sun received several awards for his innovative self-cleaning solar panel project: a **Clean Energy Institute Graduate Fellowship,** the **Smukowski Family Best Sustainable Advantage prize** at the UW Business Plan Competition and the **JARL Prize** at the Alaska Airlines Environmental Innovation Challenge.

EVAN WANG

Undergraduate student Evan Wang received the **2015-2016 Junior Medal for High Scholarship**. Each year, the University of Washington awards three High Scholarship medals to the highest-performing first year, sophomore and junior at the UW. The award recognizes Wang's outstanding academic achievements.

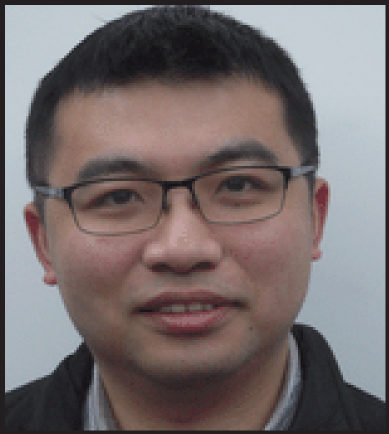


EDWARD WANG

Graduate student Edward Wang and co-authors earned a **Best Paper Award** at the 2016 International Joint Conference on Pervasive & Ubiquitous Computing. The paper was "HemaApp: Noninvasive blood screening of hemoglobin using smartphone cameras."

SCOTT WISDOM

Graduate student Scott Wisdom received two travel grants to present a paper at the **2016 Neural Information Processing Systems (NIPS) conference** in Barcelona, Spain. NIPS is a top conference for research in multi-track machine learning and computational neuroscience.



TONG ZHANG

Graduate student Tong Zhang received the prestigious **2016 IEEE Solid-State Circuit Society Pre-Doctoral Award**. The award recognizes excellence in the field for pre-doctoral candidates. There are less than 20 awards conferred worldwide.

BRYCE KELLOGG

Graduate student Bryce Kellogg was an author on a Passive Wi-Fi paper, which was presented at the 13th USENIX Symposium on Networked Systems Design and Implementation. It received the **2016 Best Paper Award**. EE adjunct faculty member and assistant professor of computer science & engineering Shyam Gollakota, associate professor of electrical engineering and computer science and engineering Joshua Smith and EE alum Vamsi Talla (Ph.D. '16) were additional authors on the paper. Passive Wi-Fi has the ability to impact the Internet of Things, which connects everyday objects to the internet, allowing battery-free household devices and sensors to communicate.

ALUMNI AWARDS

MATTHEW CLEMENT

Matthew Clements (MSEE '03) was featured on the Silicon Valley Business Journal's list of "**40 Under 40 in 2016**" for his career accomplishments and quick rise to the position of lead administrative patent judge. Clements is the lead administrative patent judge for the U.S. Patent and Trademark Office in Silicon Valley.

SAM DOMMER

Sam Dommer (BSEE '14) competed in the **2016 Rio Olympics with the Men's Eight for Team USA**. The rowing team came in fourth overall. While at the University of Washington, Sam split his time between his electrical engineering major in embedded systems and his challenging rowing schedule.

CJ HWANG

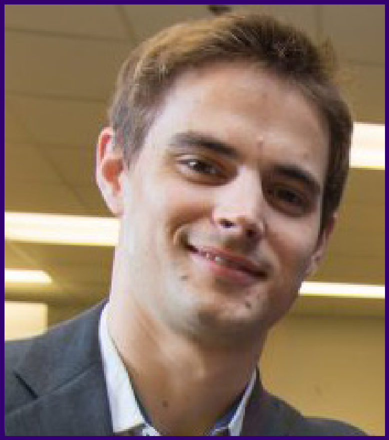
Cherng Jia "CJ" Hwang (MSEE '64, Ph.D. '66) has been awarded the **UW College of Engineering's 2017 Diamond Award for Entrepreneurial Excellence**. As the creative force behind semiconductor lasers and the founder of three companies, Hwang was honored for his dedication to societal impact and for his groundbreaking achievements in laser development.

VAMSI TALLA

Vamsi Talla (Ph.D. '16) received the **2016 WAGS/UMI Outstanding Innovation in Technology** award for his doctoral thesis. The award given by the Western Associations of Graduate Schools (WAGS) and University Microfilms International (UMI) recognizes the innovative application of technology to scholarship in a master's thesis or dissertation.

JEAN WANG

Jean Wang (MSEE '04, Ph.D. '07) has been awarded the **UW College of Engineering's 2017 Diamond Award for Early Career Achievement**. In addition to her work on Project Glass, Wang was a founding member of the robotic surgery team at Google Life Sciences. Her cutting-edge work focuses on advancing the technology to aid in everyday life.



BEN WATERS

Ben Waters' (Ph.D. '15) company, WiBotic, was named a **GeekWire "Top Ten."** GeekWire announced which top Seattle startups were transforming the tech scene. In order to join the prestigious list, a company had to exhibit a world-changing business idea. WiBotic's innovative design and functionality makes it particularly unique and adaptive in today's market.

Delia Zeutschel, Milton Zeutschel and UW EE Professor and Chair Radha Poovendran, from left.

UW EE RECEIVES $2 MILLION TO SUPPORT ENTREPRENEURIAL EFFORTS

Milton “Milt” Zeutschel (BSEE ‘60) and Delia Zeutschel are passionate about seeing engineering propel innovation and entrepreneurship at the University of Washington, its College of Engineering and for the State of Washington. It is because of this passion that the Zeutschels have given $2 million to further advance the University of Washington Electrical Engineering Entrepreneurial Capstone Program, known as ENGINE

Established in the spring of 2016, the ENGINE program enables students to work on industry sponsored projects. Students are mentored by both industry professionals and faculty. This dual engagement develops students’ skills in innovation and entrepreneurship, systems engineering, project management and product development. This new initiative offers select companies an opportunity to benefit from the vibrant innovation culture at the University of Washington’s Department of Electrical Engineering.

As an entrepreneur and a philanthropist, there could be no better partner to ENGINE than Mr. Zeutschel. From the beginning, he has invested his resources into ENGINE, a program he says would have greatly benefited him while in college. Mr. Zeutschel’s commitment to the program will endure.

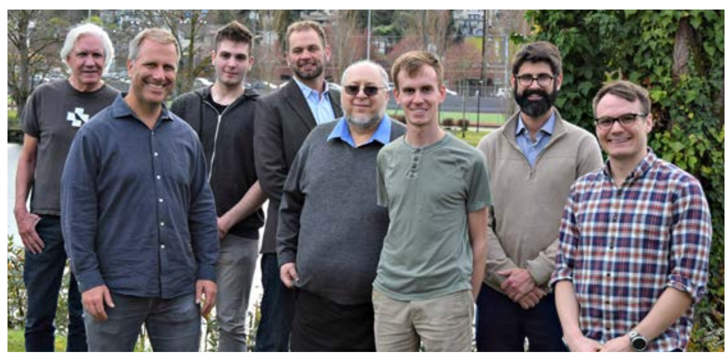
“I want to continue to engage in the program every way I can,” Mr. Zeutschel said. “I would love to be a resource for students and professors.”

The value of the ENGINE program goes beyond student experience. ENGINE fosters an innovation ecosystem at the UW, which creates a ripple effect throughout the entire State of Washington.

Associate Professor Josh Smith, Assistant Professor of CSE and Adjunct Professor of EE Shyam Gollakota, CSE postdoctoral researcher Vamsi Talla, Ph.D. student Bryce Kellogg and Ph.D. student Aaron Parks, from left.

UW RESEARCHERS RAISE $1.2M FOR THE DEVELOPMENT OF BREAKTHROUGH PASSIVE WI-FI

UW Electrical Engineering and Computer Science and Engineering researchers have raised $1.2 million to develop and commercialize a power-efficient way to generate Wi-Fi transmissions. This funding will support the UW-based startup Jeeva Wireless. This company seeks to revolutionize the way devices communicate by enabling breakthrough transmission efficiency. The company has launched the Passive Wi-Fi system, which can generate Wi-Fi transmissions using 10,000 times less power than conventional methods. Low-power options, such as Bluetooth Low Energy and ZigBee, cannot match the system’s energy efficiency.



BLUHAPTICS RAISES $1.3M TO BRING SOFTWARE TO SPACE

BluHaptics, the software company pioneering new solutions for telerobotics, has secured $1.36 million. This investment follows more than a million dollars in recent U.S. government grants, which together will be used to support the company’s expansion and launch of its first commercially-available product. The startup was founded by Professor Howard Chizeck and then doctoral student Fredrik Rydén (Ph.D. ’13). The company grew out of the work Chizeck and Rydén were conducting on haptic interaction, which relays forces, vibrations and motion to operators of robotic systems. BluHaptics’ devices are unique in that they use force-feedback control systems and 3-D displays to let customers control robots more easily and efficiently. The software can be used with oil rigs, excavation tools and – eventually – with satellites and drones.

ELECTRICAL ENGINEERING FACULTY

Anantram, M. P.
Professor
NANOTECHNOLOGY, MATERIALS & DEVICES
Ph.D., 1995 Purdue University

Arabshahi, Payman
Associate Professor & Director of Advancement
SIGNAL PROCESSING & COMMUNICATIONS
Ph.D., 1994 University of Washington

Atlas, Les
Professor
SIGNAL & IMAGE PROCESSING
Ph.D., 1984 Stanford University
NSF Presidential Young Investigator, IEEE Fellow

Bilmes, Jeff
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SIGNAL & IMAGE PROCESSING
Ph.D., 1999 UC-Berkeley
NSF CAREER Award

Böhringer, Karl F.
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MICROELECTROMECHANICAL SYSTEMS (MEMS)
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Bushnell, Linda
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IEEE Fellow, NSF ADVANCE Fellow, Army Superior Civilian Service Award

Chen, Tai-Chang
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Chizeck, Howard
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Sc.D., 1982 MIT
IEEE Fellow, AIMBE Fellow

Christie, Rich
Associate Professor
ENERGY SYSTEMS
Ph.D., 1989 Carnegie Mellon University
NSF Presidential Young Investigator

Crum, Lawrence
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MEDICAL ULTRASOUND
Ph.D., 1967 Ohio University
ASA Fellow

Darling, R. Bruce
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DEVICES, CIRCUITS & SENSORS
Ph.D., 1985 Georgia Institute of Technology

Dunham, Scott
Professor
MATERIALS & DEVICES
Ph.D., 1985 Stanford University

Fazel, Maryam
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CONTROL & OPTIMIZATION, SYSTEMS BIOLOGY
Ph.D., 2002 Stanford University
NSF CAREER Award

Fu, Kai-Mei
Assistant Professor
QUANTUM INFORMATION & SENSING
Ph.D., 2007 Stanford University
NSF CAREER Award

Hajishirzi, Hannaneh
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ARTIFICIAL INTELLIGENCE
Ph.D., 2011 University of Illinois at Urbana-Champaign

Hannaford, Blake
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BIOROBOTICS
Ph.D., 1985 UC-Berkeley
IEEE Fellow, IEEE EMBS Early Career Achievement Award, NSF Presidential Young Investigator

Hauck, Scott
Professor
VLSI & DIGITAL SYSTEMS
Ph.D., 1995 University of Washington
IEEE Fellow, NSF CAREER Award, Sloan Research Fellowship

Hwang, Jenq-Neng
Professor & Associate Chair for Global Affairs
SIGNAL & IMAGE PROCESSING
Ph.D., 1988 University of Southern California
IEEE Fellow

Jandhyala, Vikram
Professor & UW Vice President for Innovation Strategy
ELECTROMAGNETICS, FAST ALGORITHMS, DEVICES
Ph.D., 1998 University of Illinois
NSF CAREER Award

Kannan, Sreeram
Assistant Professor
INFORMATION THEORY AND COMPUTATIONAL BIOLOGY
Ph.D., 2012 University of Illinois
NSF CAREER Award

Kirchhoff, Katrin
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MULTILINGUAL SPEECH PROCESSING, MACHINE LEARNING
Ph.D., 1999 University of Bielefeld

Kirschen, Daniel
Professor & Associate Chair for Education
ENERGY SYSTEMS
Ph.D., 1985 University of Wisconsin – Madison
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Klavins, Eric
Professor
SYNTHETIC BIOLOGY
Ph.D., 2001 University of Michigan
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Kuga, Yasuo
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ELECTROMAGNETICS
Ph.D., 1983 University of Washington
IEEE Fellow, NSF Presidential Young Investigator

Lin, Lih
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Ph.D., 1996 UC-Los Angeles
IEEE Fellow

Majumdar, Arka
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NANO-OPTOELECTRONICS, OPTICAL IMAGING
Ph.D., 2012 Stanford University
AFOSR Young Investigator

Mamishev, Alex
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Ph.D., 1999 MIT
NSF CAREER Award

Nelson, Brian
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PLASMA PHYSICS
Ph.D., 1987 University of Wisconsin – Madison

Ortega-Vazquez, Miguel
Assistant Professor
ENERGY SYSTEMS
Ph.D., 2006 University of Manchester

Ostendorf, Mari
Professor
SIGNAL & IMAGE PROCESSING
Ph.D., 1985 Stanford University
IEEE Fellow

Otis, Brian
Research Associate Professor
RF/ANALOG IC DESIGN
Ph.D., 2005 UC-Berkeley
NSF CAREER Award

Patel, Shwetak
Associate Professor
UBIQUITOUS COMPUTING, EMBEDDED SYSTEMS, SENSORS
Ph.D., 2008 Georgia Institute of Technology
MacArthur Fellow, Sloan Research Fellowship, NSF CAREER Award, PECASE Award

Peckol, James
Principal Lecturer
Ph.D., 1985 University of Washington

Poovendran, Radha
Professor & Chair
NETWORK SYSTEM SECURITY & CYBER-PHYSICAL SYSTEMS
Ph.D., 1999 University of Maryland
IEEE Fellow, PECASE Award, ONR YIP & ARO YIP Awards, NSF CAREER Award, NSA Rising Star Award

Ratliff, Lillian
Assistant Professor
SMART URBAN SPACES
Ph.D., 2015 UC-Berkeley

Reynolds, Matt
Associate Professor &
Associate Chair for Research
WIRELESS POWER TRANSFER, BIOMEDICAL APPLICATIONS
Ph.D., 2003 M.I.T

Riskin, Eve
Professor & Associate Dean of Diversity & Access
SIGNAL & IMAGE PROCESSING
Ph.D., 1990 Stanford University
IEEE Fellow, Sloan Research Fellowship, NSF Presidential Young Investigator

Ritcey, James
Professor
COMMUNICATIONS & SIGNAL PROCESSING
Ph.D., 1985 UC San Diego
IEEE Fellow

Roy, Sumit
Professor
COMMUNICATIONS & NETWORKING
Ph.D., 1988 UC Santa Barbara
IEEE Fellow

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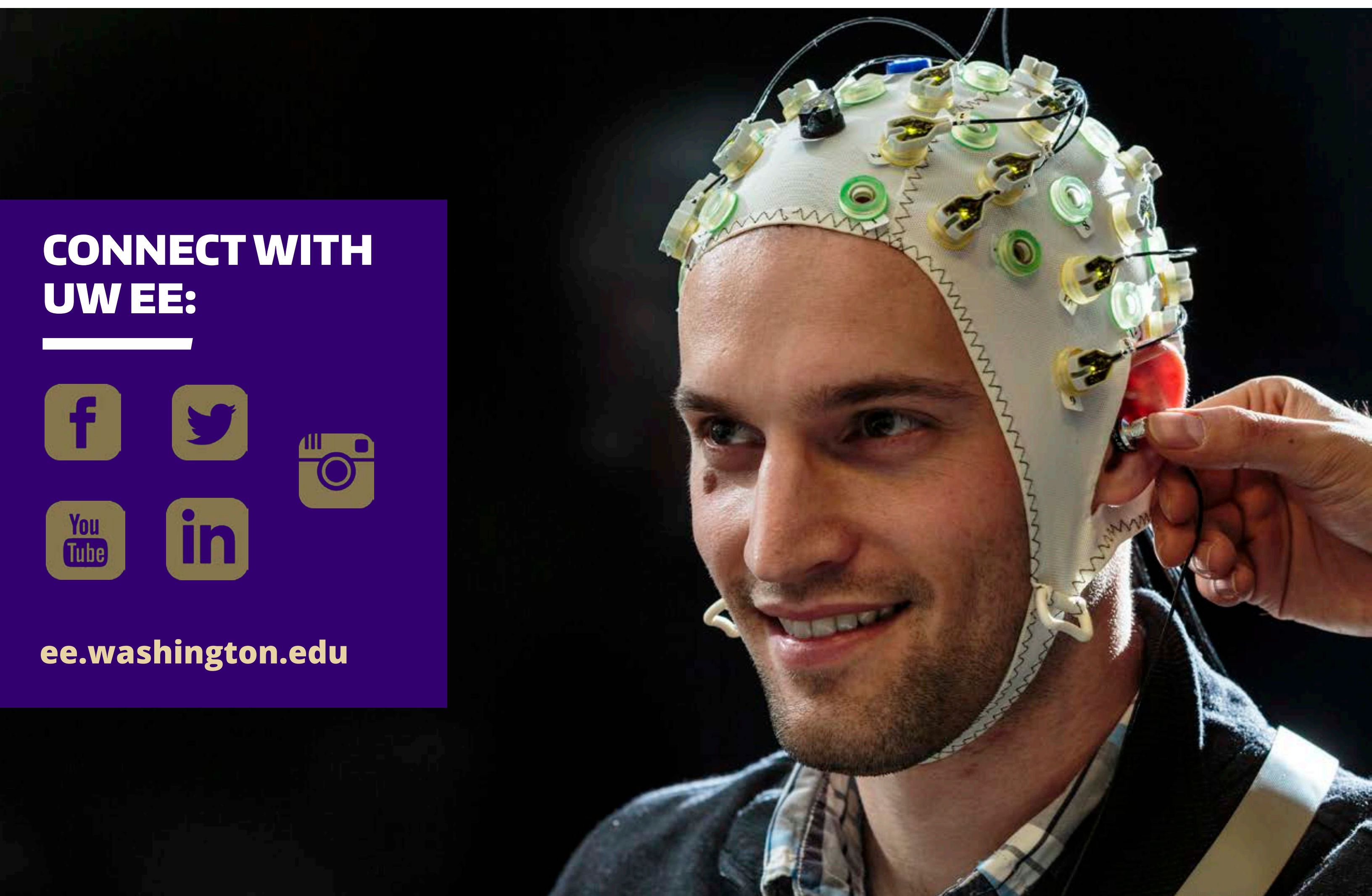

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