SPRING 2019 VOL. 33, NO. 1

SYSTEMSOLUTIONS

THE INSTITUTE FOR SYSTEMS RESEARCH
A. JAMES CLARK SCHOOL *of* *ENGINEERING*

isr.umd.edu

Power electronics

Alireza Khaligh's Maryland Power Electronics Laboratory tackles the power conversion challenges of electric vehicles, aircraft, residential solar systems and energy harvesting

director's MESSAGE

I can hardly believe a year has passed since my return to the University of Maryland and the Institute for Systems Research. I'm happy to report that, much like during my days as a graduate student in the early 1990s, ISR is one of the most intellectually diverse research centers on the campus. Indeed, much like when I was a student, I'm exposed to new ideas and concepts every day because of ISR's diversity and breadth. I'm so happy to have this opportunity to return.

I'm also thrilled to report that ISR is as central as ever to the major research questions of the day. Opportunities that are particularly exciting include:

- **Autonomy and AI:** ISR supports the Maryland Robotics Center, a group of more than 40 faculty working on everything from underwater and flying robots to the integration of perception and action. ISR faculty are making advances in formal methods, control and measurement techniques, all of which have great application to the challenges of creating trusted and verifiable autonomous systems. As the University of Maryland develops its collective approach to AI and autonomy, ISR will play a central role in research and educational activities going forward.
- **Trusted systems:** Recent reports from the Defense Science Board and MITRE have documented new vulnerability landscapes in our increasingly cyber-physical world. Examples range from Volkswagen's defeat devices to indistinguishable counterfeit parts produced by 3D printers. I am optimistic that efforts in ISR around trusted chips, formal methods, and advanced design and manufacturing all have something to contribute to this important problem.
- **Human-centered systems:** The most profound transformations that are emerging from the union of AI, computation and sensor technology are those related new, data-driven forms of understanding about human physical and cognitive performance. As my predecessor, Dr. Reza Ghodssi, continues to grow the university-wide Brain and Behavior Initiative, I'm struck by how well positioned ISR is to contribute engineering and mathematical insights to problems ranging from understanding human social behavior to the design of ingestible sensors to explore our microbiomes.

As ISR travels in its third decade, I look forward to the insights, discoveries and results that emerge from Maryland's flagship interdisciplinary research center. Stay tuned.

— Bill Regli

Adomaitis thin film experiment aboard International Space Station

Experimental work by Professor **Raymond Adomaitis'** (ChBE/ISR) Thin Film Group was launched to the International Space Station (ISS) in November.

The ISS uses large white panels to radiate its waste heat into space. The electrically insulating pigment used to coat these radiators is designed for optimal emission of waste thermal radiation and minimal absorption of solar radiation. Because the pigment can become differentially charged in low Earth orbit (LEO), Adomaitis has been working with NASA's Goddard Space Flight Center to develop ultra-thin conductive coatings that can dissipate static charge while not interfering with the optical properties of the pigments. These coatings are part of the MISSE-10 experiment now aboard the ISS, exposing a range of material samples to the surprisingly active LEO environment for more than a year in space; the samples will be returned to Earth for further evaluation.

Learn more: Additional details about the launch and experiment are at *go.umd.edu/thinfilm1118*.

AN ANTARES ROCKET, WITH THE ADOMAITIS EXPERIMENT ABOARD, BLASTS OFF FROM NASA'S WALLOPS ISLAND FLIGHT FACILITY ON NOV. 17.

IN THIS ISSUE:

Khaligh, MPEL lab address electric vehicle, aircraft and residential solar system challenges

Associate Professor **Alireza Khaligh's** (ECE/ISR) energetic and successful research program is making important strides in power electronics, devices that convert electricity from one form to another. He and his Maryland Power Electronics Laboratory students and campus collaborators received significant funding in 2018 to develop converters for electric vehicles, more electric aircraft, residential photovoltaics (PV) and energy harvesting systems. Khaligh is working with government and industry partners on a wide variety of projects and educational initiatives.

Invention of the Year

In April, Khaligh and his Ph.D. students **Jiangheng Lu** and **Ayan Mallik** won the University of Maryland Invention of the Year Award for their "Integrated Power Electronics Interface for Enhanced Electric Vehicle Charging." The invention won the physical sciences category and the overall Invention of the Year.

Currently, hybrid and all-electric vehicles have two separate batteries and charging systems: one for the engine and another for the "infotainment" system. These add to the expense of the vehicles and are an impediment to their more widespread adoption. The researchers invented an interface that simplifies the circuitry and allows the entire vehicle to use a single charger that is more than 50 percent cheaper and lighter, almost 40 percent smaller, and 8 percent more efficient. The interface can be incorporated into many vehicle makes and models, and also allows the car battery to be used as an electric source during a power outage.

A $2.37M DOE residential solar power converter project

Khaligh is the principal investigator for a three-year, $2.37M Department of Energy (DOE) cooperative agreement, "Compact and Low-Cost Microinverter for Residential Systems." The team also includes Professor **Patrick McCluskey** (ME/CALCE); **Patrick Chapman**, SunPower Corp.; and Assistant Professor **Fariborz Musavi** (EE), Washington State University Vancouver.

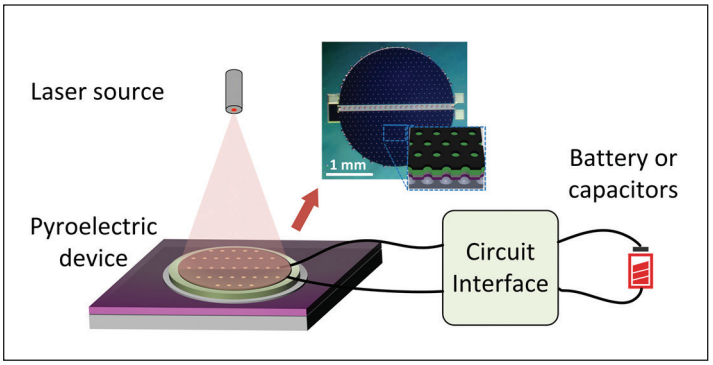
Hardware innovations are critical to address solar photovoltaic (PV) reliability challenges and lower the cost of installing and maintaining these systems. Power electronics are the critical link between PV arrays and the electric grid. Advances in power electronics can help grid operators rapidly detect and respond to problems, protect against physical and cyber vulnerabilities, and enable consumers to manage electricity use.

Khaligh's team is developing a new generation of residential system microinverters using emerging gallium nitride (GaN) semiconductors. The new microinverters will cost less to produce and deliver enhanced reliability, thermal management and packaging. The resulting products will be commercialized for residential, commercial and power plant applications by SunPower, a high-performance PV systems technology company.

The project is part of DOE's Advanced Power Electronics Design for Solar Applications program, which hopes to cut the cost of solar energy system power electronics in half by 2030.

New pyroelectric system transmits power wirelessly, harvesting and storing energy from heat source

Khaligh and his Ph.D. students **Zeyu Zhang** and **Chuan Shi** teamed with alumnus and U. S. Army Research Laboratory (ARL) materials engineer **Brendan Hanrahan** (MSE Ph.D. 2013), to build a high-power-density pyroelectric generator with an integrated, high-frequency, cycled pyroelectric energy storage system. This groundbreaking system can transmit heat wirelessly via lasers, then harvest electricity from temperature changes and store it. Their paper, "Management and storage of energy converted via a pyroelectric heat engine," was published in the Elsevier journal *Applied Energy*.



CREDIT: ZEYU ZHANG

THE INTEGRATED SYSTEM FOR THIN-FILM PYROELECTRIC ENERGY HARVESTING CAN TRANSMIT POWER WIRELESSLY AND HARVEST AND STORE ENERGY FROM A HEAT SOURCE.

Scientists long have been working on ways to harvest power from renewable environmental resources like waste heat. It would better supply electricity to small-scale devices such as those found in the Internet of Things and sensor networks. This new pyroelectric system is the first time high-frequency-cycled pyroelectric energy conversion has been successfully combined with the ability to recharge batteries.

The system consists of a laser beam heat source; an advanced energy converting device that uses a lead zirconate titanate pyroelectric thin film material; a practical synchronizing power interface; and an energy storage component. The "testbed" circuit system will make it possible to test the performance of various pyroelectric thin-film materials for the future. The system has shown great potential in thermal energy harvesting for small-scale distributed devices and could be further converted into a version incorporating all-passive energy harvesting.

The work was funded under the ARL Frontiers program, which selects specific technologies and accelerates their readiness level.

Continued funding from Boeing for more electric aircraft

Khaligh's research group has received a new round of funding from the Boeing Co. for their ongoing collaboration to develop more electric aircraft. Aircraft use a variety of power sources in their non-propulsive systems—hydraulic, pneumatic, mechanical and electrical. To optimize performance, decrease

operating and maintenance costs, increase reliability and reduce fuel emissions, the aircraft industry is developing aircraft that use electric power for all non-propulsive systems. This concept is known as "more electric aircraft."

The Boeing collaboration has already yielded a silicon carbide-based Rectified Transformer Rectifier Unit (RTRU) that is 40 percent lighter and 8 percent more efficient than what Boeing currently uses. An RTRU converts AC power generated by the aircraft's engine or APU generators for use by various electrical components of the aircraft.

Now Khaligh's group, along with Patrick McCluskey (ME/CALCE), is building an innovative GaN semiconductor-based modular power electronic RTRU for commercial aircraft such as the Boeing 787.

With research on novel circuit topologies and innovative switching schemes enabled by next-generation wide-bandgap GaN power transistors, the researchers are hopeful they can reduce the RTRU volume by a further 30 percent, while boosting overall reliability and performance of the power electronic system.

REU and IRES summer programs in power electronics

In 2018 Khaligh directed an NSF Research Experiences for Undergraduates (REU) program in transportation electrification and an International Research Experience for Graduate and Undergraduate Students (IRES) in electrified and autonomous transportation. In the REU program, undergraduates from across the U.S. worked on power electronics packaging, chargers for electric vehicles, high-energy batteries, and ultracapacitor energy storage systems.

In the IRES program, five students traveled to the Technical University of Madrid to conduct research in onboard chargers for electric vehicles, electronic packaging, fuel efficiency for autonomous vehicles, and hybrid energy storage systems.

—•—

Khaligh continues to build the capabilities of his power electronics program. Additional innovations from his group will be forthcoming across the wide spectrum of the field.

Learn more: Visit Khaligh's MPEL lab online at *khaligh.ece.umd.edu*.

Biofilm treatment device receives TEDCO MII funding

CREDIT: RYAN HUISZOON, MEMS SENSORS AND ACTUATORS LABORATORY

WIRELESS READOUT AND CONTROL SYSTEM SCHEMATIC SHOWING SENSOR EMBEDDED ON AN INSERTED URINARY CATHETER

Development of the flexible urinary catheter insert for detection, monitoring and treatment of biofilm continues to make strong progress. This April, the device won the University of Maryland Invention of the Year Award in the Life Sciences category

Professor **Reza Ghodssi** (ECE/ISR) has received new funding from the State of Maryland to help bring the device to commercialization, and his team has published its latest results in *IEEE Transactions on Biomedical Engineering*.

Maryland's Technology Development Corp. (TEDCO) has given Ghodssi $115K in Maryland Innovation Initiative (MII) funding to develop the invention towards commercialization. The device holds promise for a better way of dealing with biofilm growth in medical devices and its accompanying issues of infection.

The MII program fosters the transition of promising technologies that have significant commercial potential from the universities where they were discovered to the commercial sector, where they can be developed into products and services that meet identified needs.

"Flexible Platform for In Situ Impedimetric Detection and Bioelectric Effect Treatment of Escherichia coli Biofilms" was published in October. The paper was written by Bioengineering Ph.D. student **Ryan Huiszoon**; **Sowmya Subramanian** (EE Ph.D. 2016); ISR Postdoctoral Researcher **Pradeep Ramiah Rajasekaran**; **Luke Beardslee**, M.D., Ph.D.; Professor **William Bentley** (BIOE/Fischell Institute); and Ghodssi.

The paper describes the current state of the development of the catheter insert. The authors demonstrate that biofilm growth and reduction can be effectively monitored by measuring the impedance of electricity, and treated through the bioelectric effect, which combines low voltages of electricity with small dosages of antibiotics.

The paper also details the research team's successful efforts to miniaturize the components of the device and control it through wireless signals. Shrinking the platform increases its usefulness in additional settings, like medical devices placed within the GI tract, artificial joints and other unreachable artificial surfaces placed within the human body.

Ghodssi notes that the MII funding is enabling the researchers to fine-tune the device in preparation for *in vivo* implementation and clinical trials, allowing testing in a range of fluidic environments. "The TEDCO MII grant enables technology-driven research like ours to go through additional testing and calibration that we would not have been able to do otherwise," he says. "It allows us to focus on developing an improved prototype for the next stage in the process of bringing this device to market and improving medical care."

Learn more: Read a review of the evolution of the catheter insert at *go.umd.edu/catheter417*. Read the IEEE TBME paper at *ieeexplore.ieee.org/document/8477054*.

Neuromorphic and data-driven speech segregation

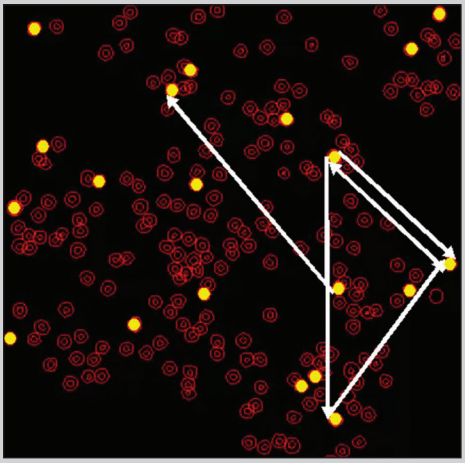
Professor **Shihab Shamma** (ECE/ISR) is the principal investigator and Professor **Carol Espy-Wilson** (ECE/ISR) is the co-PI for a three-year, $851K National Science Foundation award, "Neuromorphic and Data-Driven Speech Segregation."

Their research will investigate how the auditory cortex processes of the brain can be adapted, mimicked and applied to address the artificial intelligence (AI) signal processing challenge of robust perception in extremely noisy and cluttered environments. The neural representations of speech and music are of particular interest.

The project will develop algorithms inspired by the architecture of the brain to segregate and track targeted speakers and sound sources, test their performance, and relate them to state-of-the-art approaches that use deep artificial neural networks to accomplish these tasks.

This effort will spur the development of new neuromorphic computational tools modeled after the brain and its cognitive functions. In turn, these will provide a theoretical framework to guide future experiments into how complex cognitive functions originate and how they influence sensory perception and lead to robust behavioral performance.

A computational approach to understanding brain dynamics



CREDIT: BEHTASH BABADI

FROM THE PAPER:
BRAIN NEURAL NETWORK MAPPING

Scientists often refer to the human brain as the most complicated biological structure on Earth; perhaps the most complex object in the universe. The quest to understand how the brain functions, by mapping it down to the neural level, has proven to be a much larger and more complex project than mapping the human genome. Neuroscientists have been working on this problem for more than a century.

One approach has been to try to work out the brain's "connectome," the road map of all the connections of all the nearly 100 billion neurons in the human brain, in the hope that this structural map will give insight to how the brain works. However, the brain is a highly plastic structure that can adaptively change as it meets new challenges.

Now, research by a team of ISR theoreticians and experimentalists published in the *Proceedings of the National Academy of Sciences of the United States of America* (*PNAS*) provides a new computational approach to understanding the brain that probes the dynamic and changing functional interactions between the nodes in its neuronal networks.

The paper, "Extracting neuronal functional network dynamics via adaptive Granger causality analysis," was written by ISR-affiliated Assistant Professor **Behtash Babadi** (ECE), his graduate students **Alireza Sheikhattar** and **Sina Miran**, ISR-affiliated Professor **Patrick Kanold** (Biology), his graduate student **Ji Liu**, Professor **Shihab Shamma** (ECE/ISR) and Research Scientist **Jonathan Fritz** (ISR).

The team developed new signal processing techniques that extract functional network dynamics from neuronal data. These techniques then were used to study changes in neural functional networks.

The new approach goes beyond the connectome, showing that complex networks can be dynamically reorganized in multiple functional configurations that best suit the task the brain is engaged in the moment. In addition, the collaboration between theoreticians and experimentalists shows the promise and value of neuroengineering, an interdisciplinary fusion that will lead to further advances in the understanding of how the brain functions.

Learn more: Read the paper at the *PNAS* website: *www.pnas.org/content/115/17/E3869*. Watch a video about the work: *youtu.be/bpAhQgx9MWI*.

Current collector improvements for better batteries

Much effort has been put into novel battery technology as scientists strive to find safe, efficient, low-cost, lightweight and environmentally friendly energy sources. All-solid-state batteries, air batteries, water-based batteries, and even batteries powered by organic materials like grass are being developed. Very little effort, however, has been expended on the investigation of current collectors—the part of the battery that transfers electrons to and from an external circuit.

These collectors are usually metal-based, heavy, expensive, bulky and prone to corrosion after prolonged use.

A team led by Professors **Liangbing Hu** (MSE) and **Gary Rubloff** (MSE/ISR) has developed a thin film for current collectors composed of carbon nanotubes and cellulose nanofibers. The film has both high electronic conductivity and mechanical strength.

The carbon nanotubes provide current pathways—and high conductivity—while the cellulose nanofibers provide mechanical strength to the composite. By blending these two materials, the researchers can make lightweight films that have excellent electrical and mechanical properties, which could be beneficial in many energy applications.

The strong, lightweight material is also resistant to corrosion. The group immersed the material in concentrated sulfuric acid for more than four months, and the films maintained their high conductivity. The material's flexibility could make it a strong match for wearable energy storage devices.

Learn more: *doi.org/10.1002/aenm.201702615*

Northrop Grumman contributes third year of research funding

For the third consecutive year, Northrop Grumman has contributed $75,000 in research funding each to Professor **P. S. Krishnaprasad** (ECE/ISR), Professor **Ankur Srivastava** (ECE/ISR) and ISR-affiliated Professor **Yiannis Aloimonos** (CS). ISR is grateful to Northrop Grumman and Dr. Eric Reinke, the vice president and chief technology officer of Northrop Grumman Mission Systems, Inc., for this support.

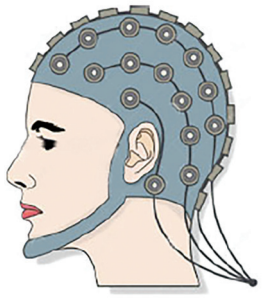
George Reynolds passes away

ISR's longtime friend from Northrop Grumman, **George Reynolds,** passed away unexpectedly July 31 while on travel in Des Moines, Iowa. He was 73. George worked at Northrop Grumman from 1996 until his retirement in 2012. He was our main contact with the company during its ISR Sustaining Partner years and played a key role working with our faculty and External Relations Director Jeff Coriale in determining technical matches for joint ISR and Northrop Grumman projects. George also was a member of ISR's Strategic Advisory Council for four years. ISR extends its condolences to George's family and to his former colleagues at Northrop Grumman.

Improving speech intelligibility testing

Hearing someone talking and understanding what they are saying are two different things. If a friend is talking to you from another room, it can be very easy to hear that they are saying something, yet difficult to understand what they are saying. People who use hearing aids often say the devices allow them to hear, but not always to understand.

Current tests used to measure hearing and understanding are two different things as well. Hearing tests are well-established and reliable, while tests that measure understanding are... not so much.



THE RESEARCHERS USED FLEMISH MATRIX SENTENCES TO BEHAVIORALLY MEASURE SPEECH INTELLIGIBILITY. THEY PRESENTED STIMULI FROM THE SAME MATRIX CORPUS WHILE MEASURING THE EEG. BY CORRELATING SPEECH ENVELOPES FROM THE MATRIX AND ENVELOPES DECODED FROM THE EEG, THEY OBTAINED AN OBJECTIVE MEASURE.

In a paper published in the *Journal of the Association for Research in Otolaryngology,* "Speech Intelligibility Predicted from Neural Entrainment of the Speech Envelope," Professor **Tom Francart,** KU Leuven, Belgium; Professor **Jonathan Simon** (ECE/Biology/ISR); and their colleagues show that by appropriating some of the same methods and technology already used in hearing tests, the accuracy of intelligibility tests can be significantly improved.

Hearing tests are typically performed in one of two ways. A person puts on headphones and indicates to the test operator whenever they hear a tone. Or a cap made up of a set of electroencephalogram (EEG) electrodes can be placed on the person's head, and it will directly and automatically record brainwaves while they listen to the sounds. Hearing tests given to babies shortly after they are born often use this method. Electrodes placed on the baby's head measure whether brainwaves occur in response to sound exposure.

The big advantage is that the EEG is an objective measure, and the person undergoing the test does not have to do anything for it to work. In fact, babies often sleep through the test.

Tests used to measure how well speech is understood are more problematic. Typically, the test requires a person to identify speech by repeating back to the tester what they think they have just heard. Because this test requires the person's participation, there are a number of ways it can go wrong. For example, the person's auditory prosthesis (e.g. hearing aid or cochlear implant) may not fit correctly. The person may have impaired cognitive function, such as a memory problem. They may not fully understand the language being spoken or not be motivated or attentive to the task.

In their research, Francart, Simon and their colleagues showed EEG-based testing could be used to measure speech understanding. The new objective method they developed not only is accurate, but also does not depend on the person's participation.

"This means the test will work regardless of the listener's state of mind," Simon explains. "We don't want a test that would fail just because the subject stopped paying attention."

Instead of presenting the person with tonal sounds while they are wearing the electrodes (as in the hearing test), the researchers had them listen to a sample of speech.

"With 64 electrodes, we measure the brain waves when someone listens to a sentence," says Francart. "We filter out the brainwaves that aren't linked to the speech sound as much as possible. We compare the remaining signal with the original sentence."

The way the brain processes speech can be inferred from the correlation between these two signals. If there is sufficient similarity, it means the person not only has heard something, but also has properly understood the message, Francart says.

The new test promises to be much better at determining speech intelligibility than the current "behaviorally" measured test. It is both automatic and objective, and it can provide more valuable information. This could lead to better diagnoses in patients with speech comprehension issues.

It will be especially useful for people struggling with cognitive issues or those who cannot provide feedback. In addition, the test could help people who have just received a hearing aid and may need it adjusted. One day it could help to automatically fit hearing aids.

"At the moment, hearing aids ensure that sounds are audible, but not necessarily intelligible," Francart says. "With built-in electrodes, the device could measure how well the speech is understood. Then it could determine whether adjustments are needed, for example, for something like background noise."

The test also could be used in developing new "smart" hearing devices that are able to continuously adapt to individual users in specific and changing environments.

Simon adds, "Adjustments could be made automatically, based on how successfully the brain is able to turn the processed speech sound into an understandable speech sound."

New unbiased stochastic derivative estimator for simulating complex systems

Professor **Michael Fu** (BMGT/ISR) and his international colleagues have published "A new unbiased stochastic derivative estimator for discontinuous sample performances with structural parameters" in the journal *Operations Research*. Their paper proposes a new unbiased stochastic derivative estimator in a framework that can handle discontinuous sample performances with structural parameters. Fu's co-authors are Peking University's **Yijie Peng**, Fudan University's **Jian-Qiang Hu**, and Vrije Universiteit Amsterdam's **Bernd Heidergott**.

Fu and his colleagues recently examined the difficulties in getting the numbers right when simulating complex systems. His paper provides an efficient and accurate methodology for estimating sensitivities in complex systems that require simulation for performance evaluation. The paper introduces a new method that can handle discontinuous sample performance measures—an open research problem with many practical applications.

The estimator the researchers formulated is unbiased and analytical, and the general framework addresses many derivative estimation problems. It can be used to price financial derivatives, analyze queueing systems, perform inventory control and management, do statistical process control, or manage supply chains, manufacturing plants, transportation systems, communications networks, and service systems like banks, amusement parks and retail stores.

To explain, Fu offers a quote from *Monte Carlo Methods in Financial Engineering,* a book popular with practitioners in the financial services industry: "Whereas the prices themselves can often be observed in the market, their sensitivities cannot, so accurate calculation of sensitivities is arguably even more important than calculation of prices." As examples, Fu says, consider how a financial professional might estimate the delta of an IBM stock option as compared to determining the price of the option itself.

An important statistical property of the estimator is that it be unbiased, meaning that the expected value of the estimator equals the quantity that it is trying to estimate (for example, the price sensitivity of a stock option). The new methodology developed by Fu and his co-authors can handle both continuous and discontinuous settings. Continuous performance measures have been addressed by past research, whereas discontinuous performance measures are more challenging. Binary outcomes are the simplest examples of discontinuous performance measures. "In the context of finance, a digital option pays off a fixed value such as $100 if above a certain threshold —the strike price — and zero otherwise," Fu explains.

Instances of structural parameters in stock options are the strike price or expiration date, in contrast to a distributional parameter, which would affect the dynamics of the underlying asset.

—ISR thanks Karen Johnson of the Robert H. Smith School of Business for this story.

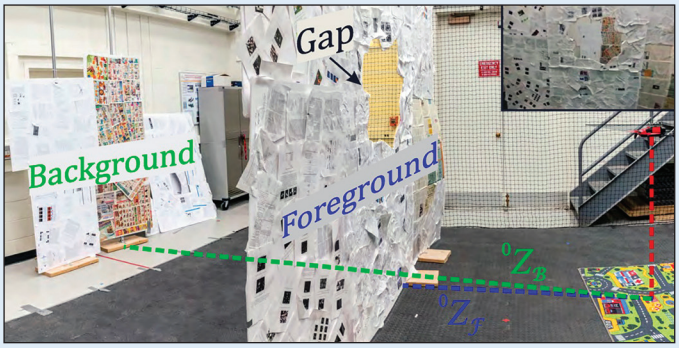
GapFlyt helps aerial robots navigate more like birds and insects

A small flock of birds flies through the gaps in a split-rail fence. Carpenter bees hover briefly around the small holes they have excavated in the side of a wood home, before slipping inside. Birds and insects are especially good at detecting and navigating their way through gaps in solid objects.

Research by the Perception and Robotics Group published in *IEEE Robotics and Automation Letters* will help give quadrotor robot drones some of the same capabilities found in nature.

"GapFlyt: Active Vision Based Minimalist Structure-Less Gap Detection For Quadrotor Flight," was written by Computer Science Ph.D. students **Nitin Sanket, Chahat Deep Singh,** and **Kanishka Ganguly;** their advisor and ISR-affiliated Professor **Yiannis Aloimonos** (CS/UMIACS); and UMIACS Associate Research Scientist **Cornelia Fermüller**.

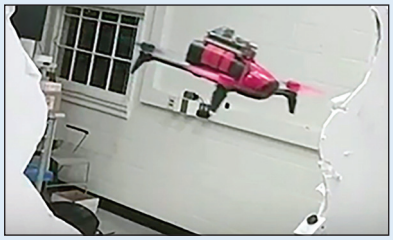
Quadrotors and other aerial robots currently use passive perception during flight: traditional computer vision algorithms that aim to build a generally applicable 3D reconstruction of the scene.



COMPONENTS OF THE ENVIRONMENT; INSET SHOWS THE VIEW OF THE SCENE FROM THE QUADROTOR'S CAMERA.

Planning tasks then are constructed and accomplished to help the quadrotor demonstrate autonomous behavior. These methods are inefficient and not task driven.

Flying insects and birds, on the other hand, are highly task driven and solve the problem of navigation and complex control without building 3D maps.



USING GAPFLYT, THE QUADROTOR SUCCESSFULLY FINDS AND FLIES THROUGH THE GAP.

The researchers designed a bio-inspired minimalist sensorimotor framework for a quadrotor to fly though unknown gaps. It requires only a monocular camera and onboard sensing and does not reconstruct a 3D model of the scene. The framework was successful in real-world experiments with different settings and window shapes, achieving a success rate of 85 percent at 2.5 m/s with a minimum tolerance of just 5 cm.

This is the first paper to address the problem of gap detection of an unknown shape and location in this way.

New funding for ISR faculty

Mean-field game theory MURI

Professor **Dana Nau** (CS/ISR), Professor **Michele Gelfand** (Psychology), and Assistant Professor **Tom Goldstein** (CS) are part of "Innovations in Mean-Field Game Theory for Scalable Computation and Diverse Applications," an Air Force Office of Scientific Research Multidisciplinary University Research Initiative (MURI).

This project aims to make real progress in developing the potential of mean field games (MFGs) through a coordinated effort based on building an overarching mathematical framework, developing accurate modeling in diverse applications, and creating a set of algorithmic tools that support fast simulation, prediction and inverse design. Nau, Gelfand and their colleagues have been integrating research on evolutionary game theory with cross-cultural psychology for the past decade.

Their subproject, "Social Behavior Analysis and Control Based on MFG Framework," uses real-world data to look at ways MFG theory could be used to analyze and validate models of human social norm dynamics. The researchers believe MFG theory has the potential to accurately demonstrate and predict how social norms change.

Bridging the gap between microelectronics, biological systems

A team of researchers is working to develop devices capable of facilitating the free exchange of information between the electronic and biological worlds with a $1.5M National Science Foundation (NSF) SemiSynBio grant. Professor **William Bentley** (BIOE/IBBR) is the principal investigator and Professor **Reza Ghodssi** (ECE/ISR), Professor **Gregory Payne** (IBBR), Assistant Professor **Massimiliano Pierobon** (University of Nebraska), and Biotechnology Scientist **Jessica Terrell** (U.S. Army Research Laboratory) are the co-PIs.

SemiSynBio is a partnership between NSF and the Semiconductor Research Corporation. It seeks to lay the groundwork for future information storage systems at the intersection of biology, physics, chemistry, computer science, materials science and engineering.

"Devices that freely exchange information between the electronic and biological worlds would represent a completely new societal paradigm," Bentley said. "Imagine what we could do by transferring all the knowledge contained in our molecular space, by tapping into and controlling molecules such as glucose, hormones, DNA, proteins, or polysaccharides in addition to ions."

The researchers will work to integrate subsystems and create bio-hybrid circuits to develop an electronically controlled device for the body that interprets molecular information, computes desired outcomes, and electronically actuates cells to signal and control biological populations. Such a system could seek out and destroy a bacterial pathogen by recognizing its secreted signaling molecules and synthesizing a pathogen-specific toxin. The group will, for the first time, explore electronic control of complex biological behaviors.

—ISR thanks Alyssa Tomlinson for this story.

DARPA Lagrange cooperative agreement to break the neural code

A team of four ISR researchers has been awarded a $1M DARPA Lagrange cooperative agreement for "An Optimization-Based Approach to Breaking the Neural Code."

The principal investigator is Professor **Steve Marcus** (ECE/ISR). He is joined by ISR-affiliated Assistant Professor **Behtash Babadi** (ECE), Professor **Michael Fu** (BMGT/ISR) and Professor **Jonathan Simon** (ECE/Biology/ISR).

The researchers are developing an innovative optimization framework tailored to non-invasive neuroimaging data from the human brain. Then framework will be scalable, risk-sensitive and real time. It will be capable of capturing the stochastic and geometric features unique to cortical function. It also will be formulated in a way that will generalize easily to multiple application areas.

Developing robotic swarm strategies

A team of four University of Maryland researchers has been awarded a $646K cooperative agreement from the Defense Advanced Research Projects Agency (DARPA) for "Robust Semi-Autonomous Swarm Tactics for Situational Awareness in Uncertain Environments." Assistant Professor **Huan Xu** (AE/ISR) is the principal investigator. The team also includes Assistant Professor **Michael Otte** (AE); ISR-affiliated Professor **Dinesh Manocha** (CS/ECE/UMIACS); and **Ming Lin** (CS/UMIACS).

The grant is among the first "core swarm sprints" awarded in DARPA's OFFensive Swarm-Enabled Tactics (OFFSET) program funding swarm autonomy and human-swarm teaming technology research. The aim is to improve the capabilities of groups of aerial and ground robots that work together to help humans accomplish tasks such as surveillance in complex and changing urban settings.

The Maryland researchers will combine multiple existing autonomous surveillance strategies into a single framework, enabling simultaneous overlapping deployment in different subsets of the environment. They will produce a set of semi-autonomous aerial swarm tactics that can be used simultaneously in different parts of the environment and will account for uncertainties, sensor errors and dynamic obstacles. They also will develop and evaluate new swarm simulation algorithms that can automatically adapt to the complexity of urban environments.

Shoukry, Krishnaprasad developing resilient-by-cognition CPS

ECE Assistant Professor **Yasser Shoukry** is the principal investigator and Professor **P. S. Krishnaprasad** (ECE/ISR) is the co-PI for a three-year, $797K NSF award, "Resilient-by-Cognition Cyber-Physical Systems." The research will improve resilience for autonomous cyber-physical systems (CPS) by integrating concepts from game theory, formal methods, and controls.

Autonomous systems in general (and self-driving cars in particular) are some of the most disruptive technologies emerging in recent years. However, safety and resilience issues associated with these systems, if not proactively addressed, may lead to a societal rejection of their adoption. The research will address such concerns by adding a layer of intelligence to the systems, allowing them to be resilient-by-cognition.

The researchers will create a principled framework for formally reasoning about cognitive CPS. The framework will build on ideas from evolutionary game theory to understand which strategies lead to the best fit when operating in adversarial environments. They will also develop an on-the-fly, correct-by-design feedback controller synthesis that executes the chosen strategy while satisfying physical constraints imposed by the micro-dynamics of the underlying CPS. Finally, they will use a data-driven strategy-mining approach to address the problem of designing a library of strategies from human demonstrations.

Ulukus to address data-related medical device issue

Professor **Sennur Ulukus** (ECE/ISR) is the principal investigator for a three-year, $360K NSF grant, "Communicating with Implanted Energy Harvesting Devices under Temperature Constraints." When medical devices are implanted in or placed on the human body, the heat given off by transmitting and processing data also can heat surrounding body tissues. This project will develop communication and computation schemes that optimize the operation of the device while keeping body temperatures within safe limits.

Ulukus will combine bio-heat models that relate power with temperature, communication-theoretic models that relate power with throughput, and energy harvesting constraints that relate power used with energy harvested. She will construct an optimization framework to determine the optimum operating principles for such systems. This framework will determine the most efficient optimum power control mechanisms, energy harvesting and energy transfer schemes, and data processing methods for the device and ensure the temperature remains within pre-specified safe limits.

Ghodssi, Bentley continue to develop biofilm-combating flexible devices

Professor **Reza Ghodssi** (ECE/ISR) is the principal investigator and Professor **William Bentley** (BIOE/IBBR) is the co-PI for a three-year, $330K NSF grant for "Development of Flexible Microsystems for Dynamic Bacterial Biofilm Management." The new award will further the researchers' development of dynamic flexible sensor microsystems for detecting, monitoring, treating and inhibiting bacterial biofilms on complex surfaces such as urinary catheters, prosthetic implants and water systems.

The researchers will develop a paradigm that accounts for surface bacterial species, fluid conditions and geometry. To manufacture the integrated flexible devices, the researchers will choose materials and fabrication processes for the specific geometric and environmental requirements of each application. An environmental model with data transmission and feedback control will be developed and used to test the devices.

The system will be able to remotely program the electrical reduction of biofilm. A wireless controlled electronic system will be developed to operate the impedance sensor and control the electrodes' biofilm removal.

This grant further develops the device that won the University of Maryland's Invention of the Year this past spring.

Fermüller, Shamma, Etienne-Cummings building 'Research Coordination Network'

University of Maryland and Johns Hopkins University faculty have received a $500K NSF grant to build the Research Coordination Network (RCN), an initiative to advance understanding of how biological systems learn complex symbolic signals, and create artificial systems with similar capabilities.

Associate Research Scientist **Cornelia Fermüller** (UMIACS) is the principal investigator and Professor **Shihab Shamma** (ECE/ISR) and **Ralph Etienne-Cummings** (JHU) are co-PIs on the grant.

By defining a common framework to describe complex symbolic signals and their variability across space and time, the RCN will develop methods and tools applicable to a wide range of domains, including language, music, action, perception, and navigation. The network will bring together neuroscience, cognitive science, applied mathematics, computer science and engineering, with emphasis on machine learning and artificial intelligence.

Ephremides leads Age of Information project

Professor **Anthony Ephremides** (ECE/ISR) is the principal investigator for the NSF award, "On the Fundamental Nature of the Age of Updates." Professor **Yin Sun** will be the collaborative researcher at Auburn University.

This project will use the new concept of Age of Information to discover the relationships between information theory and signal processing, two of the main pillars of information science. Its foundational core is the context of communication, namely the purposes and goals of signal transmission.

The project will explore how the transmission and age of received updates relate to the information structure of a signal, and how information ages over time. It will use an innovative approach to the traditional problems of signal processing by relating Nyquist's theory to causal signal reconstruction. The project also will use the Age of Information as a tool in handling the problem of caching and network control in volatile environments (e.g., the Internet of Things and sensor networks).

Barg to research data storage information recovery

Professor **Alexander Barg** (ECE/ISR) is the principal investigator for a three-year, $500K NSF award, "Information Recovery Under Connectivity and Communication Constraints." The project addresses data storage issues in modern, large-scale distributed storage systems, where the failure of individual storage nodes is an everyday operational reality.

Barg will investigate methods of data recovery in systems with limited connectivity where the cost of data repair is governed by the length of the path between the nodes, and depends on the topology of the network. He will establish fundamental limits of communication complexity of data recovery that account for connectivity properties of the underlying network and construct coding methods that ensure data integrity against node failures, incorrect information, and adversarial actions that approach the bounds of the minimum possible amount of communication.

UMD Brain and Behavior Initiative seed grants

Three research teams with ISR faculty members were chosen for funding by the University of Maryland's Brain and Behavior Initiative (BBI) in its FY18 seed grant program.

Through its seed grant program, the BBI promotes collaborations among faculty from research areas that are traditionally exclusive. New research projects are undertaken by faculty who have never worked together before. The projects with ISR faculty are:

- "A Multimodal Sensor Discovery Platform to Study the Molecular Events Underlying the Gut-Microbiome-Brain Axis," **Reza Ghodssi** (ECE/ISR), **William Bentley** (BIOE), and **Jens Herberholz** (Psychology/NACS);
- "Precision Optogenetics: msec Time Resolution Optical Imaging and Control of Neuronal Circuits," ISR-affiliated **Behtash Babadi** (ECE), and **Wolfgang Losert** (Physics); and
- "Central Nervous System Processing of Learned Vocal Communication Signals," **William Idsardi** (Linguistics/NACS), **Jonathan Fritz** (ISR), and **Robert Dooling** (Psychology/NACS).

Xu, HopFlyt receive MIPS and TEDCO funding

A new collaboration between Lusby, Maryland-based HopFlyt Corp. and Assistant Professor **Huan Xu** (AE/ISR) is supported by $100,000 in joint funding from the Maryland Industrial Partnerships (MIPS) program, an initiative of the Maryland Technology Enterprise Institute, and the company. HopFlyt also received a $25,000 pre-seed investment through the Maryland Technology Development Corporation's (TEDCO) Rural Business Innovation Initiative.

The research seeks to reduce traffic and commuting time by developing an air vehicle that could "hop" over traffic for distances up to 30 miles, carrying up to three passengers at a time. The highly autonomous but piloted vertical take-off and landing (VTOL) vehicle will be all-electric, with 16 motors that adjust to make the journey smoother for passengers.

"Our part is to work on the control laws for this," Xu explained. "We come at it from a theoretical modeling perspective."

—ISR thanks Mark Fitzgerald for this story.

ISR faculty news

Fellows

Professor **Carol Espy-Wilson** (ECE/ISR) has been elevated to the rank of Fellow by the International Speech Communication Association for "contributions to speech acoustic modeling, speech signal processing and applications to knowledge-driven speech recognition and speech enhancement."

Distinguished University Professor **John Baras** (ECE/ISR) has been named a Fellow of the American Mathematical Society for "contributions to the mathematical foundations and applications of systems theory, stochastic systems, stochastic control, network security and trust, mentoring and academic leadership."

Plenary and invited speakers

Distinguished University Professor **Gary Rubloff** (MSE/ISR) was a keynote speaker at the 18th IEEE International Conference on Nanotechnology in July. Rubloff spoke on "From Nanostructures to Mesoscale Architectures: Electrochemical Storage for Smart Things."

In June, Professor **Jonathan Simon** (ECE/Biology/ISR) gave an invited talk in Salamanca, Spain, at the 12th International Workshop on Advances in Audiology hosted by the University of Salamanca. He spoke on "Adaptation to Noise and Cortical Representation of Speech."

In May, Simon gave an invited talk on "Recent Advances in Cortical Representations of Speech using MEG" at the Auditory EEG Signal Processing Symposium in Leuven, Belgium. Professor **Pamela Abshire** (ECE/ISR) and alumna **Mounya Elhilali** (ECE Ph.D. 2004), an associate professor at Johns Hopkins University, also gave invited talks at the symposium.

Best paper award

"Bayesian analysis of a density ratio model," has won this year's Canadian Journal of Statistics Award. The paper was written by alumnus **Victor De Oliveira** (Math Ph.D. 1997), a professor in the Department of Management Science and Statistics at the University of Texas at San Antonio; and his former adviser, ISR-affiliated Professor **Benjamin Kedem** (Math). The award is presented by the Statistical Society of Canada to the authors of an article published in the journal, in recognition of the outstanding quality of the methodological innovation and presentation. The paper proposes a Bayesian approach for the analysis of a semiparametric density ratio model, a model useful for the integration of data from multiple sources.

Best poster award

"Physically based modeling for predictive simulation of a net-zero home," by Professor **Raymond Adomaitis** (ChBE/ISR) and his graduate student Alan Uy, won the Best Poster Award in the Computing and Systems Technology Division at the AIChE Annual Meeting. The research was for the 2017 Solar Decathlon, in which the University of Maryland's reACT house placed second overall and first among entries from the United States. Adomaitis and Uy developed a predictive physically based model of the house and demonstrated its utility in scheduling the home's resources.

New named chair

Professor **Sennur Ulukus** (ECE/ISR) has been named the first Anthony Ephremides Chair in Information Sciences and Systems. In 2007, Ephremides and his wife Jane established a fund to create the chaired professorship in the Department of Electrical and Computer Engineering. It provides annual support for an information sciences and systems faculty member.

New ISR joint faculty

Longtime Mechanical Engineering ISR affiliate faculty member Professor **Miao Yu** has been named to a joint appointment in ISR. Yu is the current director of the Maryland Robotics Center.

New ISR affiliate faculty

ISR welcomed four new affiliate faculty members in July.

Dinesh Manocha is the Paul Chrisman Iribe Endowed E-Nnovate Professor of Computer Science, with additional joint appointments in Electrical and Computer Engineering and UMIACS. His research

focuses on geometric and scientific algorithms with applications to computer graphics, robotics, simulations, and virtual reality. He and his students have developed software packages for physically based modeling, computer-aided design and scientific computing.

Computer Science Professor **Adam Porter** is the executive and scientific director of the university's Fraunhofer Center for Experimental Software Engineering. His research focuses on a qualitative understanding of the dynamics of large-scale software development, with a goal of identifying the fundamental mechanisms driving the costs and benefits of different software tools and methods. Porter's approach relies heavily on empirical studies, ranging from small controlled experiments, to experimentation with large-scale artifacts, to interventions in real-life industrial projects operating under real deadlines and budgetary constraints.

Professor **Richard Marciano** is the director of the Digital Curation Innovation Center within the University of Maryland's College of Information Studies. He also directs the Sustainable Archives and Leveraging Technologies lab. Marciano's research interests center on digital preservation, sustainable archives, cyberinfrastructure and big data. Before coming to Maryland, Marciano was part of the University of California, San Diego's supercomputer center.

Mechanical Engineering Assistant Professor **Mark Fuge** directs the IDEAL Lab where he uses machine learning, artificial intelligence and crowdsourcing to understand how large groups of people design things and how complex engineered systems work. His goal is to use data to make these systems better.

ISR visiting research faculty

Stephen M. Trimberger spent part of 2018 as a Visiting Research Engineer with ISR, before becoming a program manager in DARPA's Microsystems Technology Office in August. Trimberger is a member of the National Academy of Engineering, elected in 2016 "for contributions to architectures and programming tools for field-programmable gate arrays (FPGAs)." Trimberger also is a Fellow of ACM and IEEE. His distinguished career at Xilinx Research Labs, including Fellow, involved leading a research group investigating various aspects of semiconductor devices, including power optimization, die stacking, variation, hardware security, defect tolerance, multi-context FPGA architecture and software, FPGA+microprocessor hybrid, first complete FPGA synthesis library, and fault tolerance.

Wayne Phoel joined ISR in October as a Visiting Research Engineer. He has assessed and advanced technologies in wireless communications, renewable energy, and artificial intelligence, and developed frameworks for successful program initiations. Previously, Phoel was a DARPA program manager, where he initiated and cultivated research efforts on wireless systems, novel techniques for protecting from attacks, and adaptability for operation in complex environments. He also was a senior member of the technical staff at MIT Lincoln Laboratory.

Books

The publisher Springer announced that the ebook version of the *MEMS Materials and Processes Handbook* was in the top 25 percent of most downloaded eBooks in its category on SpringerLink during 2017. The 2011 handbook was edited by Professor Reza Ghodssi (ECE/ISR) and Pinyen Lin, the deputy director of the Taiwan Semiconductor Manufacturing Co.

Honors and awards

Professor **John Baras** (ECE/ISR) has been named a Distinguished University Professor of the University of Maryland. This official title is the highest academic honor the University of Maryland confers upon a faculty member. It is reserved for a small number of exceptionally distinguished scholars who have been recognized nationally and internationally for the importance of their scholarly or creative achievements and who have demonstrated the breadth of interest characteristically encompassed by the traditional role of scholar, teacher and public servant.

Baras also received the American Institute of Aeronautics and Astronautics' 2018 AIAA Aerospace Communications Award. The citation reads, "For outstanding technical contributions and commercialization leadership of Internet over satellite, hybrid satellites, and terrestrial networks, with transformational industrial, economic and societal impact."

This summer, ISR-affiliated Professor Emeritus **Ben Shneiderman** (CS/UMIACS) received his fifth honorary doctoral degree, this time from Swansea University, Wales. Swansea named Shneiderman "a pioneering computer scientist whose work has been vital in determining the essential ways we communicate with computers through for example, the clickable link and the widespread use of touchscreens." Shneiderman has been visiting and encouraging computer scientists at Swansea for many years.

Professor **Dana Nau** (CS/ISR) will be inducted into the Duke University Graduate School's Few-Glasson Alumni Society. The society recognizes alumni who have made significant accomplishments and have distinguished careers. Nau earned his Ph.D. at Duke in 1979.

Professor **Sennur Ulukus** (ECE/ISR) has been selected as a Distinguished Lecturer of the IEEE Information Theory Society. The program promotes interest in information theory at the local chapter level by supplying prominent information theory researchers to give talks at events.

Faculty in the news

Professor **Derek Paley** (AE/ISR) was a guest on the public radio show "On the Record" on March 5. The program is produced by WYPR, 88.1 FM in Baltimore. Host Sheilah Kast spoke with Paley in a show titled "Technology Inspired by Nature," which explored how researchers are incorporating the abilities of insects, birds, fish and animals to improve robots. In his segment, Paley talks about his own research to explain how understanding the fluid movements of fish can help improve underwater vehicle function. He also explains why scientists look to nature for answers.

Learn more: Listen to the interview at NPR One. Dr. Paley's segment begins at 11:30 of the podcast. *one.npr.org/?sharedMediaId=590997010:590997012*

Alumni news

Alumna **Mingyan Liu** has been named the Peter and Evelyn Fuss Chair of Electrical and Computer Engineering at the University of Michigan. Liu also is the principal investigator for a $6.25M Multidisciplinary University Research Initiative, "Multiscale Network Games of Collusion and Competition," funded by the Army Research Office. The project, built on game theory, will develop tools to understand and shape online and on-the-ground networks that drive human decision making. At Maryland, Liu received her M.S. in Systems Engineering degree in 1997 and her Ph.D. in Electrical Engineering in 2000. She was advised by Professor **John Baras** (ECE/ISR) for both degrees.

Nikolaos Sidiropoulos (EE Ph.D. 1992) was recently named the Louis T. Rader Professor at the University of Virginia. Sidiropoulos joined Virginia in August 2017 as the chair of its Charles L. Brown Department of Electrical and Computer Engineering. He also is the current Vice President of the IEEE Signal Processing Society. At Maryland, he was a student of Professor **John Baras** (ECE/ISR). He was a postdoctoral researcher and assistant Research Scientist at ISR and has served on the faculty of the University of Minnesota, the Technical University of Crete, Greece, and the University of Virginia.

Light, a company co-founded by alumnus **Rajiv Laroia** (ECE M.S. '89, Ph.D. '92), has received a $121 million investment from Tokyo-based SoftBank. Focusing on Light's core technology of a "software defined camera," SoftBank's Vision Fund is supporting development of better sensing systems for self-driving cars. Also investing in this program is the camera company Leica Camera AG. At Maryland, Laroia was advised by Professor **Nariman Farvardin** (ECE/ISR), currently the president of Stevens Institute of Technology.

Alumna **Chaitali Chakrabarti** (EE M.S. '86, Ph.D. '90) received the 2018 Distinguished Alumnus Award from the Indian Institute of Technology Kharagpur (IIT Kharagpur). Chakrabarti is a professor of electrical engineering at Arizona State University, where she has been a faculty member since 1990. Her research in VLSI architectures for signal processing and communications, algorithm-architecture co-design, and low-power embedded system design has had a major impact on the circuits and systems, signal processing and computer architecture communities. At Maryland, she was advised by Professor and current interim ECE chair, **Joseph JaJa**.

Venkataramanan "Ragu" Balakrishnan, a postdoctoral researcher with Professor **André Tits** (ECE/ISR) from 1993 to 1994, has been named dean of the Case School of Engineering at Case Western Reserve University in Cleveland. Balakrishnan had a distinguished academic career at Purdue, becoming a Fellow of IEEE and holding several leadership positions. He spent nine years as head of the School of Electrical and Computer Engineering, Purdue's largest academic unit.

Keysight Technologies, Inc. has awarded alumnus **Ravi Tandon** (EE Ph.D. 2010) the 2018 Keysight Early Career Professor Award for his work on wireless networks and cloud computing environments. Tandon is an assistant professor of electrical and computer engineering at the University of Arizona. At Maryland, Tandon was advised by Professor **Sennur Ulukus** (ECE/ISR).

Philip Twu's exciting space robotics career

Developing NASA space robots is a dream job for many engineering students—and exactly the kind of work alumnus **Philip Twu** (EE, CS BS 2008) has pursued since his graduation. Twu has worked on two different NASA space robotics projects: the Parker Solar Probe, which launched this summer; and the 2020 Mars Rover, currently in development.

As a Maryland undergraduate, Twu worked with Professor **P. S. Krishnaprasad** (ECE/ISR) in the Intelligent Servosystems Laboratory. Dr. Krishnaprasad says, "Philip is a model for many of our systems engineering and robotics aspirants." Twu also interned at Intelligent Automation, Inc. (IAI) in Rockville, Md., as an undergraduate.

Twu went on the Georgia Institute of Technology for his graduate studies, where he earned a Ph.D. in electrical engineering in 2012, concentrating in systems and controls and digital signal processing.

"Despite always having an interest in robotics, it wasn't until I joined the Intelligent Servosystems Lab that I actually got to work with robotics for the first time in my life," Twu says. "I learned that robotics is not just a straightforward extension of programming or simply hacking together different technologies until you get something that works. Rather, robotics is an interdisciplinary field and can be carefully engineered to have provable behaviors and performance characteristics if approached from a mathematically rigorous perspective."

At the Johns Hopkins Applied Physics Laboratory (APL) in Laurel, Twu was on the senior professional staff for five years, working on NASA's Parker Solar Probe. It is the first-ever mission to travel directly into the sun's atmosphere—known as the corona—about 4 million miles from its surface, well within the orbit of Mercury and more than seven times closer than any spacecraft has come before.

In 2017 Twu became a robotic systems engineer at the NASA Jet Propulsion Laboratory in Pasadena, Calif., where he is working on the 2020 Mars Rover. NASA scientists hope to determine whether Mars ever had life, characterize Martian climate and geology, and answer questions in advance of potential future human exploration.

Learn more about Philip Twu and his career: ***go.umd.edu/TwuRobots.***

CREDIT: JET PROPULSION LAB

ALUMNUS PHILIP TWU (EE, CS 2008 BS) IN FRONT OF THE "CURIOSITY" MARS ROVER TESTBED AT THE NASA JET PROPULSION LABORATORY IN PASADENA, CALIF. THE "2020" MARS ROVER TWU IS WORKING ON IS BASED ON THE CURIOSITY PLATFORM.

Alumnus **Raef Bassily** (EE Ph.D. 2011) has joined the Ohio State University's Department of Computer Science and Engineering as a tenure-track assistant professor. Bassily's research interests are in machine learning, privacy-preserving data analysis, differential privacy, information theory and coding. At Maryland, Bassily was advised by Professor **Sennur Ulukus** (ECE/ISR).

Alumnus **Thomas Winkler** (BIOE Ph.D. 2017) has been awarded a prestigious Marie Skłodowska-Curie Individual Fellowship by the European Commission. Winkler is a postdoctoral researcher in micro and nanosystems at KTH Royal Institute of Technology in Sweden. The award funds his project, "NeuroVU: Real-time Sensing in Microfluidic Models of the Neurovascular Unit." At Maryland, Winkler was advised by Professor **Reza Ghodssi** (ECE/ISR) and was part of the MEMS Sensors and Actuators Laboratory.

Winkler's Maryland research was featured on the March 2018 cover of *IEEE Sensors Letters*. "The Role of Microsystems Integration Towards Point-of-Care Clozapine Treatment Monitoring in Schizophrenia" presents the first lab-on-a-chip device capable of label- and reagent-free concurrent sensing of cellular and molecular markers.

Alumnus **Xiaobo Tan** (EE Ph.D. 2002) is the recipient of the 2018 Withrow Distinguished Scholar Award (senior category) from the Michigan State University College of Engineering.

Tan is a Foundation Professor in the Department of Electrical and Computer Engineering at Michigan State University and director of the Smart Microsystems Laboratory there. At Maryland, Tan was advised by Professor **John Baras** (ECE/ISR) and Professor **P. S. Krishnaprasad** (ECE/ISR).

Omur Ozel (EE Ph.D. 2014) has joined the George Washington University's Department of Electrical and Computer Engineering as a tenure-track Assistant Professor. Ozel's research addresses reliability, timeliness, security and robustness challenges in existing and emerging communication and computation settings. At Maryland, Ozel was advised by Professor **Sennur Ulukus** (ECE/ISR).

Student news

David Akin's high-flying RASC-AL undergrad team

ISR-affiliated Associate Professor **David Akin's** team of 19 undergraduate aerospace engineering students won first place for the theme category and second place overall at NASA's Revolutionary Aerospace Systems Concepts–Academic Linkages (RASC-AL) competition this summer. They designed a reusable hybrid propulsion rocket stage that employs innovative combinations of operations and technology to improve on NASA's baseline in-space stage for transporting crew and cargo between lunar space and Mars.

The team, composed of seniors from Aerospace Engineering's space systems design course, also won a stipend to prepare and present a paper at the AIAA SPACE and Astronautics Forum.

Akin himself won the Pioneering Exceptional Achievement Concept Honor (PEACH) Award for the most innovative and meaningful idea presented at the RASC-AL Forum. Akin and his students are a perennial powerhouse at the competition, having placed either second or winning outright many times over the years.

Learn more about RASC-AL here: isr.umd.edu/faculty/akin.

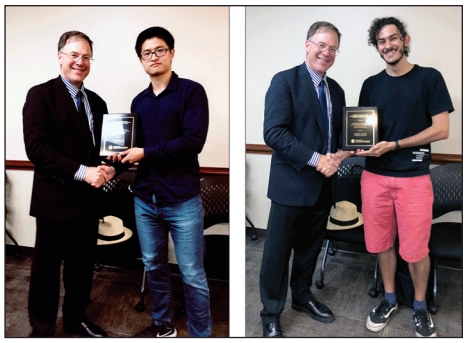
Lu and Gollob win ISR student awards

Two outstanding student awards were given at ISR's 2018 ceremony this fall.

The George Harhalakis Outstanding Systems Engineering Graduate Student Award went to electrical engineering Ph.D. student **Jiangheng Lu** in Associate Professor **Alireza Khaligh's** (ECE/ISR) research group.

Lu's research spans power engineering and energy systems engineering areas including modeling, simulation, design, and development of power electronics interfaces for electric vehicles and renewable energy systems. He is currently working on the design, development and verification of a 6.6kW integrated onboard charger using real vehicle specifications from General Motors.

The ISR Outstanding Systems Engineering Undergraduate Student Award was given to **Samuel Gollob**, a mechanical engineering



CREDIT: REBECCA COPELAND

ISR DIRECTOR BILL REGLI PRESENTS AWARDS TO JIANGHENG LU (L) AND SAMUEL GOLLOB (R).

senior minoring in computer ccience. He is a College Park Honors Scholar, a Banneker/Key Scholarship recipient and a member of the RISE program.

Gollob had his first conference paper—as first author—accepted to the 2018 IEEE International Conference on Robotics and Automation. He designed sensors that take size, weight, power, and computational complexity into account—a significant systems engineering challenge.

Ann G. Wylie Semester Dissertation Fellowship

Aneesh Raghavan, an ECE Ph.D. student advised by Professor **John Baras** (ECE/ISR), has won an Ann G. Wylie Semester Dissertation Fellowship, which provides support to University of Maryland doctoral candidates who are completing their dissertations. Raghavan's research interests are in modeling, inference and decision making of networked cyber-physical systems, and in particular in systems that include humans as key components.

Along with another student of John Baras, **Usman Fiaz**, Raghavan also was named a winner of the Graduate School's Outstanding Graduate Assistant Award.

ECE Distinguished Dissertation Fellowships

Two ISR students won ECE Distinguished Dissertation Fellowships, awarded to candidates in the final stages of dissertation work in recognition of their research excellence. The ISR winners were: **Chuan Shi**, advised by **Alireza Khaligh** (ECE/ISR) for his work, "Propulsion-System-Integrated Onboard Chargers for Electric Vehicles," and **Karim Banawan,** advised by **Sennur Ulukus** (ECE/ISR), for "Private Information Retrieval and Security in Networks."

2018 Grad Student Travel Awards

The ISR Graduate Student Travel Award is given to deserving graduate students to help defray the travel costs of attending a conference to present their research. The first three awards were given in 2017; this year seven awards have been granted.

Sunandita Patra, a computer science graduate student advised by Professor **Dana Nau** (CS/ISR), attended the sixth annual conference on Advances in Cognitive Systems (ACS), Palo Alto, Calif., in August.

Saurabh Sahu, an electrical and computer engineering graduate student advised by Professor **Carol Espy-Wilson** (ECE/ISR), attended Interspeech 2018 in Hyderabad, India, in September.

Chenxi Wen, an electrical and computer engineering graduate student advised by ISR-affiliated Associate Professor **Timothy Horiuchi** (ECE), attended IEEE Biomedical Circuits and Systems 2018, in October. The paper he wrote with Dr. Horiuchi, "Power-Law Compression Expands the Dynamic Range of a Neuromorphic Echolocation System," was the runner-up for the Best Paper Award at the conference.

Debdipta Goswami, an electrical and computer engineering graduate student advised by Professor **Derek Paley** (AE/ISR); and **James Ferlez**, an electrical and computer engineering graduate student advised by Professor **Steve Marcus** (ECE/ISR) and Professor **Rance Cleaveland** (CS/ISR), attended the 57th IEEE Conference on Decision and Control in Miami Beach, Fla., in December.

Yunchuan Li, an electrical and computer engineering graduate student advised by Professor **Michael Fu** (BMGT/ISR) and undergraduate student **Uro Lyi,** also advised by Fu, attended the INFORMS Winter Simulation Conference in Gothenburg, Sweden, in December.

ISR is grateful to the generous alumni, faculty, staff and friends who have raised funds for these awards. If you would like to contribute to the funding, visit our website: *isr.umd.edu/giving/ISR-Fellowships*.

Czech Republic–United States Workshop on Artificial Intelligence

This fall, the University of Maryland hosted the Czech Republic–United States Workshop on Artificial Intelligence. The workshop was sponsored by ISR, the University of Maryland, the Embassy of the Czech Republic in Washington, D.C., the U.S. Office of Naval Research, the Global Ministry of Defence of the Czech Republic, the U.S. Army Research Office, and the Office of the Government of the Czech Republic.

ISR Director **William Regli** and Michal Pechoucek of the Czech Technical University in Prague were the program chairs. Organizers were Luděk Moravec of the Ministry of Foreign Affairs at the Embassy of the Czech Republic in Washington, D.C., and Stephen O'Regan of the Office of Naval Research Global at the U.S. Embassy in Prague.

The international, invited workshop explored topics in artificial intelligence for robotics, transportation, and cybersecurity. More than 80 experts from academia, industry, government labs and funding agencies participated. Topics included AI and cybersecurity; AI futures, limits and applications; policy and legal implications of AI, perception and acting; assured and trusted autonomy; human and machine symbiosis; and international collaboration opportunities and mechanics.

Keynote speakers were Jason Matheny, Intelligence Advanced Research Projects Agency; Subbarao Kambhampati, Arizona State University and the Association for the Advancement of Artificial Intelligence; and Petr Somol, Czech Academy of Sciences.

Workshop participants came from many organizations in both the Czech Republic and the United States. Czech institutions included ČAS, ČVUT, the Czech Institute of Informatics at ČVUT, Charles University, the Ministry of Foreign Affairs, Czech Republic, Masaryk University, CISCO, GoodAI, Rossum.AI, AgentFly Technologies, AVAST, Lidove Noviny and BlindSpot.AI.

U.S. participation came from the University of Maryland, the Center for New American Security, the National Science Foundation, IARPA, the University at Buffalo, the Defense Advanced Research Projects Agency, Drexel University, the University of Pennsylvania, Johns Hopkins University, ARO, ONR, ONR Global Prague, Fraunhofer USA, the U.S. Army Communications-Electronics Research, Development and Engineering Center, the Air Force Office of Scientific Research, the University of Pennsylvania, the Center for New American Security, ASU, AAAI, and Carnegie Mellon University.

Regli is speaker, 'Risers' workshop chair at DARPA 60th anniversary symposium

ISR Director **William Regli** (CS/ISR) was a featured speaker at the Defense Advanced Research Projects Agency's (DARPA) D60: DARPA's 60th Anniversary Symposium in September.

Regli, a former deputy director and acting director of DARPA's Defense Sciences Office, moderated a roundtable on "DARPA and Academia: Lessons and Insights." The panel recognized the contributions universities have made to the Department of Defense and DARPA. Speakers offered insights and lessons learned on higher education research. Panelists included Stephen Cross of the Georgia Institute of Technology; Alan Rudolph from Colorado State University; and Stefanie Tompkins of the Colorado School of Mines.

Regli also chaired the "DARPA Risers" workshop during the D60 event. First organized by Regli and featured at DARPA's 2015 "Wait What?" Technology Forum, DARPA Risers identifies early-career scientists and engineers, specifically students and post-doctoral scholars, that DARPA program managers believe have both exceptional technical expertise and a drive for service.

During the closed-door workshop, the Risers presented posters about their research to an audience of DARPA program managers and DARPA leadership. Three of the Risers presented their work to all symposium attendees at a special plenary session on the last day of the DARPA D60 celebration.

Staff news

Susan Frazier Outstanding Systems Engineering Staff Award

Ania Picard, the assistant director of administrative affairs for the Maryland Robotics Center, is the winner of ISR's 2018 staff award.

Maryland Robotics Center Director **Miao Yu**, writes: "I have known Ania for almost 20 years, and her quality of work, dedication, accessibility and responsiveness is impressive, and she has done tremendous work with amazing quality and dedication to provide the highest level of support to the center. I can't be more grateful for her sense of responsibility, accessibility, and responsiveness."

Retirements

Jeffrey Coriale, ISR's director for external relations since 1996, retired from his position at the end of July. Coriale was responsible for facilitating research relationships between ISR faculty and sponsors in industry and government. He also directed the highly successful Visiting Scientists program, which brought Japanese engineers from Honda and Toshiba to ISR, where they worked on projects of mutual interest with ISR faculty. Eighteen visiting scientists participated in the program from 1999–2014.

Jason Strahan, ISR's director of administrative services for the past 13 years, retired from his position at the end of December. Strahan was responsible for overseeing ISR's budget, financial administration, personnel operations and proposal and grant disbursement services for faculty. He first worked for ISR as an undergraduate student employee back in 1997.

Former ISR Visiting Scientist advances at Honda

Congratulations to former ISR Visiting Scientist **Kazutomo Nishida**, who has been named president of Honda R&D Asia Pacific. From 2001–2002, as part of the Visiting Scientist program with Honda R&D, Nishida conducted research with Professor **Christopher Davis** (ECE) on sensor and control systems for various types of engines.

The ISR Visiting Scientist program allows companies to send employees to work closely with jointly selected faculty hosts on topics of mutual interest. The program provides a natural vehicle for shoulder-to-shoulder collaboration with ISR faculty and students; education in systems engineering, allied sciences, and business practices; knowledge transfer between systems methodologies and application domains; and training in state-of-the-art tools including those based on ISR research.

Postdoctoral robotics fellowships

The Maryland Robotics Center has launched a new postdoctoral fellowship program to foster multidisciplinary collaborations among its faculty and enable high-impact exploratory research in robotics. The program is jointly funded by the Maryland Robotics Center and the dean of the A. James Clark School of Engineering.

Proposals from robotics faculty were solicited in spring 2018 in two categories: human-robot interaction and bio-inspired autonomous systems. The program committee selected four proposals for funding.

The winning faculty tearms were each awarded funding for one postdoctoral fellow for one year. The four postdoctoral fellows selected to work with the winning faculty teams are **Behzad Sadrfaridpour, Hamed Saeidi, Artur Wolek** and **Ahmed Ramadan**.

Human-robot interaction fellowships

"Modularizing Fine-Motor Tasks for Collaborative Robots with Active Vision and Tactile Sensing." Faculty team: Associate Research Scientist **Cornelia Fermüller** (UMIACS), ISR-affiliated Professor **Yiannis Aloimonos** (CS/UMIACS) and Professor **John Baras** (ECE/ISR). This project aims to develop flexible modules for a set of fine-motor manipulation tasks for robots and seeks to create a model by combining robotic action with vision and sensing to enable robots to understand what currently is happening and predict the near future.

"Intelligent Robotic Systems for Damage Control Surgery." Faculty team: ISR-affiliated Associate Professor **Nikhil Chopra** (ME) and Assistant Professor **Axel Krieger** (ME). This project focuses on providing immediate support to patients suffering from traumatic injury in the critical first hour after injury occurs. It will provide remote surgeons to assist medics and non-surgeons in performing damage control surgery using on-site, AI-equipped autonomous robots.

"Soft Tactile Sensing for Therapeutic Robotics." Faculty team: ISR-affiliated Professor **Elisabeth Smela** (ME) and Associate Professor **Anindo Roy** (Neurology), University of Maryland School of Medicine. The goal of this research is to equip therapeutic robots with tactile sensing to enhance their performance and reliability. It will enable bio-inspired robots to assist people in walking and other functional tasks.

Bio-inspired autonomous systems fellowship

"Multi-Vehicle Sensing and Control with Autonomous Aerial Robots." Faculty team: Professor **Derek Paley** (AE/ISR) and ISR-affiliated Associate Professor **Timothy Horiuchi** (ECE). This project is focused on replacing manned aircraft with unmanned aircraft systems (UAS) in situations involving air-to-air coordination. The research will take inspiration from insect groups to formulate and demonstrate the navigation of UAS in an environment which involves multiple systems engaging in a chase-evade game, where the role of the chasers and evaders continuously changes.

A. JAMES CLARK
SCHOOL OF ENGINEERING

The Institute for Systems Research
2173 A.V. Williams Building
University of Maryland
College Park, MD 20742

ADDRESS SERVICE REQUESTED

SYSTEMS SOLUTIONS is a newsletter for colleagues, research partners, alumni and friends of the Institute for Systems Research, A. James Clark School of Engineering, University of Maryland.

ISR is a permanent state-supported institute of the University of Maryland within the A. James Clark School of Engineering, and one of the original National Science Foundation Engineering Research Centers.

CONTACT
2173 A.V. Williams Building, University of Maryland, College Park, MD 20742
Phone: (301) 405-6615

ISR ONLINE
Web: isr.umd.edu Facebook: ISRUMD
Twitter: ISR_UMD YouTube: ISRUMD *and* UMDRobotics Vimeo: isr

Editor: Rebecca Copeland
rebeccac@umd.edu
Front cover photo: John T. Consoli

ISR.UMD.EDU | ISRUMD | ISR_UMD | ISRUMD and UMDRobotics | isr

Maryland students place third in autonomous drone race

An interdisciplinary team of undergraduate and graduate students affiliated with the Maryland Robotics Center took third place in the autonomous drone racing event at the prestigious 2018 IEEE International Conference on Intelligent Robots and Systems (IROS) in Madrid.

The Maryland team received support from the Brin Family Prize and the Maryland Robotics Center. Its quadcopter made it through the course in about 90 seconds, placing ahead of competitors from Mexico, the Netherlands, Spain and Korea. The winning team, which completed the course in 31.78 seconds, was from the University of Zurich.

Competitive autonomous drone racing is an engineering and computer science challenge that requires an understanding of computer vision, the ability to develop algorithms that incorporate gate detection, and programming logic so the drone can understand when it has completed tasks. Team members do not fly the drones themselves; they must program the machines to navigate the course on their own, flying through a series of gates, recognizing opportunities and avoiding obstacles. The objective is to complete the course in the fastest time possible.

In Madrid, the competition course consisted of eight challenging gates, whose locations could change during any run. Gate number six was a "jungle gym" that required the drone to detect which "quadrant" was active and only fly through that one. Gate number seven had a rotating arm that the drone had to avoid while it passed through.

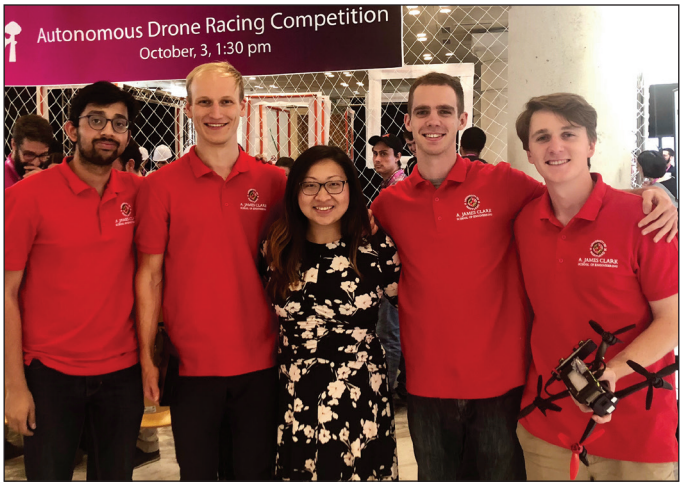


PHOTO COURTESY OF HUAN XU

L-R: MSSE STUDENT ROHIT NAMBIAR; VISITING AE GRAD STUDENT VINCENZ FRENZEL; DR. HUAN "MUMU" XU (AE/ISR); SENIOR AE/CS UNDERGRAD STUDENT MATTHEW VAUGHN; AE MS GRAD STUDENT DEREK THOMPSON.

"This was the first year we competed, and our goal was to come in and finish the course," said the team's advisor, Assistant Professor **Huan "Mumu" Xu** (AE/ISR). "We never really focused on speed. That definitely changes next time."