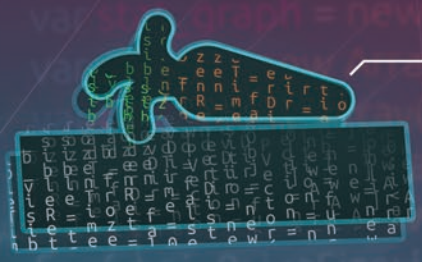
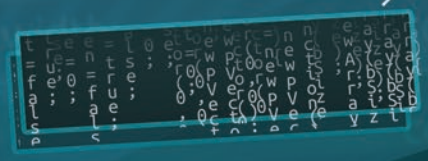
VIRGINIA TECH

ece

THE BRADLEY DEPARTMENT OF
ELECTRICAL & COMPUTER
ENGINEERING



When the rabbit eats the carrot, you win



When the rabbit touches a brick, it stops

The player controls the rabbit with the keyboard

2017

GAME CHANGINEERING

VirginiaTech

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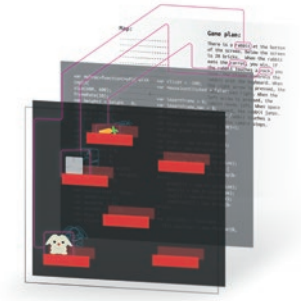
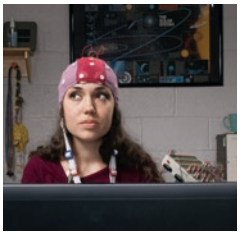
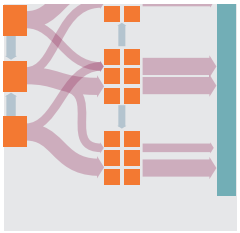
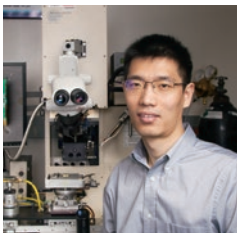
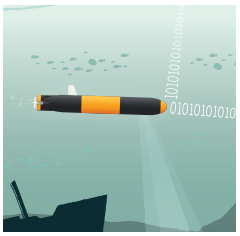










Editor: **Scott Bailey**

from the

ADVISORY BOARD CHAIR

Ken Schulz (MSEE '84)
Chair
ECE Advisory Board

THE VIRGINIA TECH ECE ADVISORY BOARD has had another fulfilling year serving the department. In 2016, we welcomed five new members: Anthony Fairfax from CensusChannel LLC., John Kelly from NCA&T, Amit Puri from Intgenicomm, Mark Walters from General Motors, and Sam Yakulis from Lockheed Martin.

We thank outgoing board members Kirsten Brown, Christopher Burton, Mike Newkirk, Mike O'Neill, Rob Virostek, Johnathan Whitcomb, and Peter Savagian for their service to the department.

Since July 2016, board members have been providing industry perspective to ECE's exciting new RED grant initiative from the National Science Foundation. This initiative is transforming the ECE curriculum based on the idea of threshold concepts. The board's input focused on our motivation for choosing ECE as a field, and what we consider to be the qualities of an excellent alumna or alumnus from our program.

In 2016 we also saw continued growth in the Major Design Experience (MDE) class, formerly known as "Two Semester Senior Design Capstone." To better serve the students and industry sponsors, the ECE department added a Spring-Fall sequence to the existing Fall-Spring sequence. This addition allows more students to take the MDE class, plus it provides our industry sponsors a better opportunity to hire interns during the summer between semesters.

The board looks forward to helping Luke Lester prepare for continued growth of the ECE department and to contributing to the exploration of new majors within the B.S. degree program, including the future "destination areas."

I would like to express my sincerest thanks to the board, our Vice-Chair Lynn Hamilton-Jones, and Luke, for their support and the opportunity to serve the ECE department.

Kenneth Schulz
Chair, ECE Advisory Board

from the ece DEPARTMENT HEAD

Luke Lester
ECE Department Head

THE IMPRESSIVE GROWTH of the Bradley Department of Electrical and Computer Engineering at Virginia Tech continues unabated.

In 2016, we greeted 530 new undergraduates into the electrical engineering (EE) and computer engineering (CPE) degree programs, which is up approximately 17 percent compared to the previous calendar year. In January 2017, we conducted a census of the number of ECE undergraduates that we advise and found that number to be 1,480. Wow! Fortunately, we completed our expansion of ECE Student Services in 2016 and now have eight academic advisors and staff to advise these students on course choices and career options in ECE. We are very proud of our renewed emphasis on high-quality advisement and believe it is contributing much to the undergraduate experience.

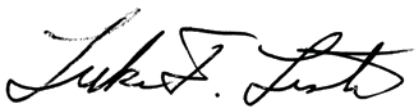
We have also grown our graduate program to 610 students, again primarily through an increase in master of engineering (MEng) students, which is growing more and more popular with international students seeking good jobs in U.S. high-tech industries. Meanwhile, the Virginia Tech College of Engineering overall is expecting to enroll about 1,775 first-year students from the high school ranks, plus 500 or so transfer students. As I have said in previous annual reports, ECE is keeping pace with this growth by hiring aggressively. In 2016, we hired eight new faculty members. We introduce seven of them starting on page 18, and the other was introduced in our last report. In 2017, we have already hired four new faculty members and have authorization to bring on another four.

Our continued efforts to get the word out through our "Focus on Research" publication in the fall, this annual report, and the visibility of our faculty's research on Google Scholar has rewarded us with another good year in the U.S. News & World Reports rankings. I am pleased to tell you that our graduate program in electrical engineering has improved to 18th in the country and computer engineering to 17th. These are our best graduate rankings ever, and the third time that both degree programs have simultaneously been in the top 20.

This annual report celebrates our department's excellence, including highlights such as the cover story on GameChangineer, which has been developed by Professor Michael Hsiao to teach young students how to create video games using plain, logical English. In the past year, Dr. Hsiao has introduced GameChangineer to many students and teachers throughout Southwest Virginia, and ECE has further plans to make it available to all counties in Virginia through 4H Youth Development.

I am also proud to inform you that in 2016, ECE won a prestigious engineering education grant entitled "Radically Expanding Pathways in the Professional Formation of Engineers" from the NSF Revolutionize Engineering Departments (RED) program. Spearheaded by Professor Tom Martin, this five-year project will foster experiential learning and open-ended design. Our new ECE curriculum will increase the number of paths to an engineering degree for students, giving them the freedom to choose a variety of concentrations—from biomedical applications to digital arts—and provide outreach opportunities for K-12 students in underserved and underrepresented populations.

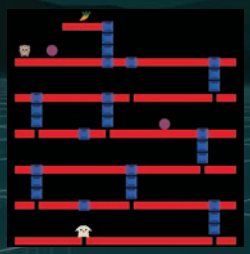
If you are interested in helping to support these projects or others that are featured in this report, please do not hesitate to contact me, or the College of Engineering advancement team. Go Hokies!

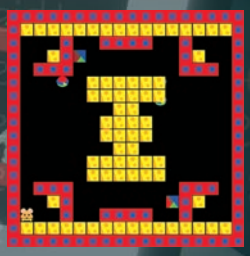


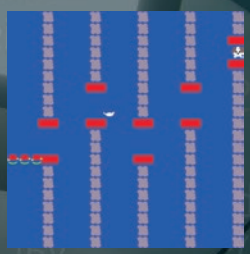
Luke Lester
Department Head

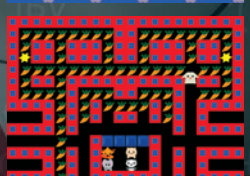
GAME CHANGINEERING

Learning logic and language through video game design







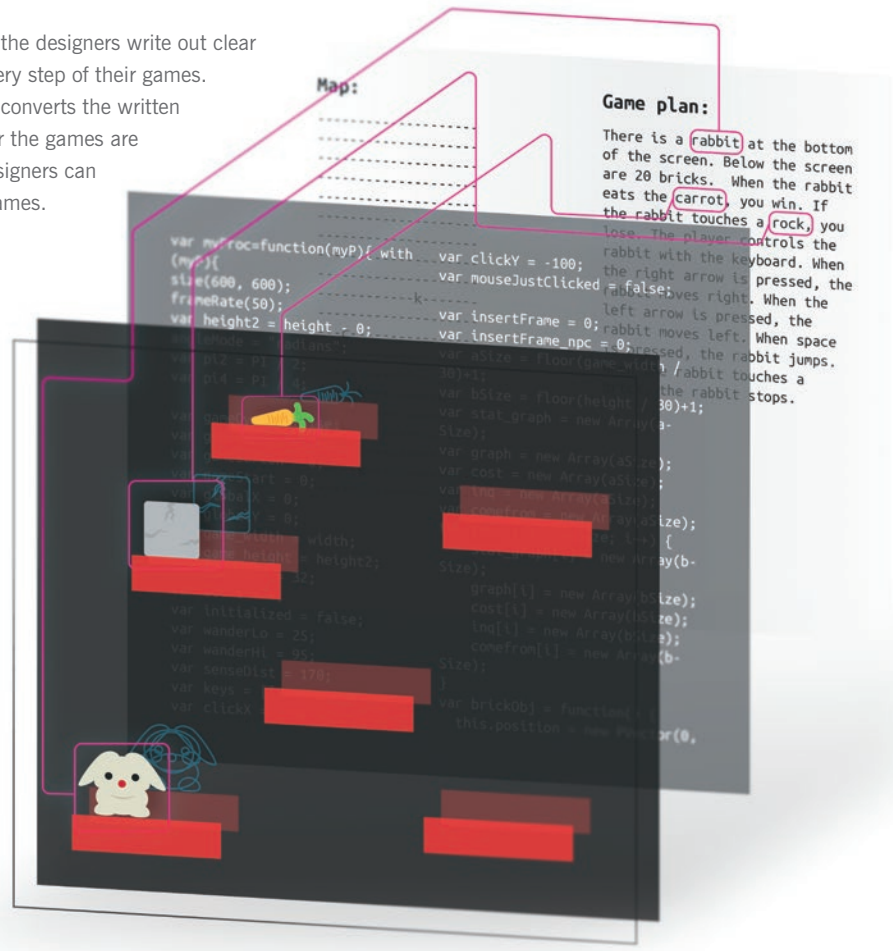


Most American third-graders don't know how to write in JavaScript, but they are learning how to read and write in English. Now they can do all three simultaneously while engaging in something they enjoy—making up games.

ECE Professor Michael Hsiao has just filed a patent for his platform, GameChangineer, which piggybacks on the allure of video game design to introduce programming concepts and reinforce English language lessons for students of all ages.

Hsiao's inspiration for GameChangineer came in 2012. He was translating a message with Google Translate and wondered if he could apply his research, software, and educational experience to the problem of translating English into computer code.

It was easy for Hsiao to decide to use video



IN GAMECHANGINEER, the designers write out clear written instructions for every step of their games. The system automatically converts the written plan into game code. After the games are successfully compiled, designers can see, play, and test their games.

games as the vehicle for the training he had in mind. "I wanted it to be educational, and the best reward for programming your own game is getting to play it," said Hsiao. "I can't think of a better way to teach."

GameChangineer started as a pet project, but as Hsiao discovered, it evolved into an all-consuming endeavor. He now spends most of his time each week refining and adding to the platform.

When he was first developing GameChangineer, Hsiao had to teach himself modern game design, and he has developed a course to teach ECE students the same skills. ECE 4525–Video Game Design and Engineering was first offered in Fall 2015. Furthermore, undergraduate students from Virginia Tech have helped to populate the site with sample video games, now totalling more than 100.

CODE DESIGN BEST PRACTICES

Good code design follows a certain order: idea, plan, and implementation, said Hsiao—and planning is essential.

"Computer science teachers and professors have told me that their students' biggest stumbling block is an inability to think something through," said Hsiao. "Students want to rush through to implementing code without first having a blueprint."

In GameChangineer, the game design and functionality rests entirely on a written game plan. The designer writes out instructions for every step of the game, applying programming concepts such as logical reasoning, problem-solving, algorithmic design, and critical and computational thinking.

While a game designer can invent his or her own game from scratch, many people like to re-create or reinvent their favorite games—such as Pac-Man, Donkey Kong, Frogger, and Downhill Ski. Hsiao encourages this approach too, saying that it allows designers to break down a familiar game into its basic components and see how they fit together.

COMMON BUGS

Being able to write clear instructions is essential for strong programming and GameChangineer exercises this skill by drawing the game designer's attention to trouble spots and guiding the debugging process.

Bugs usually take one of two forms, said Hsiao: pronoun confusion or commands.

"Pronouns are one of the hardest things about deciphering natural English," said Hsiao. For example, in the sentence, ["When a rabbit catches a carrot, it eats it,"] it is unclear if the rabbit is eating the carrot, or if the carrot is eating the rabbit.

"In the virtual world, anything is possible," said Hsiao.

In GameChangineer, the returned error message will read, "There are two or more

CONTINUED ON NEXT PAGE

MICHAEL S. HSIAO is an IEEE Fellow and a recipient of the National Science Foundation CAREER Award. His current research interests include design automation of hardware and software, such as automated synthesis, test, verification, and diagnosis of complex computing systems.

CONTINUED FROM PREVIOUS PAGE

pronouns in this sentence. Please change non-subject to exact character."

Game designers also stumble by issuing commands instead of describing the desired actions. ["When the fox collides with the bird, explode."]

"They're used to dealing with systems like Siri on their phones," said Hsiao. "But when you issue commands in game design, a lack of subject/object/verb combinations can lead to confusion."

COMPILATION

Finally, GameChangineer automatically converts the written plan into game code, even in the presence of bugs. The buggy sentences are treated as comments. For 15 English sentences, the platform generates more than 1,000 lines of code.

"This compilation was one of the trickier things to figure out because a natural language like English is more fluid than code," said Hsiao. "Converting it required a lot of fuzzy compilation, which is the secret sauce in the patent."

After the game has been successfully compiled, designers can see, play, and test their game. If a game is free of bugs, they also have the option to share their game with others by posting it in the gallery.

"A third-grader posted this one this morning," Hsiao noted, pointing to a game entitled Flappy Bird. "Yes, even third-graders can do this."

…And not a moment too soon, said Hsiao, since computer science is becoming an education priority statewide.

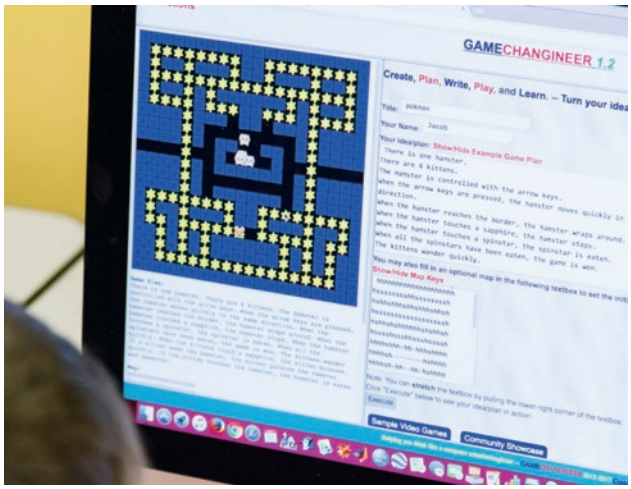
IN SCHOOLS

Last spring, Virginia Governor Terry McAuliffe signed legislation that calls for the state's Board of Education to incorporate computer science, computational thinking, and computer coding into the Standards of Learning curriculum.

"JavaScript doesn't come easily to elementary school children or teachers," he said.

Hsiao believes that GameChangineer can help bridge this gap. Thanks to his work

> "There aren't many video games that can get students interested in sentence structure."



WHILE A GAME DESIGNER can invent a game from the ground up, many people like to recreate their favorite games. GameChangineer helps new designers plan and write clear instructions by drawing attention to trouble spots and guiding the debugging process.

introducing it to local school districts, many students in and around Blacksburg are already using the platform.

After demonstrating GameChangineer for the first time in January 2016, Hsiao began working with outreach programs like Kindergarten to College, a college aspirations program. Hsiao then piloted his platform to schools in Salem, Roanoke County, Montgomery County, and Radford City.

Teachers tried it out for a week, and a few asked to continue because their students were hooked, said Hsiao.

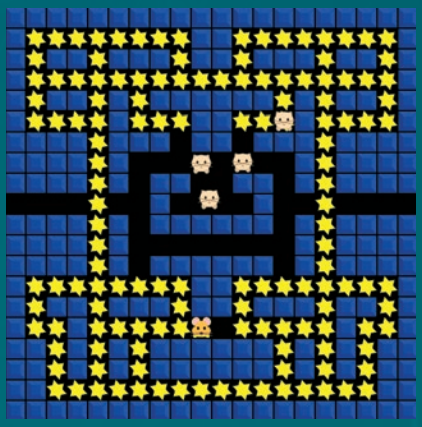
"Two to three English teachers are actually using this in their classrooms, too," said Hsiao. "There aren't many video games that can get students interested in sentence structure."

Hsiao plans to offer training sessions to additional Virginia school systems in the coming months.

LOOKING FORWARD

GameChangineer is not limited to educational purposes. Hsiao's technology could eventually be incorporated into robotic systems, enabling a controller to type and load written instructions without having to code them.

But Hsiao sees this first as a fun and creative way to learn programming concepts and discover the logic and critical thinking behind popular games. ece



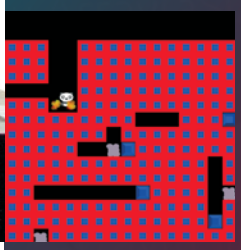
POKMON

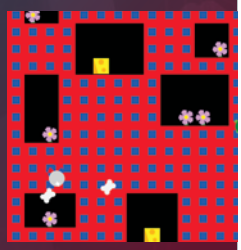
CREATED BY A HIGH SCHOOL STUDENT

The following is the actual text used to generate the game above:

There is one hamster.
There are 4 kittens.
The Hamster is controlled with the arrow keys.
When the arrow keys are pressed,
the hamster moves quickly in the same direction.
When the hamster reaches the border,
the hamster wraps around.
When the hamster touches a sapphire,
the hamster stops.
When the hamster touches a spinstar,
the spinstar is eaten.
When all the spinstars have been eaten,
the game is won.
The kittens wander quickly.
When the kittens touch a sapphire,
the kitten bounces.
If a kitten sees the hamster,
the kitten pursues the hamster quickly.
If the kitten touches the hamster,
the hamster is eaten and gameover.

Make your own games with GameChangineer at
http://gc.ece.vt.edu





Objectively detecting ADHD

IN A MOCK SESSION, undergraduate researcher Sarah Hanson (BSEE '17) tests out the attention-focused computer task that had been administered to the children participating in the longitudinal study. "We use some of our experimental data to train our machine-learning algorithms, and other data to test it," she said.

Despite the growing number of children and adolescents identified as having Attention Deficit Hyperactivity Disorder (ADHD), there is no objective diagnosis protocol. Current methods depend heavily on subjective observations by parents, teachers, and physicians.

"It would be very useful to provide a method of hands-off diagnosing," said ECE Professor Louis Beex. So he's building one.

Beex has spent the last 15 years researching and developing a method to diagnose ADHD based on data alone, which may not even require a physician to be present.

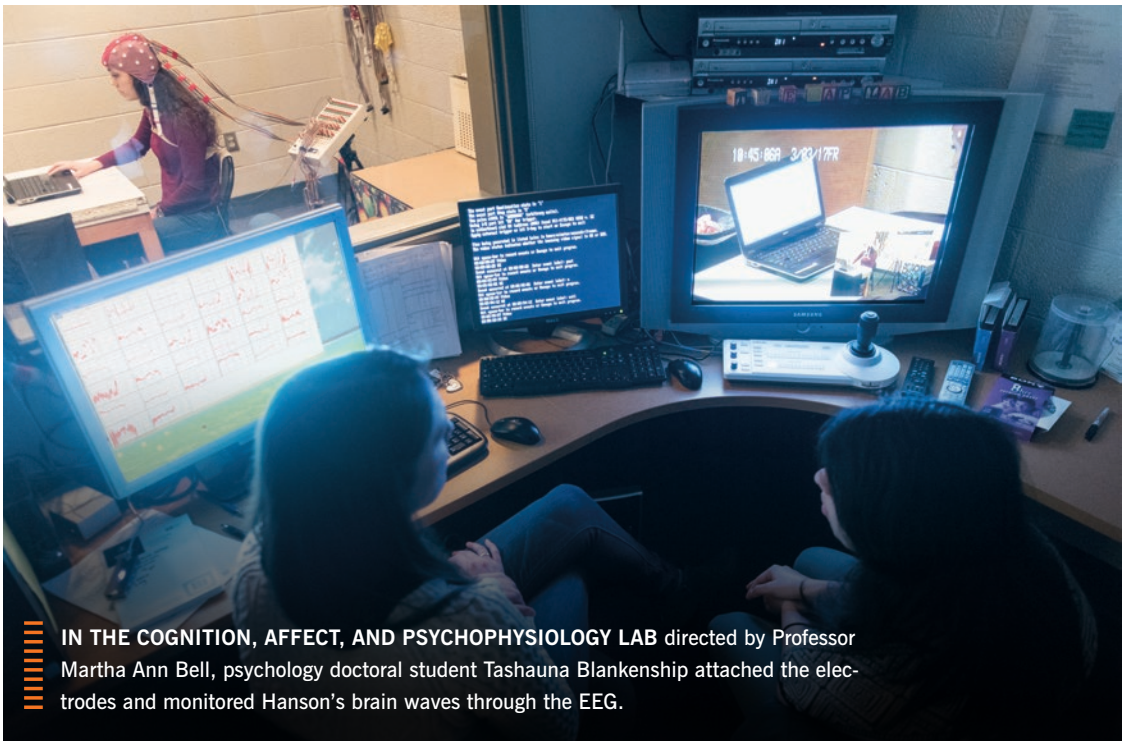
Current ADHD diagnoses involve extensive interviewing of the children in question, their parents, and their teachers. The process is time-consuming and can be unreliable. A more reliable diagnosis may finally involve functional magnetic resonance imaging (fMRI), but that method is expensive, said Beex. And rightly or wrongly diagnosed, a child will still be affected by medications like Ritalin, which is commonly prescribed for ADHD.

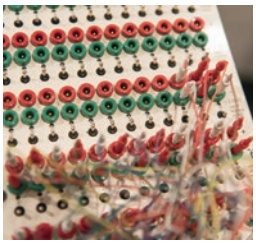
"Recent literature has suggested that this medicine can have a long-term affect on the heart," he said.

In collaboration with Professor Martha Ann Bell in the Department of Psychology, Beex began working on a new approach that involves using electroencephalogram (EEG) data to discern the brain wave patterns associated with ADHD.

During their first attempt, Beex and his students analyzed EEG data of children at rest, with a success rate of around 60 percent. "Not very good," he noted.

Now they are trying a different test. Beex and his team are currently working with more recent data collected by Bell and her students in the Cognition, Affect, and Psychophysiology (CAP) Lab. This EEG data was recorded while children, some of whom had already been diagnosed with ADHD,





IN THE COGNITION, AFFECT, AND PSYCHOPHYSIOLOGY LAB directed by Professor Martha Ann Bell, psychology doctoral student Tashauna Blankenship attached the electrodes and monitored Hanson's brain waves through the EEG.

were actively engaged in computer tasks that required focus and motor skills.

Children between the ages of 6 and 9 visited the research lab as part of an ongoing longitudinal study in the CAP Lab. After the electrodes were placed on their heads, the children were prompted to follow simple instructions based on visual cues, while the EEG tracked and recorded their brain wave patterns.

"Brain signals can be thought of as rhythms or ribbons of frequency bands," said Beex. "EEGs measure the signals as they change over time and frequency."

By passing the signal through low- and high-pass filters, decimation, and multi-resolution parametric spectral estimation, Beex and his team can look at these brain wave patterns on very fine timescales—so fine that they hope to trace where in the brain a signal originates, as well as the pathways it travels.

Machine-learning techniques like K-Nearest Neighbor, Gaussian Mixture Models, and Universal Background Model classifiers helped the researchers select a combination of channels that would best show whether or not the subject had ADHD.

"We found that only two or three channels were relevant to ADHD detection if we were monitoring the brain during the attention tasks," said Beex.

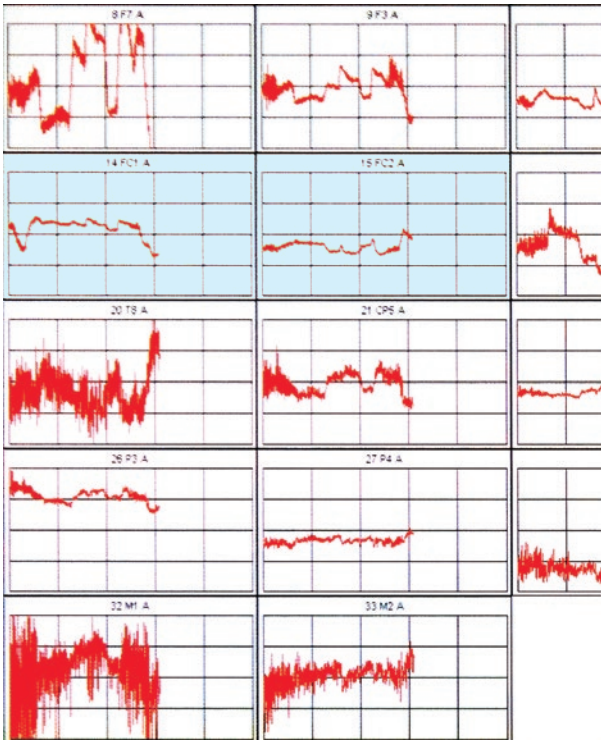
After analyzing the different channels and modeling the data, Beex and his students compared their findings to each child's diagnosis. And although the research is limited by the amount of data available, the team has achieved 85–95 percent accuracy rates so far.

While much work remains, Beex believes this technology could revolutionize the way ADHD is detected/diagnosed and—subsequently—streamline how it is treated.

"We'll be able to diagnose ADHD in a school cafeteria with a couple of electrodes hooked up to a laptop," said Beex. If a diagnosis is positive, he hopes that the same methods will also be used to test the effectiveness of behavioral therapy—interventions that can help children with ADHD manage their symptoms with no side effects and no long-term risks.

But ultimately, Beex is driven toward a farther-reaching goal: he wants to know why humans develop this disorder in the first place and what, if anything, can be done to address it.

"By looking at the data in great detail and identifying the pathways involved, we are investigating ADHD, not as an inherent property in the architecture of the brain, but as something that developed," said Beex. ece



AFTER SIGNAL PROCESSING and feature extraction, FC1 and FC2 (highlighted) are among the four channels that reveal the most useful information for Beex's research.

A culture of change

The tech changes: Should the education?

Today's fast-changing technology challenges engineering departments to re-evaluate how they prepare the next generation. What are the most fundamental skills and knowledge that no electrical or computer engineer should be without? How much hands-on experience should students gain, with technology that may be obsolete as soon as they graduate?

Last year, the ECE department embarked on a multi-year effort to evaluate and shape its culture and curriculum for the world that faculty, students, and alumni will face tomorrow. The effort is supported by a $2 million grant from the National Science Foundation (NSF) program called Revolutionizing Engineering Departments (RED), which is focused on the professional formation of engineers for the 21st century. The ECE department is one of only 13 departments to receive this grant in the past two years.

"We would like to create a new curriculum model that blends science, engineering, creativity, and design," says Luke Lester, ECE department head and principal investigator. "There is no field that does not overlap with electrical and computer engineering. To remain the go-to career for innovation, we must prepare electrical and computer engineers to solve problems in all areas."

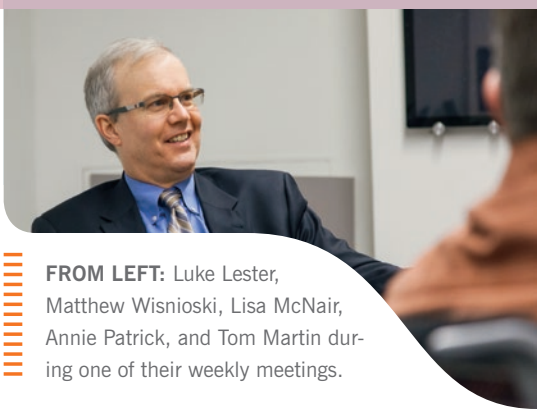
The curriculum effort is facilitated by an interdisciplinary team including Lester; Tom Martin, ECE professor and Bradley Faculty Fellow of Education; Lisa McNair, associate professor of engineering education; Matthew Wisnioski, associate professor of science and technology in society (STS); Steve Harrison, professor of practice in computer science; Jeremy Ernst, associate professor in integrative STEM education; Liesl Baum, research assistant professor in the Institute for Creativity, Arts, and Technology (ICAT); Benjamin Knapp, ICAT director; and Annie Patrick, an STS Ph.D. student.

The RED grant project kicked off in July 2016, with interviews of faculty, staff, students, and alumni to collect information and get a baseline reading of the department culture.

Today, ECEs are asked to work on projects from smart textile design to cancer research. At Virginia Tech alone, research teams work on biomedical devices, oil mining, chemical analysis in space, artificial brains, and the vehicles of the future.

The core skills for any of these efforts are problem-solving and—sometimes more importantly—problem setting, according to Martin. Problem setting is where the process begins: how to define a problem so that it can be solved. Teaching these skills has always been a challenge, he acknowledges.

> "There is no field that does not overlap with electrical and computer engineering...we must prepare [ECEs] to solve problems in all areas."



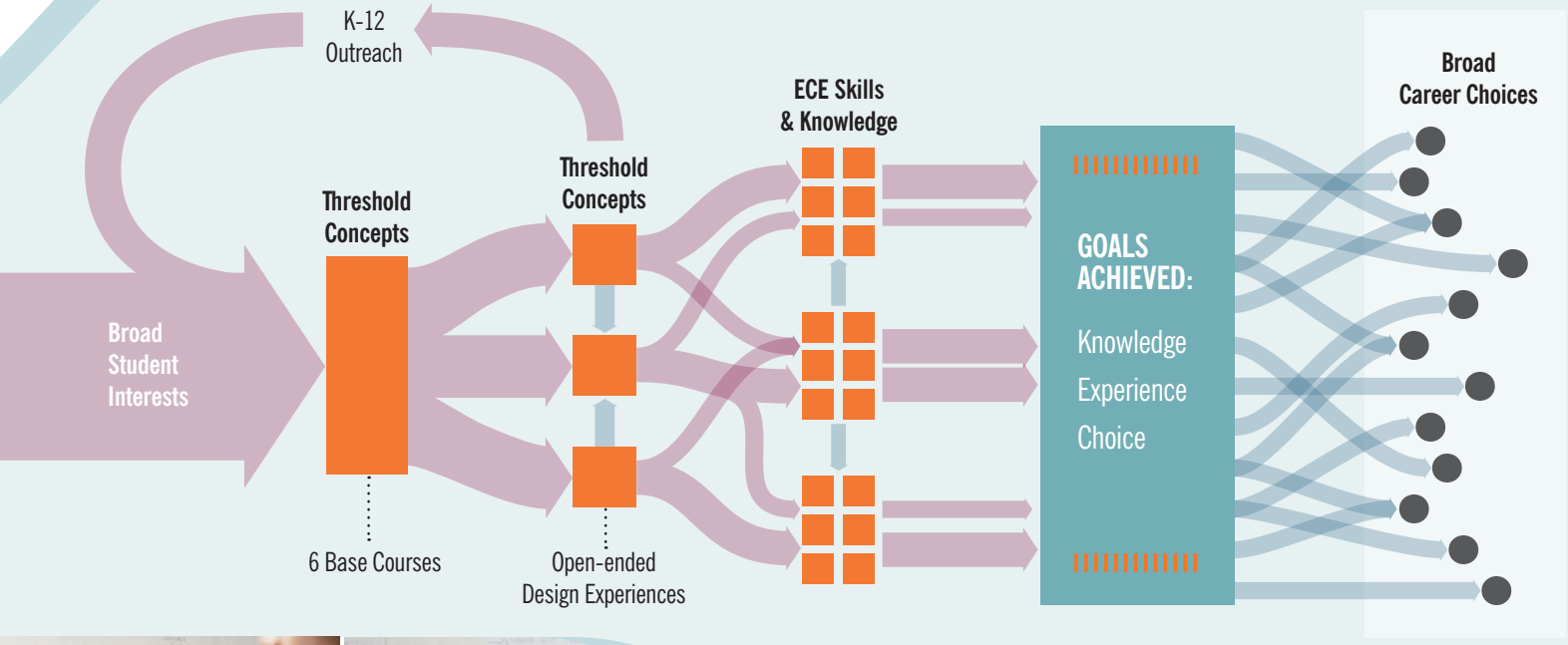
FROM LEFT: Luke Lester, Matthew Wisnioski, Lisa McNair, Annie Patrick, and Tom Martin during one of their weekly meetings.

EVOLVING CURRICULUM

Since its inception 125 years ago, the ECE department has regularly updated its curriculum to reflect changing technology and demands. As tools became smarter and so many tasks became software- and computer-based, the department created the introductory circuits labs using a "do-it-at-home" model, ensuring that students had the tools and equipment to both build their labs and experiment with personal projects.

In 2014, the department began to offer a new senior design model where students work on a wide range of industry-sponsored projects from developing light-trapping technology to testing vehicle cybersecurity penetration.

For extracurricular projects, students can access the department's Design Studio complex. The AMP Lab opened its doors in fall 2012 as a fully-equipped space for students to work on personal engineering projects—from artificial limbs to improved speaker systems. These projects allow students to pursue any area that interests them, letting them overlap



THE INTERDISCIPLINARY TEAM facilitating the curriculum effort. BACK ROW: Steve Harrison, Annie Patrick,Tom Martin, and Matthew Wisnioski. FRONT ROW: Luke Lester and Lisa McNair.

electrical and computer engineering with other disciplines, and tackle projects outside their regular coursework. Many students start by using the same components and setups they have on hand from their lab courses.

The next iteration of Virginia Tech's ECE experience will build on these freedoms and move some earlier into the curriculum, while giving students options for multiple pathways to earn their degree. The curriculum team is not planning just an update, however, but is also exploring the fundamental issues for creating a significantly different experience.

"We'd like to broaden the range of careers students can pursue, and broaden the pool of students who choose ECE," explains Martin. For example, there might be a student who wants to be a doctor, and chooses an undergraduate degree in electrical and computer engineering because it's the basis for so much medical equipment. The ideal program, according to Martin, would still prepare students for traditional ECE careers, but also open options for students who want to explore other areas at the same time.

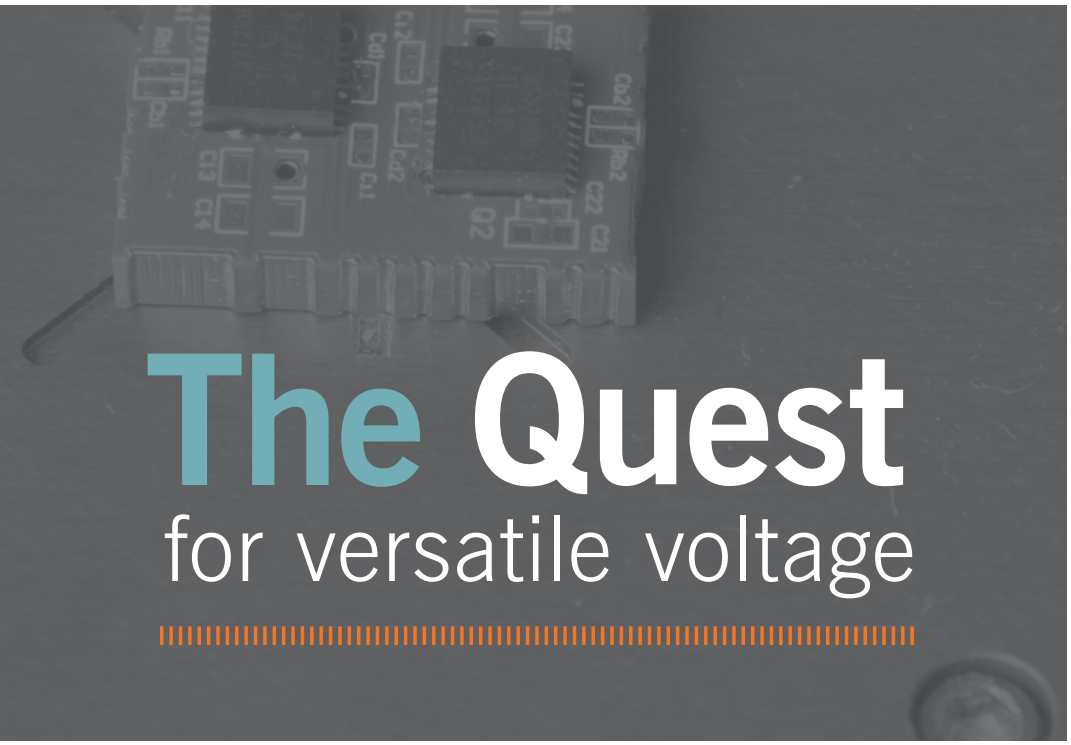
Martin would also like to avoid a situation he has seen frequently: an electrical engineering student takes Introduction to Computer Engineering and wants to take similar classes, but would need to add an extra semester or year because the curriculum is already so packed. "We want to give students enough information to make a reasonable choice early on, and make it easy to change their minds," says Martin. This is particularly valuable for students who are interested in applications of ECE that combine two or more aspects of the department that have historically been separate, like software defined radio. "Is it EE or CPE?" Martin asks. "You need both, and right now it's hard to get that mix in our program without double-majoring."

CONCEPTS & CHALLENGES

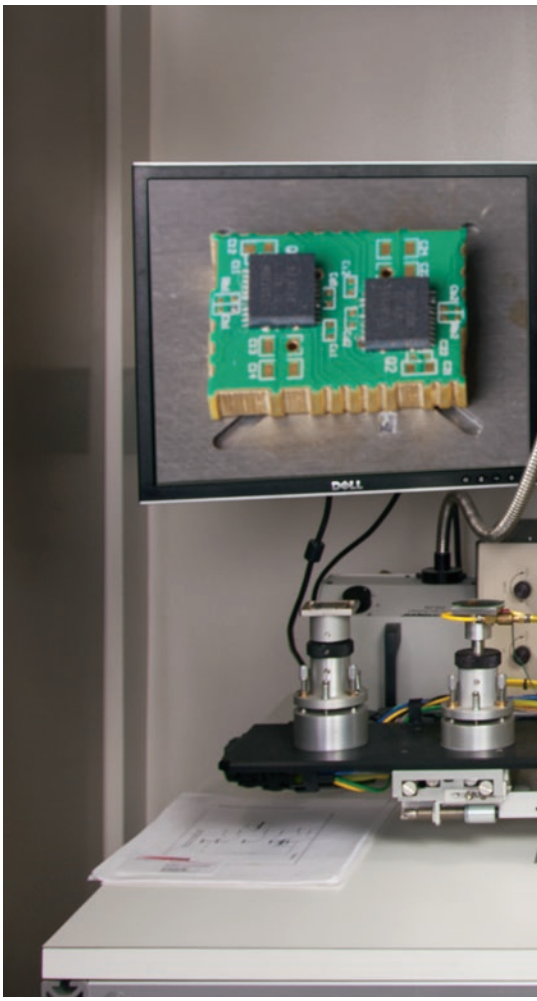
An early conversation in the new curriculum effort centers on threshold concepts: the difficult concepts that unlock new levels of understanding for multiple areas and that change the way students think. "These concepts are hard for students to grasp, but once they understand them, a lot of other things make sense," says Martin. The first challenge, according to Martin, is to identify these concepts. The next challenge is to move as many as possible into the early years of the undergraduate curriculum so that students have flexible options for their futures.

Facilitators are running focus groups among the faculty, students, and ECE advisory board members to help identify these concepts. A number of professors have left these groups and continued the conversation—meeting in the hallway to discuss new ideas and potential tactics for change.

Part of the challenge is to change what it means to be a Virginia Tech ECE, says Martin. "The perception can sometimes be that you're an engineer when you've run the gauntlet of classes." Instead of asking if students can pass a set of classes, we are asking if they can solve the problems they need to solve. ece



The Quest for versatile voltage



Qiang Li receives CAREER Award to reinvent the voltage regulator

IN a world with innumerable small electronic devices, battery life has become a major concern. We regularly grumble about how often we need to recharge our smartphones, wearable devices, and remote sensors.

Qiang Li, an ECE assistant professor, plans to help solve this problem by reinventing the voltage regulator—a device that typically ferries power to microprocessors. Today's voltage regulators can be power hogs, Li says. They are not able to respond quickly enough to meet the widely varying demands of a microprocessor with maximum efficiency.

Li's dream voltage regulator can deliver varying, or dynamic voltage levels as needed by the microprocessor. At 20-50 MHz, it has a frequency more than 10 times higher than traditional converters. The proposed voltage regulator can dramatically reduce microprocessor power consumption to increase battery life by 50 percent or more.

Li, who specializes in power electronics, was awarded the National Science Foundation (NSF) Faculty Early Career Development (CAREER) Award for this effort. The CAREER grant is one of the NSF's most prestigious awards, given to junior faculty members who are expected to become academic leaders in their fields.

LOCATION, LOCATION, LOCATION

Li must solve many issues in his quest. The first is the location on the chip. The impedance between the voltage regulator and the microprocessor prevents conventional voltage regulators from responding quickly. If the voltage regulators can be placed close to the microprocessor, he says, the system could support the desired dynamic voltage and frequency scaling.

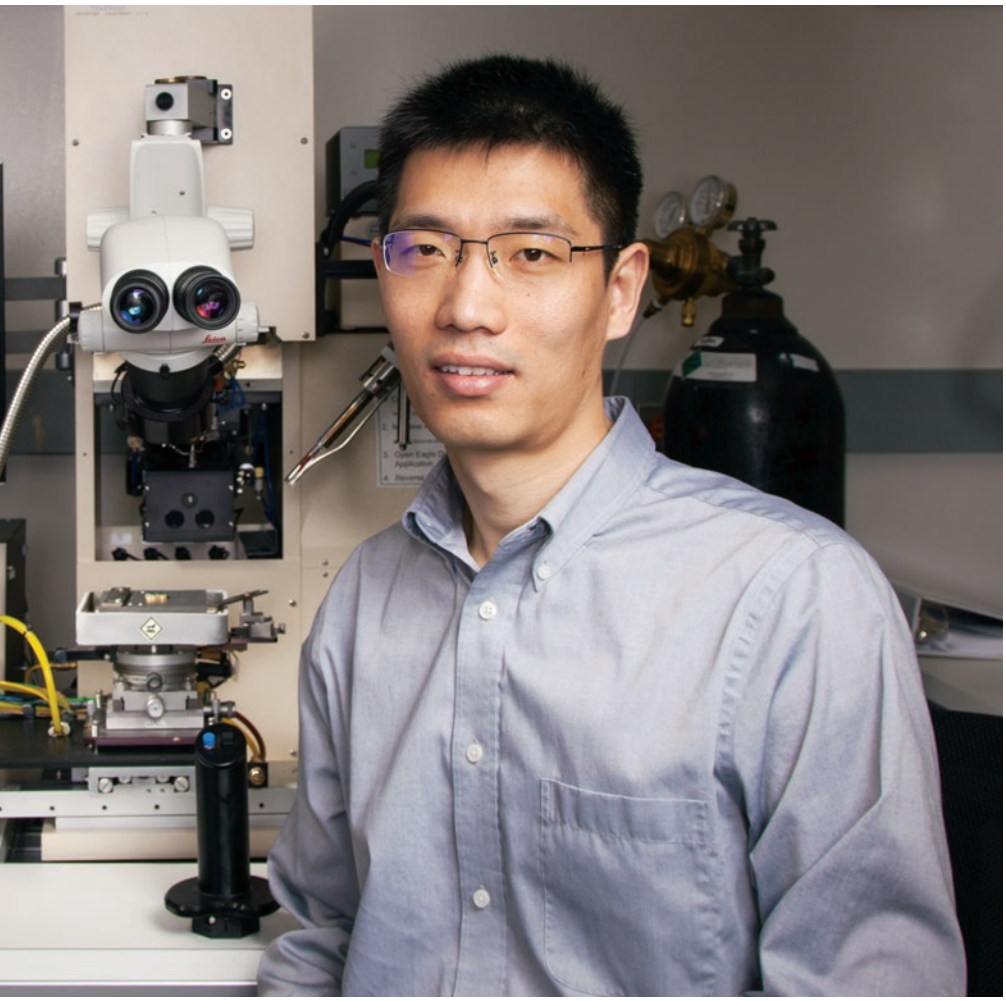
Getting close to the microprocessor is difficult, however. Today's voltage regulators contain passive components, such as inductors and capacitors, that are "bulky and occupy a considerable footprint on the motherboard," Li says.

His solution is to save space by integrating multiple inductors into a single-piece magnetic core, using a lateral flux inductor structure. This structure, he says, will allow the voltage regulator to achieve low-profile, high-density, low-winding-resistance, and confined flux at the same time.

"It's a very effective power consumption reduction technique for microprocessors."

ANOTHER DIMENSION

In seeking a smaller footprint and greater proximity to the microprocessor, Li is also exploring 3-D integration methods, such as printed circuit board embedding and 3-D



QIANG LI was awarded the NSF CAREER award for his research, which aims to reinvent the voltage regulator for maximum efficiency.

printing. He is collaborating with interdisciplinary researchers within the university and in industry to discover options.

MORE SPEED

But a shorter power delivery path and smaller footprint are not enough: the frequency must also increase. Li's goal is 10 times higher. This is achievable, he says, but it may cause increased thermal stress, switching losses, and electromagnetic interference (EMI). The complex tradeoffs must be managed for efficiency and reliability, but achieving dynamic voltage and frequency scaling is a challenge worth undertaking, he says. "It's a high-risk, high-return project."

The project's education component will incorporate high-frequency power converter design into the ECE curriculum and offer professional development opportunities for power electronics industry engineers via short courses.

Li will also be collaborating with the Virginia Tech Center for the Enhancement of Engineering Diversity (CEED) to provide opportunities for K-12 students and underrepresented groups to learn about technologies typically only worked on by people with advanced degrees in power electronics. ece

VIRGINIA TECH

ece

CURRENT FACULTY MEMBERS WITH

NSF CAREER Awards

2017 Qiang Li
2013 Walid Saad
2012 Joseph Baker
2011 Yaling Yang
2010 Paul Ampadu
2008 Masoud Agah
2008 Leyla Nazhandali
2008 Jung-Min Park
2007 Patrick Schaumont
2007 Yong Xu
2005 Tom Martin
2005 Allen MacKenzie
2004 Thomas Hou
2003 Dan Stilwell
2001 Michael Hsiao
1999 Sanjay Raman
1997 Mark Jones
1995 Luke Lester
1995 G.Q. Lu

SCOTT BAILEY and his team launched a sounding rocket into the polar night to measure nitric oxide accumulation in the upper atmosphere.

MERRICK PEIRCE

Reading the atmosphere by starlight

ECE Professor Scott Bailey and his team launched a NASA rocket experiment into the polar night to measure the altitude profile of nitric oxide—a noxious upper-atmospheric gas.

Nitric oxide (NO) is created when the aurora interacts with the upper atmosphere. Streams of highly energetic electrons in the aurora tear apart molecules such as nitrogen. When nitrogen bonds break, the atoms interact with molecular oxygen to form nitric oxide.

If the gas moves down into the stratosphere, it destroys ozone. "Even a small reduction in ozone can affect upper atmospheric winds and potentially change global temperature profiles," said Bailey.

During the last 10 years, there were several winters where atmospheric scientists observed plumes of nitric oxide—assumed to originate from auroral interactions—descend and begin to eat away at the ozone layer, said Bailey.

"We're not sure why these descent events are happening now and never before," said Bailey. "It's possible that they were occurring, and our instruments are finally precise enough to detect them, but they could also signify a change in the atmosphere."

Sunlight destroys nitric oxide molecules in less than a day, making them difficult to study. However, in the polar night, nitric oxide abundances can grow large.

"We needed a technique to make direct measurements in the polar night," said Bailey.

SCOTT BAILEY

ABOVE: Communications antennae at the Poker Flat Research Range in Alaska.
RIGHT: Justin Carstens, Karthik Venkataramani, and William McClintock prepare the rocket.
BELOW RIGHT: A television camera inside the payload was used to help point the rocket.

Bailey, along with co-principal investigator William McClintock from the University of Colorado, Justin Carstens, a research associate, and Karthik Venkataramani, a Ph.D. student, set out to measure nitric oxide accumulation during the 24-hour darkness of the Arctic winter.

On January 27, after a month of intense preparation in temperatures that plunged to 50 below zero, the Polar Night Nitric Oxide (PolarNOx) experiment was launched on a NASA sounding rocket from the Poker Flat Research Range in Alaska.

As the rocket climbed to an altitude of 176 miles, its sensors locked onto Algenib, a star located deep in the polar night that was chosen because it shines relatively brightly in the ultraviolet spectrum that nitric oxide absorbs.

During the eight-minute journey, a spectrograph measured the starlight as it passed through nitric oxide molecules in the atmosphere.

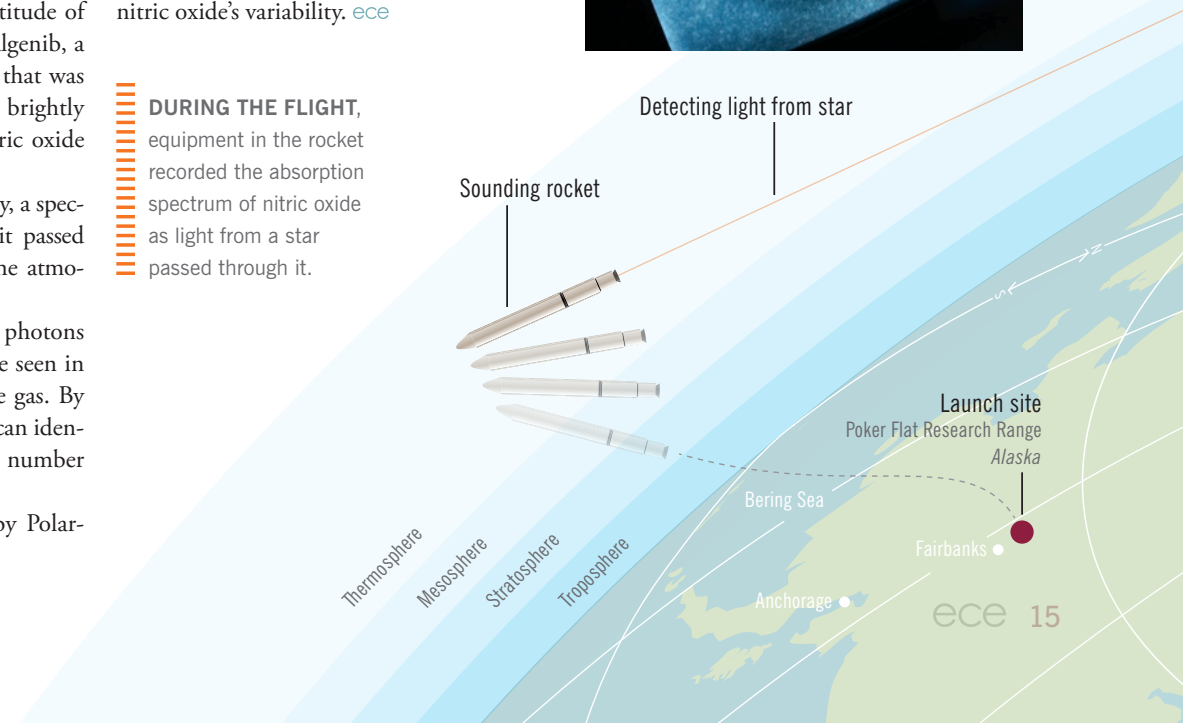
Nitric oxide molecules absorb photons in distinct frequencies, which can be seen in the electromagnetic spectrum of the gas. By analyzing the spectrum, researchers can identify and study the temperature and number density profile of nitric oxide.

Thanks to the data collected by PolarNOx, Bailey’s team will begin analysis. After they correct the data to account for the motion of the rocket—a slow process requiring that they treat each second of data differently—they will transform it into a profile of nitric oxide as a function of height.

“This is not a new technique—it’s been done for other atmospheric gases, including ozone,” said Bailey. “But it’s the first time anyone has used it to study nitric oxide.”

And it won’t be the last time. Now that they know the technique works, Bailey and his team can use it in the future to study nitric oxide’s variability. ece

DURING THE FLIGHT, equipment in the rocket recorded the absorption spectrum of nitric oxide as light from a star passed through it.



Flying packets

Students launch SDR into space

PHOTOS COURTESY ZACH LEFFKE

ON August 17, 2016, a Terrier-Improved Malemute sounding rocket launched from the NASA Wallops Flight Facility as part of the Rocksat-X program. It contained a student-built payload that demonstrated the commercial viability of software-defined radios (SDRs) in satellite applications.

RockSat-X is coordinated by the Colorado Space Grant Consortium initiative through NASA's Sounding Rocket Program office. It provides lower cost access to space for university design teams.

Every university participating in the RockSat-X program is allotted one modular payload space on a rocket. Thanks to generous donations from Virginia Tech, Orbital ATK, and A.I. Solutions, the Virginia Tech undergraduate team has been involved in this program for the past five years, building satellite payloads and testing them on satellite rockets.

"This is a true rocket launch," said Hume Center researcher Zach Leffke (MSEE '13), who is the Virginia Tech Ground Station (VTGS) principal investigator. "The students have to design their payload to survive all the stresses that a launch entails."

The undergraduates, including Greg Scott (BSCPE '16), designed and hardened their payload—a hardware sensor suite that measured the pressure, temperature, accelerations, and rotation rate of the rocket in flight.

"It was a fairly simple sensor suite taking fairly simple measurements," said Leffke. "But the point was to send that data over a software-defined radio, proving that a commercially available SDR can survive the stresses of launch and be used in space."

The rocket sustained more than 20 Gs under launch conditions, reaching Mach 5.6, and achieved an altitude of 153 kilometers at apogee.

"The rocket was high enough over the Atlantic Ocean that we could pick up its radio signal," said Seth Hitefield, an ECE Ph.D. student and a member of the VTGS operations team. "And that's what made this experiment feasible for us—we could livestream the data to Blacksburg."

It was 15 minutes from rocket launch to splashdown, but the team only had five minutes to turn on the payload, feed the data into the SDR, and transmit it to the Blacksburg tracking station.

Because it was the first time the team had tried this experiment, and because the payload components were not space-rated, the threshold for success was one transmitted signal packet, plus the survival of all the sensors.

The team detected 182 packets and decoded seven completely. They had hoped to receive a couple thousand packets, but two rocket anomalies contributed to the discrepancy between the results and their best estimates.

Due to a malfunctioning de-spin mechanism, the directional-pointing antenna didn't end up pointing toward Blacksburg, which reduced the quality of the signal. Unfortunately, NASA failed to retrieve the payload after it hit the Atlantic Ocean—a rare occurrence—which meant that the students were unable to decode the rest of the packets or recover their equipment.

"But we proved what we wanted to prove with the packets we got," said Leffke. "And much of what it means to be an engineer is asking 'what important parameters did I not account for in the initial model?' and 'what did I miss?'"

For the Virginia Tech Rocksat-X team, the answers to these questions will be reflected in next year's satellite rocket payload. ece

TOP LEFT: The rocket launch at the NASA Wallops Flight Facility.
TOP RIGHT: Virginia Tech students erect an antenna at the Blacksburg ground tracking station.
BOTTOM LEFT: Zach Leffke waits for launch at the NASA Wallops Flight Facility.
BOTTOM RIGHT: Sebastian Welsh (BSCS '17) fine-tuning the payload after mounting.

JEAN REVILLARD / REZO

PAIGE KASSALEN (BSEE '15) stands with Solar Impulse 2, as part of the solar-powered aircraft's ground crew.

Textbooks to tarmac

Making solar-powered flight a reality

When 23-year-old Paige Kassalen (BSEE '15) joined the 16-person ground crew of the world's first solar-powered plane (Solar Impulse 2), there was no textbook to help her catch the wing of the 5,100-pound aircraft or run the power system of its inflatable mobile hangar.

"It was an experimental aircraft, a flying laboratory," she explained. "We never knew which problems we were going to encounter."

Kassalen, a commercial trainee for Covestro, was selected to represent the high-tech chemical manufacturer as an electrical engineer on the groundbreaking team.

She recalled one of the "most dramatic incidences" of the 17-leg journey when the protective hangar partially deflated, subjecting the plane's tail to the structure's massive weight for approximately two-and-a-half minutes.

"My heart stopped," she said. "We were supposed to continue this around-the-world mission and end up in Abu Dhabi, but I was thinking it might be over in Dayton, Ohio."

Kassalen was on the team of engineers charged with identifying the cause of the accident and developing a solution to prevent a reoccurrence during the rest of the trip.

Solar Impulse 2 successfully completed its global flight on July 26, 2016, and Kassalen is still being recognized for her role as the youngest and only American member of the aircraft's international ground crew team. Earlier this year, she was named one of Forbes' 30 Under 30.

Kassalen credits ECE's project-based curriculum for providing her with the problem-solving experience she needed for success. Although Solar Impulse 2 was much larger in scale than the projects she did in the classroom, it required the same problem-solving skill set and toolbox.

> "That spirit of adventure, that sprit of exploration and trying something new and making a better world, that's what I want to do."

"I never thought I'd get comfortable with it," said Kassalen, talking about her project responsibility. "Then there was a moment in Egypt where I was standing on the runway and thought it was perfectly normal. There was no right way to do it—you do whatever you can to make sure the wing doesn't hit the ground."

Concepts she learned in the classroom connected to work in ways she didn't expect. She recalled sitting in the hangar one day thinking about the power generator, and remembering material from Associate Professor Jaime De La Ree's power systems class.

"I would think 'Wow this is so relatable. I understand this. I'm speaking this language and I get it,'" she said.

But being a new engineer on a historical aviation mission wasn't always easy, said Kassalen. There was a big difference between the fear of getting a poor grade in class and the responsibility of being liable if the hangar collapsed, cutting short a 12-year project.

Initially, Kassalen spent time learning and finding mentors. She said she was determined to be a reliable engineer.

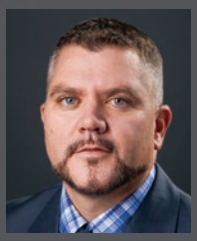
"It's harder to keep trying and pushing yourself if you don't have a strong support system," she said. "That's what I had at Virginia Tech," and she wanted to build a similarly strong support system at Covestro and on the Solar Impulse team.

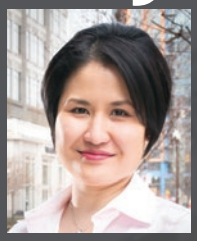
Today, she's still pushing herself and has adopted Solar Impulse 2's new slogan to "take it further."

"That spirit of adventure, that sprit of exploration and trying something new and making a better world, that's what I want to do," she said. ece

new faculty members


Paul Ampadu


Arthur Ball


Tam Chantem


Ryan Gerdes


Kendall Giles


Jia-Bin Huang


Ryan Williams

VIRGINIA TECH'S ECE FACULTY is growing at an aggressive pace. As more graduate and undergraduate students choose our department to prepare them for their careers, we are strategically adding faculty members to support our teaching, research, and outreach missions.

This year, we would like to introduce seven new members of our faculty.

Arthur Ball brings his years of professional design experience to enhance our undergraduate projects and courses. Kendall Giles is contributing his cybersecurity and computational background to coordinating the ECE efforts in Virginia Tech's online Master of Information Technology program.

Tam Chantem and Ryan Gerdes are supporting our program in the National Capitol Region, in cyber-physical systems, intelligent transportation and real-time embedded systems.

At the Blacksburg campus, Paul Ampadu pioneers research in networks-on-chip, Jia-Bin Huang specializes in computer vision, computer graphics, and machine learning, and Ryan Williams investigates distributed multi-agent systems.

Our new faculty members bring experience and education from across the country, including Cornell, the University of Southern California, the University of Notre Dame, the University of Iowa, Johns Hopkins University, the University of Illinois at Urbana-Champaign, and Virginia Tech.

2017 FACULTY MEMBERS*

116 total faculty members

77 tenured/tenure track

30 research faculty

9 teaching faculty

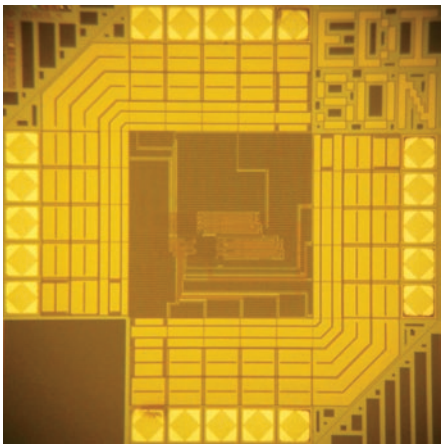
*As of April 1, 2017

Heterogeneous networks-on-chip

Professor Paul Ampadu dreams of putting more than 1,000 electronic/photonic/nanomechanical cores on a single chip. He wants to shrink large data centers—like Amazon server warehouses—into an integrated system (with the same processing capability) that might fit in the palm of your hand.

Ampadu seeks to realize this vision by developing reliable, energy-efficient, heterogeneous Networks-on-Chip (NoC), putting a twist on the conventional System-on-Chip (SoC) design.

SoCs are typically bus-based, using a single lane of communication to connect all



Ampadu Group Fabricated Dual-Core Sensor

of the components on the chip—microcontroller, memories, timing sources, etc. While this approach works well when there are only a few systems to arbitrate, says Ampadu, issues arise as the number of cores increases.

"The big disadvantage with a bus system is that it is quite unscalable, with worsening latency and deadlocks as the number of cores increases," says Ampadu. "When everybody tries to access a bus at the same time, it can lead to nightmares of delay and arbitration inefficiency."

Ampadu's research focuses on re-engendering the non-scalable SoC design into a more structured, regular, and modular design of a network for components to interact with each other.

With a mesh network-on-a-chip topology, all nodes can access resources without a shared bus. One node (core) can interact with any other via a series of simple hops.

"A design like this is scalable in the same way the internet is," says Ampadu. "Even if the world population increases to 20 billion, people will still be able to get online."

While hopping brings scalability into reach, each hop introduces lag time. But, Ampadu explains, performance is based on how many tasks the systems can process in a set unit of time.

"As soon as a node passes off a task, it's ready for the next one," says Ampadu. Even with the slight latency increase, "we can accomplish more in the same amount of time."

Ampadu, his Ph.D. student Venkata Sai Kiran Adigopula, and his master's students Shamit Bansal, Vinidhra Sivakumar, Sathyapriya Subramani, and Vigneshwaran Venugopal Kalaiarasi are also researching topics in many-core task allocation, approximate computing and storage, and joint reliability/security for many-core chips.

Ampadu's research practices have been influenced by the perspective shift conceived by Claude Shannon in the 1940s, which prioritizes preserving data over improving the physical medium through which data is transferred.

"We do the same thing," says Ampadu. "We focus on coding information so that we can transmit and receive it reliably."

In this way, his research team has been able to worry less about the unreliable transistor and interconnect components that accompany modern aggressively-scaled nanotechnologies, and rather, focus on signal-processing and information-theoretic approaches to process information. The group has modeled a reliable and energy-efficient 1,000-core chip using this approach.

"It works beautifully," says Ampadu. ece

INTRODUCING

Paul Ampadu

- Joined ECE Fall 2016 as Professor
- Associate Professor, University of Rochester, 2010–2016
- Assistant Professor, University of Rochester, 2004–2010
- Dr. Martin Luther King Jr. Visiting Associate Professor, Massachusetts Institute of Technology (MIT), 2011–2013
- Ph.D., electrical and computer engineering, Cornell University, 2004
- M.S., electrical engineering, University of Washington, 1999
- B.S., electrical engineering, Tuskegee University, 1996
- National Science Foundation CAREER Award, 2010
- Black Engineer of the Year Special Recognition Award, 2010
- IEEE Circuits & Systems Elected Board of Governors Member, 2010-2016

Powering students' practical proficiency

FOR most ECE students, the 15-year-old Electric Circuit Analysis Laboratory course is their first hands-on experience with electrical engineering. This year, it's undergoing a facelift.

Besides updating the lessons and equipment, ECE Instructor Arthur Ball is refocusing the labs to give students a working understanding of how to design circuits, not just analyze them.

"So much of the degree is theoretical book learning," he said. "But if you're heading into industry, you'll need to convert theory into practical skills."

Ball draws on his own industrial experience in designing commercial products. Before joining ECE in 2015, he was a senior design engineer at Blacksburg-based VPT, where he was responsible for the design of highly integrated dc-dc radiation-hardened thick-film, hybrid point-of-load, and bus converters for satellites and space vehicles.

As an ECE instructor, Ball serves as project coordinator for the master's of engineering students and advisor for the interdisciplinary Battery Operated Land Transport (BOLT) Team.

The BOLT Team is a student-driven design project with the goal of developing an internationally competitive all-electric motorcycle for zero emissions, clean carbon, and the highest possible performance.

Ball also advises several research projects, including NASA's Breakthrough, Innovative and Game-changing (BIG) Idea Challenge. The team—Liz Doggett (BSEE '18), Kshitej Jadhav (BSEE '19), Rex Peel (BSME '17), and Ben Swartz (BSEE '17)—recently submitted a proposal to design cost-effective modular space tugs, a type of spacecraft used to transfer payloads. They hope that their design, which would move between Earth and the Moon, could handle a wide array of payloads and assist SpaceX rockets to use the moon as a staging area for a Mars mission.

In his capacities as lab re-designer and instructor, project coordinator, and faculty advisor, Ball enjoys the challenge of teaching practical skills to students who have a wide range of backgrounds and experiences.

For a student with an eye toward a career in industry, "Electric Circuit Analysis Laboratory could be one of the most important classes," said Ball. ece

BELOW: Arthur Ball (center) and BOLT team members Dustin Stahl (BSME '15), Ben Whitney (BSEE '17), Gordon O'Neill (BSCPE '17), Jesse Stowe (BSCPE '17), and Christopher Mowery (BSEE '18). **BOTTOM:** Mowery helps assemble the battery carriage for the team's motorcycle.

INTRODUCING

Arthur Ball

- Joined ECE August 2015
- Ph.D., electrical engineering, Virginia Tech, 2009
- M.A., electrical engineering, Virginia Tech, 2004
- B.S., electrical engineering, mechanical engineering, Bluefield Sate College, 2001
- National Science Foundation Fellow
- Pratt Fellow

Cyberphysical maneuvers

DAN SNOOK

While driving, many of us have experienced the panicky feeling of uncertainty at the sound of an approaching siren. Where is the source? Which way should we move?

ECE Assistant Professor Tam Chantem is designing a semi-automated emergency response system that will provide guidance on the best action to take in this situation. In some cases, the system will even take that action for you.

"A semi-automated emergency response system reduces the time it takes emergency vehicles to reach their destinations," said Chantem. "And it increases the safety of all vehicles involved."

Chantem's research focuses on advancing automated vehicles and leveraging communication to coordinate human behavior. The semi-automated emergency response system is an everyday application of this technology. She is also taking a real-time system approach to designing efficient runtime algorithms that provide route and maneuver guidance to automated vehicles on highways or in cities.

Besides designing and developing embedded and cyberphysical systems, Chantem also investigates methods to increase efficiency while securing them against malicious attacks.

INTRODUCING

Tam Chantem

- Joined ECE in August 2016
- Assistant Professor, Utah State University, 2011-2016
- Ph.D., computer science and engineering, University of Notre Dame, 2011
- M.S., computer science and engineering, University of Notre Dame, 2008
- B.S., computer engineering, Iowa State University, 2005
- B.S., computer science, Iowa State University, 2005
- Air Force Office of Sponsored Research Summer Faculty Fellow, May 2015–July 2015

EFFICIENT

"Everyday activities are increasingly enabled by embedded systems," said Chantem.

In an embedded system, a deadline violation (when something doesn't happen at the right time) can have dangerous or disastrous consequences, she explained. For example, a car needs to respond to its brakes before it hits a wall.

Current approaches to actions like this make very simplistic assumptions, said Chantem, often resulting in wasted hardware and energy resources.

"If you design a system that always prepares for the worst-case scenario, it will be very inefficient," said Chantem. "We're finding better ways to model and analyze embedded systems by explicitly accounting for system dynamics when these systems interact with the users and the environments."

By analyzing, modeling, and predicting dependencies between the physical state and timing parameters, Chantem is seeking to reduce the size, weight, and power requirements of next-generation embedded systems.

SECURE

Even the sleekest, most efficient cyberphysical system can be hacked, so Chantem also focuses on securing automated systems. She is protecting critical information against attacks that target the physical sensing mechanism.

But not all critical information is created equal, and Chantem builds systems with different levels of protection to address the trade-off between efficiency and security. "You can think of these kinds of systems as valuables in your house—the most important things are locked in a safe, the less important ones are in a locked drawer," she explained. Partitioning security in this manner increases the resiliency of the system and reduces wasted energy.

Because these systems must access critical information, Chantem is also creating secure environments through which sensitive data can move. ece

DANN SNOOK

INTRODUCING

Ryan Gerdes

- Joined ECE August 2016
- Assistant Professor, Utah State University, 2012–2015
- Ph.D., electrical engineering, Iowa State University, 2011
- M.S., electrical engineering, Iowa State University, 2006
- B.S., electrical engineering, Iowa State University, 2006
- B.S., computer engineering, Iowa State University, 2004
- Utah State University, Department of Electrical and Computer Engineering, Teacher of the Year, 2013, 2015
- National Science Foundation Creating Effective Future Faculty in Engineering Award, 2009–2011

Fortifying autonomous algorithms

Autonomous transportation systems promise efficiency, safety, and speed—plus, no one has to drive. But in its current state, autonomous transportation is riddled with vulnerabilities.

ECE Assistant Professor Ryan Gerdes is thinking like a hacker to fortify the system at many different levels—in groups of moving cars, in the communication between cars, and in each individual vehicle.

VEHICLE PLATOONS

"Humans do not drive safely," said Gerdes, who explained how most drivers speed and tailgate. "But we do tend to get where we're trying to go with surprisingly few accidents."

Autonomous vehicles would set speeds and following distances, which would improve safety but decrease road capacity.

He described one solution as vehicle platooning, or road trains, in which a collection of autonomous vehicles acts in a tight, coordinated way. The lead vehicle sets the speed, and while the following vehicles receive some information from the leader, they primarily focus on the car in front of them in accordance with rules for speed and spacing. This allows the vehicles to travel in close packs at high speeds, increasing road capacity without sacrificing safety.

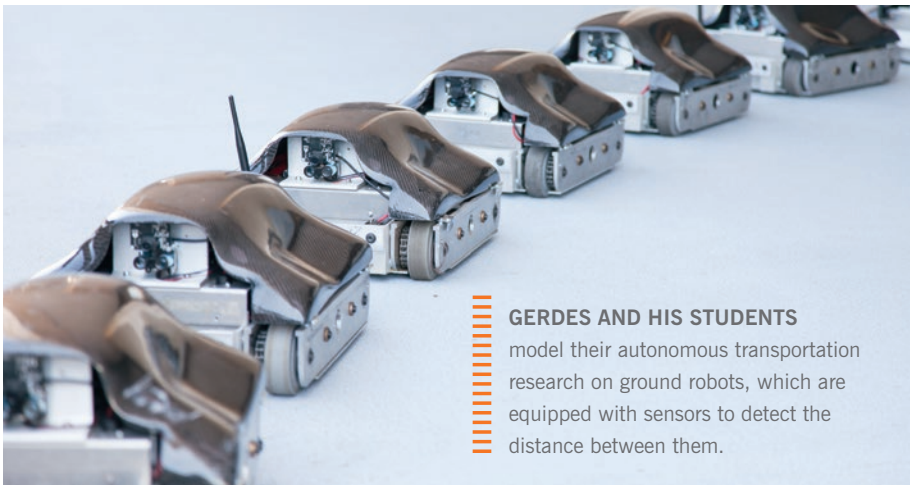
While vehicle platoon systems can make traffic more efficient and safe, they haven't been fully examined in the context of adversarial environments.

"Terrorists, agents for corporate sabotage—autonomous transportation hasn't been designed with an adversary in mind," said Gerdes. "And when we started looking at how the present system would respond to malicious activity, what we found was alarming."

All the algorithms Gerdes and his team have examined to date were vulnerable to a single bad actor who could usurp the role of leader—even, in some cases, from the rear of the platoon. One malicious vehicle would be able to destabilize an entire platoon, said Gerdes, causing accidents of high severity or perpetual traffic jams from which the system may not be able to recover.

Gerdes also aims to defend automated transportation from within individual cars, specifically in the critical radar sensors, which are subject to malicious attack.

Gerdes' goal is to strengthen the young industry and prevent any adoption slowdown due to security fears. "You can't build a perfect system," said Gerdes. "But we can make a resilient system that fails in better ways." ece



GERDES AND HIS STUDENTS model their autonomous transportation research on ground robots, which are equipped with sensors to detect the distance between them.

INTRODUCING

Kendall Giles

- Joined ECE May 2016
- M.F.A., creative writing, University of Southern Maine, 2013
- Ph.D., computer science, Johns Hopkins University, 2007
- M.S., computer science, Johns Hopkins University, 2004
- M.S., information systems, Virginia Commonwealth University, 2002
- M.S., electrical engineering, Purdue University, 1993
- B.S., electrical engineering, Virginia Tech, 1991

Cybersecurity at a distance

FOR the fourth consecutive year, Virginia Tech's Master of Information Technology program placed second among the nation's distance-learning programs in the U.S. News & World Report online education rankings. The program, which is offered jointly by ECE, the Department of Computer Science, and the Pamplin College of Business, continues to grow. Kendall Giles joined ECE in May 2016 to develop new courses, teach, and help coordinate the department's involvement with the program.

With six academic degrees—a doctoral degree in computer science; master's degrees in information systems, electrical engineering, and computer science; a bachelor's degree in electrical engineering; and a master of fine arts in creative writing—plus more than two decades in industry, Giles has the breadth of experience to relate to people from diverse backgrounds.

He enjoys the challenge of coordinating ECE's involvement in the program, which attracts a wide range of students, from working professionals with deep industry experience to mid-career-changers starting from scratch. "These students are working and wrestling with real-life issues," said Giles. "I can draw from the lessons I learned in industry and academia to customize the learning experience."

Giles is also designing and teaching ECE 5984, Cybersecurity and the Internet of Things, which uses the Internet of Things as the vehicle to introduce the basic principles of cybersecurity. "Only some of our students want to become cybersecurity professionals," said Giles. "But anyone who graduates from Virginia Tech with a master's of information technology should at least understand the fundamentals of security."

The program complies with Virginia Tech's Integrated Security Destination Area initiative, an effort to provide faculty and students with new tools to advance and ensure the security of our vital social, political, and financial networks.

EVERY WEEK, Kendall Giles pre-records his lectures for the upcoming module.

Giles also teaches Principles of Computer Security in the Department of Computer Science, another course in the security destination area. The class includes computer engineering students, and Giles likes teaching a diverse student body.

"When I come up with a course or teach a class that everyone can get something out of, I feel like I've done my job well," said Giles. ece

INTRODUCING

Jia-Bin Huang

- Joined ECE August 2016
- Ph.D., electrical and computer engineering, University of Illinois at Urbana-Champaign, 2016
- M.S., electrical and computer engineering, University of Illiniois at Urbana-Champaign, 2012
- B.S., electronics engineering, National Chiao-Tung University, 2006
- 2015 Cognitive Science/Artificial Intelligence Award

JIA-BIN HUANG is using training data and principles of machine learning to teach computers how to anticipate what comes next in a visual scene.

Visual precognition

A man sits alone in a busy café. Steam floats above the porcelain cup in his hand. After inhaling the fragrant scent, he raises the cup to his lips, and…

Any human watching this scene play out could tell you that he's probably about to take a sip of his drink. But arriving at this seemingly obvious conclusion takes on a new level of genius if a machine is predicting what happens next.

"Humans have this extraordinary ability to anticipate actions based on visual cues," said ECE Assistant Professor Jia-Bin Huang. "A machine does not have those skills. Yet."

Huang, who joined the ECE faculty in 2016, recently completed his Ph.D. at the University of Illinois at Urbana-Champaign. With help from two graduate researchers (Badour AlBahar, MSCPE '18, and doctoral student Jinwoo Choi), Huang is researching ways to enable machines to see the world like humans do. He is crafting algorithms that teach computers how to understand and synthesize visual data—both images and video.

This endeavor is increasingly difficult because teaching a system to understand visual scenes often relies on the use of training data, which can be expensive and scarce. Therefore, Huang is seeking to achieve even greater results in visual learning and inference using relatively few labeled examples.

One of his main interests focuses on training computer systems to anticipate consequences in visual scenes, like the man in the café. To do this, he is designing algorithms that can learn from huge databases of existing videos—like YouTube. He will apply principles of machine learning, specifically deep learning (cascades of nonlinear transformation), to expand a computer's capacity to absorb large amounts of data.

"If we can teach them how to understand the visual world, they will be able to interact in a wide variety of scenarios," said Huang. "It's a very important step toward intelligence." ece

Distributed decisions at scale

IN the not-too-distant future, our smart cars, bridges, buildings, and cities will all be talking to each other, says ECE Assistant Professor Ryan Williams. This highly interconnected infrastructure will rely on sensors, distributed intelligence, and robotic teams.

"In the coming decades, we'll have teams of fully autonomous, distributed robots," says Williams. But how will large-scale autonomous systems coordinate and compute in a distributed or decentralized way?

This is the question that Williams poses in his research and strives to answer in his Laboratory for Coordination at Scale (CASLab).

COMPUTATIONAL BALANCING

Williams and graduate students Anand Bangad and Siddharth Bhal are designing algorithms to carry out multi-robot computation, where a system composed of many robots autonomously assigns and distributes computational tasks. In this setup, the network could sense if the workload is heavier in some sectors, then dynamically adjust to correct it and complete the task in the most efficient way.

MULTI-SCALE PLANNING

In the flurry and excitement of robot design and development, we commonly assume that whatever robots are sensing is worth sensing, Williams says. One arm of his research explores this assumption, questioning if it is the best use of resources. Williams wants to know what is appropriate to sense and when to sense it.

Williams and doctoral student Jun Liu have been applying tenets of decision theory to develop multi-scale planning algorithms. The algorithms equip teams of robots with the ability to autonomously decide what to observe when, then self-deploy and report back to further refine the plan.

This distributed scale computing and decision-making would lend itself to any number of applications, including environmental modeling. For example, in the first phase of an oil spill, high-intensity monitoring is necessary. As the spill is transported by currents and becomes more predictable, its monitoring shifts into a phase that's longer-lived but less resource-intensive. The impact on wildlife happens at different timescales, and the surface area increases.

NETWORKED SECURITY

As autonomous drone capabilities expand, researchers grapple with new challenges in modeling and in security.

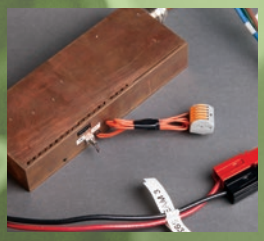
For example, multi-robot teams that can adapt to their environment are being vetted for infrastructure inspection—drones that can inspect bridges, ships, or tanks.

However, a flexible model exposes a security risk. How does one secure a system that learns? Williams and doctoral student Remy Wehbe have begun investigating.

"It's a very interesting question, and one that's relevant, given the recent advances in deep learning," said Williams. ece

ABOVE TOP: Doctoral student Pratik Mukherjee holds a quadrotator. Mukherjee is working with Williams on directed graph topology control of multi-agent systems. **ABOVE BOTTOM:** An Internet of Things (IoT) node for ubiquitous computing.

student projects



ECE PRIORITIZES HANDS-ON EXPERIENCES. In addition to class projects, the two-semester Major Design Experience provides teams of students with simulations of the post-college world through projects specified and directed by industry partners.

The department also offers a variety of extracurricular projects, where students can work on interdisciplinary teams. Hyperloop, RockSat-X, and DEEP-X are among many student-driven teams that have gained international reputations for innovation and excellence.

ECE students can also pursue their own passions. The AMP Lab provides a learning environment for independent projects—where members can use tools they need to create their dreams and gain skill.

The following pages feature some of the many student projects going strong in ECE.

LITTLE BOX, BIG POWER

More than 2,000 teams from across the world registered for Google's $1 Million Little Box Challenge, an open competition to design and build a small kilowatt-scale inverter with a power density greater than 50 watts per cubic inch. ECE's Future Energy Electronics Center team was the only U.S. team to place in the top three—and the only student team.

Lanhua Zhang (Ph.D. '16), Xiaonan Zhao (Ph.D. '18), and Rachael Born (MSEE '16), advised by ECE professor Jin-Sheng (Jason) Lai, competed in the January 2016 challenge to drastically decrease the size of a power inverter.

Inverters take direct current from solar panels and batteries, converting it to the alternating current used in homes. These devices are generally about the size of a case of wine.

Making these inverters smaller would enable more solar-powered homes and more efficient distributed electrical grids, and could help bring electricity to the most remote parts of the planet, according to Google's Little Box Challenge website.

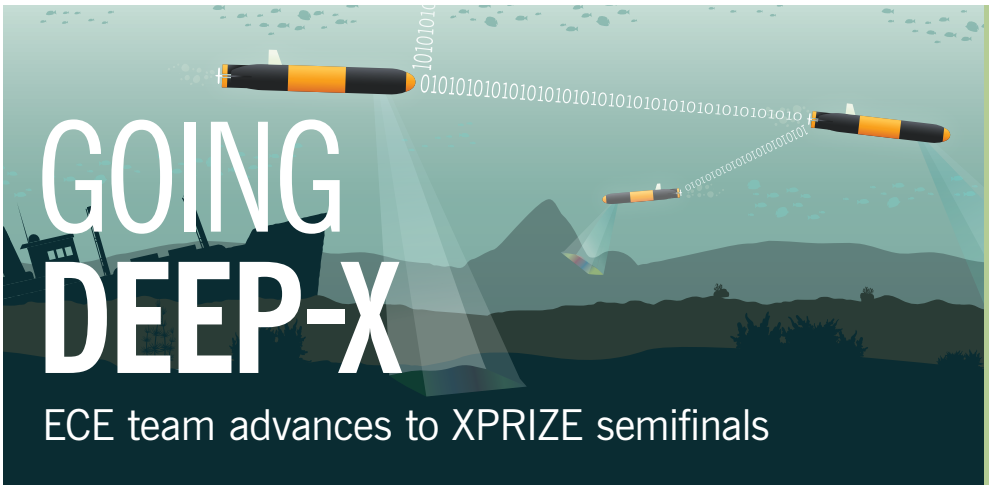
THE FEEC TEAM placed among the top three finalists in an international competition to drastically decrease the size of a power inverter. Their inverter, pictured above, is 28 cubic inches.

"In order to qualify for the competition, the inverter had to be smaller than 40 cubic inches," said Lai, the James S. Tucker Professor of Electrical and Computer Engineering. "We got it down to 28 cubic inches."

The FEEC team was one of 18 finalists whose inverters were chosen for testing at the National Renewable Energy Laboratory's Energy Systems Integration Facility in Golden, Colorado.

At this stage, the inverters underwent a 100-hour simulation of real-life conditions that included the kind of rapid power cycling a solar power system would experience on an intermittently cloudy day. The FEEC team was one of only three teams to successfully complete this stage of the competition.

The team received technical support on thermal modeling and electromagnetic interference measurements from their partners, including Industrial Technology Research Institute and Rhymebus Corp., both from Taiwan; VPT Inc., Blacksburg; and Nanyang Technological University, Singapore. ece



GOING DEEP-X

ECE team advances to XPRIZE semifinals

COURTESY VT NEWS

GRADUATE STUDENTS Jack Webster and Stephen Krauss assemble the 690 AUV. The Javelin AUV that they are developing for the ocean discovery XPRIZE competition is based on the successful 690 design.

Underwater autonomous robots operating 2,000 meters deep will compete against each other and the nature of the ocean in the first round of the Shell Ocean Discovery XPRIZE in late fall 2017.

Virginia DEEP-X, a team of students and faculty led by Professor Dan Stilwell, and 21 other semifinalists will square off in the $7 million global competition. The team is extending its prior accomplishments in subsea robot design, subsea navigation, and collaborative autonomy to explore the vast, unplumbed depths of the ocean.

"The deep ocean is poorly known," said Stillwell. "We have much better maps of the Moon, Mars, and even Venus than our own oceans."

While the technology to conduct high-fidelity surveys already exists, it is slow and extraordinarily expensive, explained Stilwell. XPRIZE seeks technology that is orders of magnitude faster and less expensive than the current state of the art.

DEEP-X is answering the XPRIZE's challenge by developing a coordinated team of small, low-cost autonomous underwater vehicles (AUVs).

In the first of two rounds, teams test their entries at a depth of 2,000 meters, mapping at least 20 percent of the 500 km^2 competition area at five meters resolution. They will be also be identifying and imaging at least five archeological, biological or geological features at any depth—all within 16 hours.

Round two, the final deep-sea test, will take place at 4,000 meters below the surface, and teams are required to map at least 250 km^2 of the seafloor.

DEEP-X APPROACH

The DEEP-X team, which is a collaborative project between Virginia Tech and Old Dominion University, has integrated acoustic communication systems into the AUVs so that they can communicate underwater using sound. Communication is necessary for collaboration. The same communication technology also aids navigation, which is the process by which an AUV determines its location. Every time an AUV hears a data packet from another AUV, it is able to infer the range to the other AUV, which is helpful for estimating the location of the AUV.

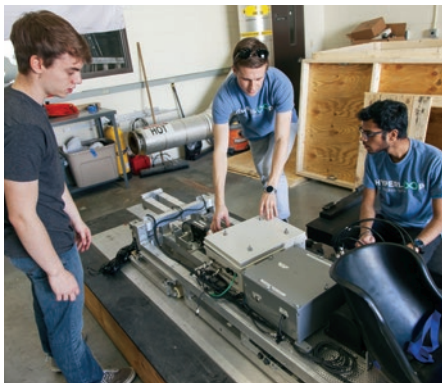
LISTENING UNDERWATER

Subsea communication using sound is notoriously unreliable. "One challenge for communication is that the density of seawater varies within the ocean due to variation of temperature and salinity, among other characteristics, and that changes in density can dramatically affect how sound travels through the ocean. A layer of dense, cold water, for example, might effectively block acoustic communication," said ECE Assistant Professor Ryan Williams, who is participating with the effort. "This makes communication with the surface—and therefore pinpointing robot location—a tricky task."

Autonomous coordination is paramount for a task this ambitious, said Williams. "XPRIZE's ocean mapping effort is arguably harder than putting a robot on the moon because of the parameters they're asking for."

But it's about learning how to think big, said Williams—or, in DEEP-X's case, think deep. ece

IN THE LOOP



DAVID GOLDSMITH

TOP: Ritzinger and Gubanov show new recruit Shinde the ins and outs of the Hyperloop pod.
BOTTOM: SpaceX employees help push the Virginia Tech pod out of the test track.

> "Virginia Tech is building a 600-foot open-air test track... we won't have to go to California every time we need to test something."

A January competition found Virginia Tech undergraduates pitting their design skills against teams from all around the world, vying to make their mark on the future of transportation.

The teams tested Hyperloop pods that they had designed and built. Hyperloop is a proposed mode of transportation where pod-like vehicles are propelled through a near-vacuum tube at speeds approaching 800 km/hr.

"No one has ever done Hyperloop before," said Anissa Dadkhah (BSEE '19), the incoming electrical lead for Virginia Tech's Hyperloop team. "You can't just look up the answers in a book."

While the concept of high-speed travel through tubes is not new, the Hyperloop hype surged in 2012, when Elon Musk issued a white paper inviting innovators to refresh the idea with updated technologies.

SpaceX created a competition around the concept to encourage progress.

After Virginia Tech placed fourth in the first stage of the competition—a 2016 international pod design competition hosted by Texas A&M University—the multidisciplinary engineering team received an invitation to build their design, test, and run their pods along SpaceX's 1-mile testing track.

This past January, the Virginia Tech team proceeded to the next step: SpaceX's Hyperloop Pod Competition I outside of SpaceX headquarters in Hawthorne, California, where 27 university teams from around the world competed with their first generation prototype designs.

"We worked really hard to modularize everything for the competition officials and make it as simplistic as possible," said Hyperloop lead Andrey Gubanov (BSCPE '19). "And since we might have been the first team to complete the systems check, I think we succeeded."

The Virginia Tech pod design, which underwent several iterations before achieving its current form, is a sled outfitted with Halbach magnetic arrays in each of the four

corners. The passive magnetic arrays bend magnetic flux—on one side of the array the magnetic field increases, on the other side it decreases. The SpaceX pusher accelerates pods past their levitation speeds.

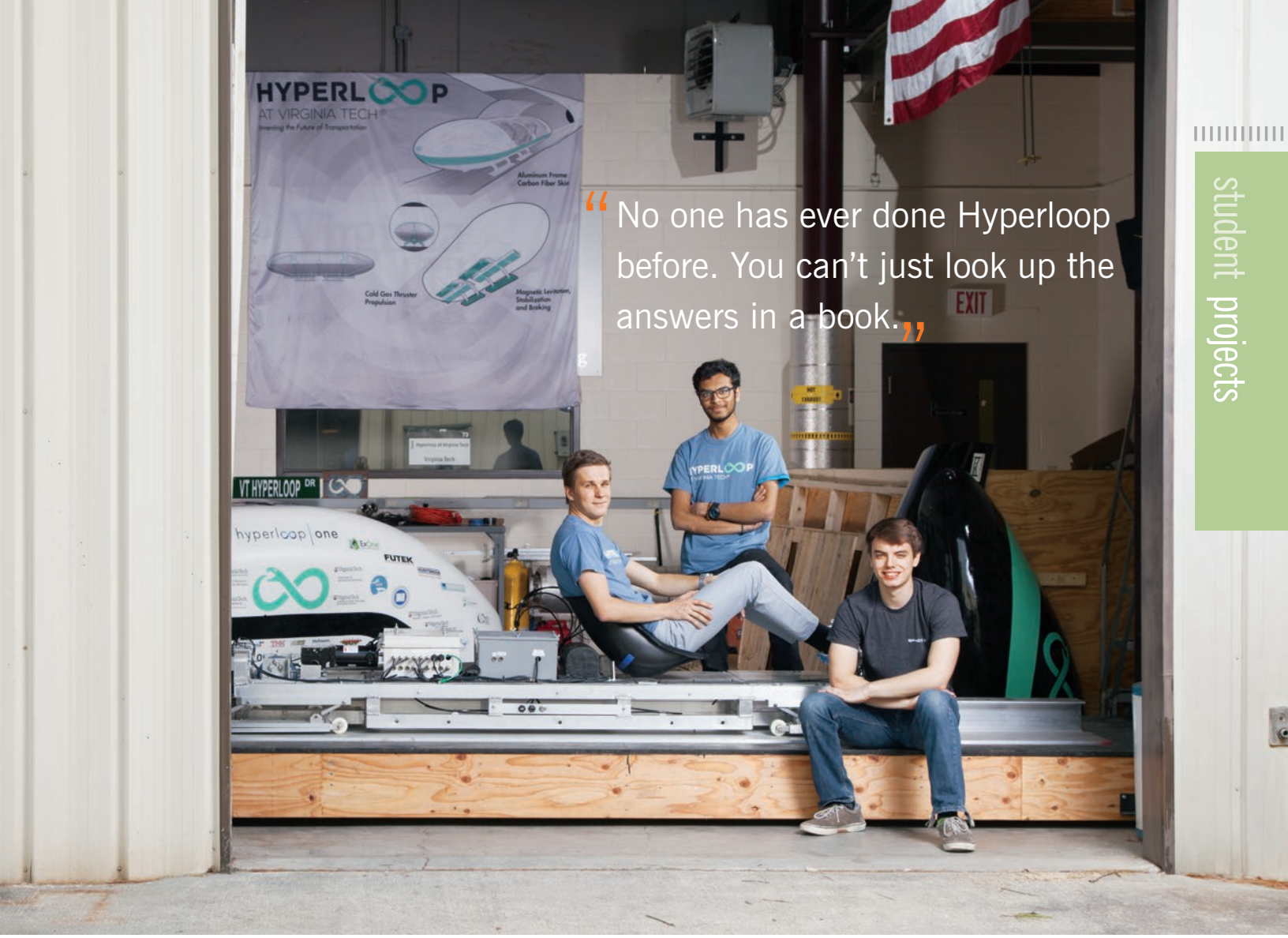
"There's some drag to begin with, but at 30 mph, the drag turns to lift, and the pod starts levitating," said Hyperloop Software Lead Matthew Ritzinger (BSCPE '18). "Then we can really get it moving."

While SpaceX guidelines capped the speed at 50 mph during the competition, the pod is designed to surpass 200 mph.

Virginia Tech placed fourth overall, and was the highest placed undergraduate team.

Hyperloop is strongly supported by generous gifts from Dan and Lorraine Hodge, Virginia Tech, and a number of industrial sponsors. In recent months, participation and interest in Hyperloop has flourished: the team roster increased from 29 students in the fall semester to 70 this spring.

"We're really excited with how the proj-



> "No one has ever done Hyperloop before. You can't just look up the answers in a book."

ect is going," said Gubanov. "Virginia Tech is building a 600-foot open-air test track, which is an amazing addition—we won't have to go to California every time we need to test something."

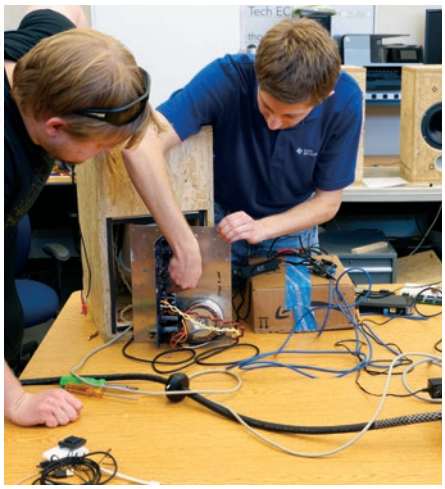
In preparation for the next stage of the competition, which is planned for next August, the team will be outfitting the pod with a secondary propulsion tank donated by Orbital ATK, "the type of tank used for maneuvering satellites in space," said Ritzinger.

Equipped with this and other innovations, said Gubanov, the Virginia Tech team is confident it will excel in Competition II, which will focus on a single criterion: maximum speed. ece

DAVID GOLDSMITH

TOP: From left: Hyperloop Lead Andrey Gubanov (BSCPE '19), propulsion testing recruit Shashank Shinde (BSCPE '19), and Software Lead Matthew Ritzinger (BSCPE '18) with the Hyperloop pod, which is designed to surpass 200 mph. The pod sleeve can be seen in the background. **BOTTOM:** The Hyperloop test track at SpaceX headquarters in Hawthorne, California.

BOB LINEBERRY



BOB LINEBERRY

TOP & MIDDLE: Rich Dumene (BSEE '17) and Ben Wengert (BSEE '17) built a hi-fi Wi-Fi BeagleBone-based speaker system that won the 2016 Texas Instruments Best BeagleBone Award.

BOTTOM: AMP Lab founder Bob Lineberry. The AMP Lab is supported by a generous donation from VPT, which is part of the HEICO Electronic Technologies Group.

AMPED UP

Thanks in part to resources provided by ECE's in-house Autonomous Mastery Prototyping (AMP) Laboratory, Rich Dumene (BSEE '17) and Ben Wengert (BSEE '17) designed and built a hi-fi Wi-Fi BeagleBone-based speaker system that won the 2016 Texas Instruments (TI) Intern Design Challenge Best BeagleBone Award.

"The hardest part was the marathon soldering," commented Dumene. "There were 246 components, none of them larger than a grain of rice—and they kept blowing up."

The speaker system incorporates a TI BeagleBone Black, a credit card-sized computer, running a Linux distribution as the media-streaming element. Using a universal plug-and-play renderer as the lossless, wireless audio system, the students incorporated Advanced Linux Sound Architecture and a 32-bit stereo digital-to-analog converter.

The amplifier uses an active crossover filter that splits between high and low frequencies to improve sound quality.

"All of the signals are transformer isolated, buffered by the amplifier, and output to another stereo jack," said Wengert. "This allowed us to daisy-chain identical speakers together to increase the volume."

But Dumene and Wengert's feat had a foundation in their experiences working on the AMP Lab's Modular Speaker System project. The speaker system that resulted from this earlier project was nearly indestructible and so loud that it can cross the pain threshold.

"Our goal was to build a speaker that would survive four years in a frat house without breaking," said Dumene. "You can kick it over while it's playing and nothing would happen."

The instructional laboratory, which was established in the fall of 2012, provides students with resources and guidance to gain practical skills and to experiment and create.

"This is the challenge I issue to all the AMP Lab students: make something," said Bob Lineberry, AMP Lab's founder. "I don't care what it is, just make something and get it to work."

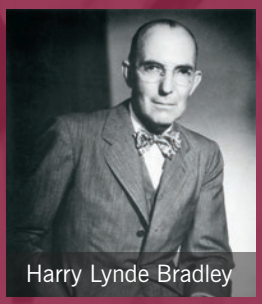
> "Our goal was to build a speaker that would survive four years in a frat house without breaking."

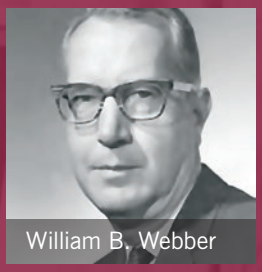
When Dumene and Wengert joined the AMP lab as first-years, they quickly gravitated toward audio electronics. "I go for the speaker projects because there's something you can see and hear," said Wengert. "This sounds good, or this sounds bad. It's tactile."

While Lineberry mentors all the AMP Lab participants, the students drive their own projects. "I just turn the students loose," he said.

As far as the TI contest went, they "blew everyone else out of the water," said Dumene, and came home with something more than the Best BeagleBone Award—an increased passion for audio electronics. ece

30 years of the BRADLEY ENDOWMENT


Harry Lynde Bradley


William B. Webber

IN SPRING 1987, the late Mrs. Marion Bradley Via established a generous endowment for the enhancement of the Department of Electrical Engineering. This endowment was in honor of Mrs. Via's late father, Harry Lynde Bradley, who was a pioneer in the electric motor control industry and cofounder of the Allen-Bradley Company of Milwaukee, which is now part of Rockwell Automation.

In recognition of this endowment, the department is called The Bradley Department of Electrical and Computer Engineering. Income from the endowment funds undergraduate scholarships, graduate and postdoctoral fellowships, and professorships in the continuing effort to improve the quality of our ECE programs. These fellowships and scholarships are among the most competitive in the country.

IN 1994, William B. Webber (EE '34) established a fund to encourage women engineers. Webber's career took him to Westinghouse, the U.S. Signal Corps, then to a booming company co-founded by an army buddy—Tektronix, Inc. Today, the William B. Webber Fellowship is awarded to high achieving women pursuing a graduate degree in electrical or computer engineering.

Since 1987, more than **260 students** have received scholarships or fellowships as Bradley or Webber Fellows and Bradley Scholars.

More than **$18 million** in scholarships and fellowships have been awarded to ECE students.

2016 | 2017

BRADLEY & WEBBER *FELLOWS*

30 years *of the* **BRADLEY** ENDOWMENT

Noah Allen

Bradley Fellow

BSEE '09 Georgia Institute of Technology,
MSEE '14 Virginia Tech
Advisor: Louis Guido

RESEARCH: Allen is focusing on creating gallium nitride (GaN) high-power devices for power conversion applications. He is examining the effects of GaN growth parameters on the material properties and on power devices fabricated from GaN.

Ryan Chan

Bradley Fellow

BSCPE '15 Binghamton University – SUNY
Advisor: Masoud Agah

RESEARCH: Chan is developing miniaturized separation columns for gas chromatography, systems through the use of MEMS fabrication techniques, to realize a monolithic integration on a single chip.

Colin Burgin

Bradley Fellow

BSCPE '16 Virginia Tech
Advisor: Peter Athanas

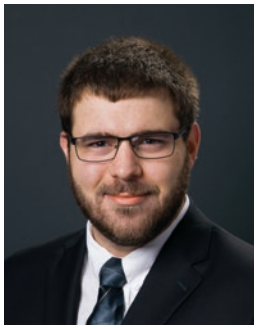
RESEARCH: Burgin is exploring automatic test packet generation for P4 devices.

Jacques Delport

Bradley Fellow

BSEE '13, MSEE '14 Virginia Tech
Advisor: Virgilio Centeno

RESEARCH: Delport is using cascading and hidden failure models to find critical points in a power system, then using game theory models to see interactions between potential attackers trying to take down the system and the utilities trying to protect it. He is also creating a large open-source model for the eastern interconnection power system.



Anthony Carno

Bradley Fellow

BSCPE '15 Bucknell University
Advisor: Binoy Ravindran

RESEARCH: Carno is identifying key characteristics of pieces of code and using them to predict how it will run on various systems. He will then use these predictions to identify the best systems to use for performance or energy efficiency.

Sean Douglass

Bradley Fellow

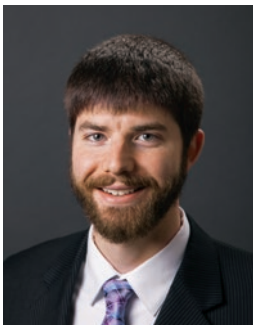
B.S. Applied Physics, '16
Bridgewater College
Binghamton University – SUNY
Advisor: Cameron Patterson

RESEARCH: Douglass is configuring secure hardware and software for field-programmable gate arrays (FPGAs) that will be used in unmanned aerial vehicles (UAVs). He anticipates a career in security after earning his degree.

12 Bradley Fellows and Scholars have become faculty members at universities.

ALUMNI INCLUDE:
1 medical doctor
1 patent attorney
1 novelist

AT LEAST 10
Bradley Fellow/Scholar alumni have been entrepreneurs.



Steven Hauser

Bradley Fellow

BSEE '12 Virginia Tech
Advisors: Alan Michaels (Hume Center) and A. A. (Louis) Beex

RESEARCH: Hauser is applying machine learning to wireless communication systems. He is researching how imperfections in a receiver can affect convolutional neural networks designed for modulation classification using only time series data.

Kikkeri Kruthika

Webber Fellow

BSEE '16 Virginia Tech
Advisor: Masoud Agah

RESEARCH: Kruthika is investigating the drug response of various cancer cell lines based on their dielectrophoretic signatures using a disposable microfluidic chip. She is also developing a low cost dielectrophoretic chip for real-time detection of small populations of bacteria in water.

Larkin Heintzman

Bradley Fellow

BSEE '15 Western Kentucky University
Advisor: Ryan Williams

RESEARCH: Heintzman works in the Laboratory for Coordination at Scale, specializing in observability relating to multi-robot systems.

Markus Kusano

Bradley Fellow

BSCPE '14 Virginia Tech
Advisor: Chao Wang

RESEARCH: Working in several areas of software testing and verification, particularly concurrency, Kusano has been developing methods to increase software reliability while providing automated fault localization and repair. His research uses stateless model checking, symbolic model checking, symbolic execution, and numerical abstract interpretation.

Ji Hyun

Bradley Fellow

BSEE '14, MSEE '16 Virginia Tech
Advisor: Dong Ha

RESEARCH: Hyun is designing low-power integrated circuits for piezoelectric energy and thermal energy harvesting applications, such as harvesting energy from vehicles traveling over bridges or roads.

Taylor McGough

Bradley Fellow

BSCPE '14 Virginia Tech
Advisor: JoAnn Paul

RESEARCH: McGough is researching aspects of computational complexity and computer architecture.

2016 | 2017

BRADLEY & WEBBER *FELLOWS*

30 years *of the* **BRADLEY** ENDOWMENT

Daniel Neel

Bradley Fellow

BSCPE '16 Virginia Tech

Advisor: Peter Athanas

RESEARCH: Neel is working on hardware acceleration of local gene sequence alignment, saturating a large comparison matrix via high-bandwidth communication provided by a hybrid memory cube, which is an innovative stacked DRAM device.

Natalie Moore

Webber Fellow

BS ECE '16 Cornell University

Advisor: Jeffrey Reed

RESEARCH: Moore is simulating machine learning techniques for automatic modulation classification. After earning her degree, she hopes to work on wireless communication system security.

Christopher O'Lone

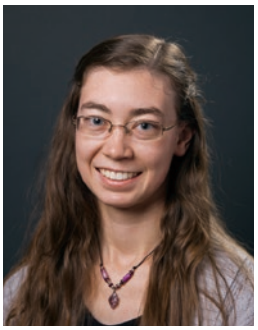
Bradley Fellow

BSEE '12, MSEE '13

Lehigh University

Advisor: R. Michael Buehrer

RESEARCH: O'Lone is investigating how wireless network localization performance is affected by the unpredictable geometry of modern wireless networks. His goal is to obtain a complete statistical characterization of localization performance throughout an entire network.



Ellen Robertson

Webber Fellow

BSEE '14 Virginia Tech

Advisor: Gregory Earle

RESEARCH: Robertson is designing an instrument to characterize the energy distribution of neutral particles in front of low earth orbit satellites. She is simulating the electric potential and flow of charged particles through the instrument, which will then be tested in a realistic environment.

Timothy Pierce, Jr.

Bradley Fellow

BSEE '13 Hampton University,
MSEE '16 Virginia Tech

Advisor: Alfred Wicks (ME)

RESEARCH: Pierce is applying knowledge from Mobile Hybrid Power Systems to the power grid. His specific research areas are storage, coronal mass ejections (CMEs), and controlled shutdown.

Walker Sensabaugh

Bradley Fellow

BSCPE '16 Virginia Tech

Advisor: Binoy Ravindran

RESEARCH: Sensabaugh is working to improve the speed of context switches by predicting the next task and preemptively warming up parts of the cache and translation lookaside buffer (TLB). This would reduce the performance impact of preemptive based schedulers in highly threaded environments.

3 FIRMS have hired the most Bradley Fellow/Scholar alumni (5 each):

- **Intel**
- **Northrop Grumman**
- **Johns Hopkins University Applied Physics Laboratory**

Bradley Fellow/Scholar alumni work for **159 DIFFERENT EMPLOYERS.**

The most common job title is **SENIOR ENGINEER.**

Maymoonah Toubeh

Webber Fellow

BE '14 American University of Kuwait

Advisor: Robert McGwier

RESEARCH: Toubeh is applying machine learning algorithms to the fields of signal processing, natural language processing, and robotics. Currently, she is working on a novel artificial neural network Arabic dialect classifier.

Oscar Yu

Bradley Fellow

BSEE '15

University of Texas at Austin

Advisor: Jason Lai

RESEARCH: Yu's research focuses on power converters, inverters, and renewable energy applications.

Natalie White

Webber Fellow

BSEE '16 University of Tennessee Knoxville

Advisor: Masoud Agah

RESEARCH: White is designing a high-throughput, label-free, expandable microfluidic chip for monitoring changes in the electrical properties of cells in response to drugs. This chip will eventually be part of a system for rapid, low-cost characterization of cell drug response.

Jason Ziglar

Bradley Fellow

BSEE/Biomedical Engineering '05 Duke University, MS Robotics '07 Carnegie Mellon University

Advisors: Alfred Wicks (ME) and Ryan Williams

RESEARCH: Ziglar is developing methods for automating the design and reconfiguration of robotic systems.

2016 | 2017 BRADLEY *SCHOLARS*

Elizabeth Hutz

Bradley Scholar

BSCPE '18

INTERNSHIP: In the summer of 2016, Hutz was an intern at UTC Aerospace Systems. She performed hardware and software tests in their Embedded Software group on Pulse Health Monitoring Systems (PHMS), which collect data from helicopters. She will return for summer 2017.

BRADLEY *ALUMNI*

NAME	TITLE	COMPANY/FIELD	LOCATION
JoAnn Adams S BSEE '94	Co-Owner	Big Fish Design	Centreville, Va.
Robert Adams F MSEE '95, Ph.D. '98	Professor, ECE	University of Kentucky	Lexington, Ky.
Shawn Addington F BSEE '90, MSEE '92, Ph.D. '96	Professor and Head, Department of Electrical and Computer Engineering	Virginia Military Institute	Lexington, Va.
Sarah S. Airey S BSCPE '01		Speech Recognition	Cambridge, U.K.
Christopher R. Anderson S/F BSEE '99, MSEE '02, Ph.D. '06	Associate Professor	United States Naval Academy	Annapolis, Md.
Matthew R. Anderson S BSCPE '04	Network Architect	Cisco Systems	Philadelphia, Pa.
Nathaniel August F BSCPE '98, MSEE '01, Ph.D. '05	Senior Technical Lead and Staff Engineer	Intel Corporation	Portland, Ore.
Stephen P. Bachhuber F BSEE	Senior Member of Technical Staff	Qorvo	High Point, N.C.
Mark Baldwin F BSEE '93, MSEE '05, Ph.D. '08	Engineer	Dominion Power	Glen Allen, Va.
William D. Barnhart S/F BSEE '00, MSEE '02	Electronics Engineer	Northrop Grumman	Redondo Beach, Calif.
Benjamin Alan Beasley S BSEE '09	Associate	Zeta Associates, Inc.	Fairfax, Va.
Brian Berg F BSEE '90, MSEE '91, Ph.D. '01	President and Founder	Dimmersion, LLC	Agoura Hills, Calif.
Ray Bittner F BSCPE '91, MSEE '93, Ph.D. '97	Senior Hardware Engineer	Microsoft Research	Redmond, Wash.
Aric Blumer F Ph.D. '07	Lead Engineer	Moog Components Group	Blacksburg, Va.
Brian Browe F BSEE '97, MSEE '99			
Kirsten Ann Rasmussen Brown S BSEE '94	Vice President, Office of the Chairman	MicroStrategy Inc.	Tyson's Corner, Va.
Steven Edward Bucca F BSEE '87, MSEE '89	RF Engineer	ATK, Bell Aerospace	Broomfield, Colo.
Mark B. Bucciero F BSCPE '01, MSCPE '04	Computer Engineer	Logos Technologies	Raleigh, N.C.
R. Michael Buehrer F Ph.D. '96	ECE Professor	Virginia Tech	Blacksburg, Va.
Charles Bunting F MSEE '92, Ph.D. '94	Associate Dean of Research, College of Engineering, Architecture, and Technology and Bellmon Chair	Oklahoma State University	Stillwater, Okla.
Carey Buxton F Ph.D. '01	Electrical Engineer	NASA Langley Research Center	Spotsylvania, Va.
Scott Cappiello S BSCPE '94	Senior Director, Product Management	Paxata, Inc	San Diego, Calif.
Matthew Carson S BSEE '98	Logistics Coordinator		South Asia
Matthew Carter F BSEE '09	Software Engineer	Metavine	San Jose, Calif.
Ricky Castles S BSCPE '03, MSCPE '06, Ph.D. '10	Assistant Professor	East Carolina University	Greenville, N.C.
Eric D. Caswell F Ph.D. '01	Director, Small Antenna Engineering	L-3 Randtron Antenna Systems	Linthicum Heights, Md.
Daniel Dae Cho S BSEE '06	IP Associate	Sheppard Mullen Richter & Hampton LLP	San Diego, Calif.
Jeffrey R. Clark F MSEE '03, Ph.D. '06	Proprietor	Black Dog Writing & Editing	Blacksburg, Va.
Ross Clay S BSCPE '09	Software Developer, Distributed Databases	Twitter	Raleigh, N.C.
Brittany Clore S BSCPE '10, MSCPE '12	Lead Cyber Security Engineer	The MITRE Corporation	McLean, Va.
Kevin B. Cooley S BSEE '02	Electrical Engineer	Automation Controls, Inc.	Newport News, Va.
Thomas Alan Cooper S BSEE '10, MSEE '12	Software Design Engineer	KEYW Corporation	Severn, Md.
Carrie Aust Cox F MSEE '00	Senior Staff Engineer	Qualcomm	Apex, N.C.
David Casteel Craven S BSCPE '08	Senior Systems Design Engineer	AMD	Austin, Texas
Stephen Douglas Craven F Ph.D. '08	Electrical Engineer	Tennessee Valley Authority	Chattanooga, Tenn.
Cass Dalton S BSCPE '03	Software Engineer	Technology Management Associates	Chantilly, Va.
Phillip A. Danner S BSCPE '91	AVP, Engineering	Union Pacific Railroad	Omaha, Neb.
Paul U. David F MSEE '15			
Bradley A. Davis F BSEE '86, MSEE '88, Ph.D. '00	Engineer	General Dynamics	Marion, Va.
Scott Davis S BSCPE '00	Software Engineer Manager	Kollmorgen	Radford, Va.
Thurman Shaver Deyerle F BSEE '10, MSEE '13	Senior Hardware Engineer	Qualcomm	San Diego, Calif.
Brian M. Donlan F MSEE '05			

NAME	TITLE	COMPANY/FIELD	LOCATION
Thomas H. Drayer F BSEE '87, MSEE '91, Ph.D. '97	Technical Director	Department of Defense	
Bradley Duncan F Ph.D. '91	Executive Director, Graduate Academic Affairs	University of Dayton	Dayton, Ohio
Gregory D. Durgin F BSEE '96, MSEE '98, Ph.D. '00	Associate Professor, ECE	Georgia Tech	Atlanta, Ga.
William Ashley Eanes S BSEE '95	Business Relations Manager	Duke Energy Corporation	Greensboro, N.C.
Richard Ertel F Ph.D. '99	Senior Staff Engineer	L-3 Technologies	
Lucy Fanelli F MSEE '14	Computer Engineer	Sandia National Laboratories	Albuquerque, N.M.
Brian Flanagan S/F BSEE '97, MSEE '98	Senior Design Engineer	Intel	Austin, Texas
Kevin Flanagan S BSCPE '00, MSCPE '01	ASIC Design Engineer	Intel	Folsom, Calif.
Todd B. Fleming F BSCPE '94, MSEE '96	Principal Engineer	Fleming Technologies	Blacksburg, Va.
Ryan Fong S/F BSCPE '01, MSCPE '04	Senior Engineer	Fourth Dimension Engineering	Laurel, Md.
Michael Fraser F MSEE '12, Ph.D. '16			Blacksburg, Va.
Jayda Blair Freibert S BSEE '98	Sales Director	Kelvin	Richmond, Va.
Daniel Friend F Ph.D. '09	Associate	Zeta Associates	Fairfax, Va.
Bradley H. Gale S BSEE '97		USPS	
Robert M. Gardner, Sr. F BSEE '03, MSEE '05, Ph.D. '08	Manager, Electric T&D Services	Dominion Energy	Richmond, Va.
Daniel J. Gillespie S BSCPE '95	Manager	Huron Consulting Group	Portland, Ore.
Brian Gold S BSEE '01, MSCPE '03, Ph.D. '09	Engineering Director	Pure Storage	Mountain View, Calif.
Jonathan Graf S BSCPE '02, MSCPE '04	Founder and CEO	Graf Research	Blacksburg, Va.
Timothy Gredler S BSCPE '03	Controls Manager, Chillers	Daikin Applied	Staunton, Va.
Christopher Griger S BSCPE '02	Principal Hardware Architect	National Instruments	Austin, Texas
Daniel Hager S BSCPE '08, MSCPE '09	Embedded Software Engineer	Lockheed Martin Aeronautics	Atlanta, Ga.
Adam P. Hahn S BSCPE '03	Senior Software Engineer	Bloomberg LP	New York, N.Y.
Alexander Hanisch S BSCPE '03	Modeling and Simulation Scientist	Joint Warfare Analysis Center	Dahlgren, Va.
Nathan Harter F MSEE '07	Senior Systems Engineer	G3 Technologies, Inc.	Mount Airy, Md.
Dwayne Allen Hawbaker F BSEE '89, MSEE '91	Principal Professional Staff	The Johns Hopkins University APL	Laurel, Md.
William C. Headley F BSEE '06, MSEE '09	Research Scientist, Hume Center	Virginia Tech	Blacksburg, Va.
Matt Helton S BSEE '01	Control Systems Support Supervisor	Eastman Chemical Co.	Kingsport, Tenn.
Ben Henty F MSEE '01	Chief Scientist, Signals Group	The Johns Hopkins University APL	Laurel, Md.
Jason Hess F BSEE '97, MSEE '99	Manager for HW Engineering, Internet of Things Group	Cisco Systems	Austin, Texas
Erik Hia F BSCPE '99, MSCPE '01	Senior Manager, R&D Software	ADVA Optical Networking	Raleigh-Durham, N.C.
Daniel J. Hibbard F BSEE '02, MSEE '04	Engineering Director	Trident Systems	Fairfax, Va.
James E. Hicks F MSEE '00, Ph.D. '03	Senior Engineering Specialist	The Aerospace Corporation	Chantilly, Va.
Kristen Hines F MSCPE '16			
Hugh E. Hockett S BSCPE '03	Senior Software Engineer and Master Inventor	IBM	Raleigh-Durham, N.C.
Spencer Hoke S BSCPE '03	Staff Software Engineer	Qualcomm	Raleigh, N.C.
Andrew S. Hollingsworth S BSCPE '03	Software Engineer	Charon Technologies	Herndon, Va.
Michael Hopkins F Ph.D. '14	Senior R&D Imagineer	Walt Disney Imagineering	Glendale, Calif.
Ellery L. Horton S BSCPE '04	Software Development Engineer in Test	Cision	Morrisville, N.C.
Keith Cristopher Huie F MSEE '02	System Engineer	Raytheon	Dallas/Fort Worth, Texas
Ryan Hurrell S BSEE '03	Senior Engineer	Siemens-Healthcare Molecular Imaging	Knoxville, Tenn.
John Todd Hutson S BSEE '93	Manager, Internet Engineering	Sprint Corp.	Reston, Va.
Ryan Irwin F Ph.D. '12	Software Engineer (Data Infrastructure)	Yelp	San Francisco, Calif.
Daniel A. Johnson F BSEE '98, MSEE '01	Senior Business Manager	Capital One	Richmond, Va.

NAME	TITLE	COMPANY/FIELD	LOCATION
Callie Johnston S BSCPE '14, MSCS '16	Associate Professional Staff I	The Johns Hopkins University APL	Laurel, Md.
Edward Andrew Jones S BSEE '07	Graduate Research Assistant	University of Tennessee	Knoxville, Tenn.
Kevin Jones F BSEE '09, MSEE '11, Ph.D. '13	Principal Engineer	mc2 Technical Solutions	Richmond, Va.
Basil Thomas Kalb S BSEE '98	Owner	Bootstrap Software Solutions	Fairfax, Va.
Nicholas Kaminski F BSEE/CPE '10, MSEE '12, Ph.D. '14	Research Staff Member	Institute for Defense Analysis	Washington, D.C.
Adam Steven Kania S BSEE '01	Customer Support Territory Manager	Caterpillar Inc.	Hamburg, Germany
David Kapp F MSEE '93, Ph.D. '95	Revolutionary Avionics Protections Team Lead	Air Force Research Laboratory	Wright-Patterson AFB, Ohio
Dimosthenis Katsis F BSEE '95, MSEE '97, Ph.D. '03	Flight Science Engineer	Blue Origin, LLC	Kent, Wash.
Nathan Kees F BSEE '08, MSEE '14	Senior Design Engineer	VPT Inc.	Blacksburg, Va.
David L. Kleppinger, Jr. S BSCPE '04, MSCPE '08, Ph.D. '10	Software Development	Electrical Distribution Design	Blacksburg, Va.
Paul A. Kline F Ph.D. '97	Principal Research Scientist	Aster Labs	Shore View, Minn.
William Kuhn F BSEE '79, Ph.D. '96	ECE Professor	Kansas State University	Manhattan, Kan.
Zachary La Celle S BSCPE '09	Engineer	Robotic Research, LLC	Gaithersburg, Md.
Evan Lally F BSEE '03, MSEE '06, Ph.D. '10	Optical Systems Engineering Manager	Luna Innovations	Blacksburg, Va.
Jeff Laster F BSEE '91, MSEE '94, Ph.D. '97	Principal Technical Manager, Raytheon	Mentor Graphics	Dallas, Texas
Mark Alan Lehne F Ph.D. '08	Principal Engineer	Rohde-Schwarz Inc.	Beaverton, Ore.
Charles Lepple F BSEE '00, MSEE '04	Senior Research Engineer	The Johns Hopkins University APL	Laurel, Md.
Jason E. Lewis S/F BSEE '99, MSEE '00	Hardware Architect	ABB	Lewisburg, W.Va.
Joseph C. Liberti F BSEE '89, MSEE '91, Ph.D. '95	Chief Scientist	Venture Labs	Basking Ridge, N.J.
Zion Lo S BSEE '94	Senior Software Engineer/Architect	IQNavigator Inc.	Centennial, Colo.
Janie A. Hodges Longfellow S BSCPE '01	Head of Engineering Operations	Agilent	Fairfax, Va.
Daniel L. Lough F BSCPE '94, MSEE '97, Ph.D. '01	Deputy Director, Advanced Cyber Effects Office	National Reconnaissance Office	Chantilly, Va.
Amy Malady F BSEE '09	DSP Engineer	Applied Signal Technology	Sunnyvale, Calif.
Annie Martin F BSEE '04	Software Developer	athenahealth	Watertown, Mass.
Cheryl Duty Martin S BSEE '95	Research Scientist	Applied Research Lab, University of Texas at Austin	Austin, Texas
Stephanie Martin S BSEE '04	Engineer, Assistant Section Supervisor	The Johns Hopkins University APL	Laurel, Md.
Michael F. Mattern S BSEE '02	Systems Lead - Telematics	Cummins Inc.	Columbus, Ind.
Christopher A. Maxey S BSCPE '02, MSEE '04	Technology Development Manager	BAE Systems	Arlington, Va.
Eric J. Mayfield S BSEE '97, MSEE '98	Technical Director	Department of Defense	Fort Meade, Md.
David Mazur S/F BSEE '11	Architect-Packaged Power Technology	Rockwell Automation	Milwaukee, Wis.
Patrick McDougle S BSEE '03			
Brian Joseph McGiverin S BSCPE '96	Senior Software Engineer	Intel	Cary, N.C.
John McHenry F BSEE '88, MSEE '90, Ph.D. '93	Senior Electrical Engineer	Department of Defense	Fort Meade, Md.
Keith McKenzie	Ph.D. Student	University of Tennessee, Knoxville	Knoxville, Tenn.
David R. McKinstry F MSEE '03	Principal Systems Engineer	Ultra Electronics 3 Phoenix Inc.	Chantilly, Va.
James W. McLamara F BSEE '02	Graduate Student	North Carolina State University	Raleigh, N.C.
Garrett Mears S BSCPE '00	Freelance CTO and Startup Advisor		London, U.K.
Vinodh Menon S BSCPE '02	Chief Operating Officer	EveryoneOn	McLean, Va.
Michael Mera S BSEE '03	Lead Electrical Engineer	United States Army	Picatinny Arsenal, N.J.
Carl E. Minton F BSEE '97, MSEE '02	Systems Engineer	Arion Systems,Inc.	Chantilly, Va.
John Morton F MSEE '98	Senior Systems Engineer	Engenium Technologies	Columbia, Md.
Stephen Nash S BSCPE '03	Software Engineer	Allied Associates International	Gainesville, Va.
Troy Nergaard F MSEE '02	Director of Technical Product Management	Doosan GridTech	Seattle, Wash.

NAME	TITLE	COMPANY/FIELD	LOCATION
Michael Newkirk F BSEE '88, MSEE '90, Ph.D. '94	Principal Professional Staff	The Johns Hopkins University APL	Laurel, Md.
Paul Nguyen S/F BSEE '98	Vehicle Operations Officer	US Air Force	
J. Eric Nuckols F BSEE '97, MSEE '99	Co-Founder	InPhase Research Corporation	Fairfax, Va.
Abigail Harrison Osborne S BSCPE '04	Home School Teacher		
Neal Patwari S BSEE '97, MSEE '99	ECE Associate Professor	University of Utah	Salt Lake City, Utah
Paul Uri David F MSEE '15		Ettus Research	Santa Clara, Calif.
Joseph Allen Payne, Jr. S BSEE '00	Advisory System Architect	Northrop Grumman	Linthicum, Md.
Linh My Pham S BSCPE '07	Post-Doctoral Fellow	Harvard University	Cambridge, Mass.
William B. Puckett F MSEE '00			
Yaron Rachlin S BSEE '00	Technical Staff	MIT Lincoln Laboratory	Cambridge, Mass.
Parrish Ralston F BSEE '06, MSEE '08, Ph.D. '13	Principal Engineer	Northrop Grumman Electronics Systems	Linthicum, Md.
David Reusch F BSEE '04, MSEE '06, Ph.D. '12	Director of Applications Engineering	Efficient Power Conversion Corporation	Blacksburg, Va.
Richard Steven Richmond F MSEE '01	Senior Staff Design Engineer	Silicon Labs	Austin, Texas
Amy M. Ridenour F	Lead Power Conversion Engineer	GE Energy Connections	Salem, Va.
Christian Rieser F BSEE, MSEE '01, Ph.D. '04	Capabilities & Innovation Leader	The MITRE Corporation	Charlottesville, Va.
Jamie N. Riggins S/F BSEE '04, MSEE '06	Electrical Engineer	United States Air Force	Fort Meade, Md.
Gray Roberson F Ph.D. '07	Senior Technical Staff Engineer	Kollmorgen	Radford, Va.
Pablo Max Robert F MSEE '98, Ph.D. '03			
Thomas Rondeau S/F BSEE '03, MSEE '06, Ph.D. '07	Program Manager	DARPA	Arlington, Va.
Thomas Rose S BSEE '94	Product Manager for Avionics	Boeing	St. Louis, Mo.
Jonathan Scalera F MSCPE '01	Assistant Professor of Radiology	Boston University School of Medicine	Boston, Mass.
Javier Schloemann F BSCPE '04, MSEE '07, Ph.D. '15	Signal and Image Processing Engineer	Northrop Grumman	Raleigh-Durham, N.C.
Amy Rose S BSCPE '03	Technical Project Manager and Master Inventor	Lenovo	Raleigh-Durham, N.C.
David Craig Schroder S BSEE '05	Vice President of Business Development	Blue Nano	Charlotte, N.C.
Steven Schulz F MSEE '91	Technical Fellow	FF Inc.	Los Angeles, Calif.
Ian Schworer F BSCPE '03, MSEE '05	Vice President	TriplePoint Capital	Menlo Park, Calif.
Jeffrey T. Scruggs F BSEE '97, MSEE '99			
Kashan Ali Shaikh S BSCPE '02	Lead Engineer	GE Global Research	Albany, N.Y.
Adam Keith Shank S BSCPE '07	Software Engineer	IBM	Raleigh, N.C.
Raymond Ashley Sharp S BSEE '02	Manager	Northrop Grumman	Redondo Beach, Calif.
Rebecca Kay Shelton F MSEE '08	Electronics Engineer	US Army Primary Standards Laboratory	Huntsville, Ala.
Jacob R. Simmons S BSCPE '08, MSEE '10	Software Engineer	CommScope	Forest, Va.
Roger Skidmore F BSCPE '95, MSEE '97, Ph.D. '03	CEO	EDX Wireless	Austin, Texas
Jeff Smidler S BSEE '99	Construction Sales Manager	Automated Logic	Richmond, Va.
Amanda Martin Staley S/F BSEE '99, MSEE '01	Lead Multi-Discipline Systems Engineer	The MITRE Corporation	McLean, Va.
Graham David Stead S BSCPE '93	Chief Technology Officer	WaveMetrix & Acta Wireless	San Diego, Calif.
Jennifer Hastings Steele S BSEE '96	Electrical Engineer	Department of Defense	
Neil Steiner F MSEE '02, Ph.D. '08	Principal Software Engineer	BetaPrime Consulting	Reston, Va.
Douglas Sterk F BSEE '00, MSEE '03	Senior Design Engineer	VPT Inc.	Blacksburg, Va.
Scott Stern S BSEE '93	Program Manager	Compunetix, Inc.	Monroeville, Pa.
Samuel S. Stone S BSCPE '04	Associate	Goodwin Procter	Boston, Mass.
Anne Palmore Stublen S BSEE '91	Instructor	Wilson Hill Academy	Leawood, Kan.
Seema Sud F Ph.D. '02	Engineering Specialist	The Aerospace Corporation	Reston, Va.
Juan Suris F Ph.D. '07	Principal	Prudential Fixed Income	Westfield, N.J.

BRADLEY *ALUMNI*

NAME	TITLE	COMPANY/FIELD	LOCATION
Ethan Swint F Ph.D. '12	Staff Mechanical Engineer	Tesla Motors	Sacramento, Calif.
David L. Tarnoff F BSEE '87, MSEE '91	Associate Professor, Department of Computing, College of Business and Technology	East Tennessee State University	Johnson City, Tenn.
Alexander James Taylor F BSEE '02, MSEE '04	Senior Software Engineer	The MathWorks	Boston, Mass.
Daniel J. Tebben F Ph.D. '06	Scientist	The Johns Hopkins University APL	Laurel, Md.
Benton Thompson F MSEE '11	Software Engineer	G3 Technologies Inc.	Ashburn, Va.
Richard Tillman F BSEE '12, MSEE '14, Ph.D. '16	Senior Professional Staff	The Johns Hopkins University APL	Laurel, Md.
Jerry Towler S BSEE '08, MSEE '11	Research Engineer	Southwest Research Institute	San Antonio, Texas
Rose Trepkowski F BSEE '04, MSEE '04			
Christian Twaddle S BSCPE '01	Program Manager	ITT	Columbia, Md.
David Uliana F BSCPE '11, MSCPE '13	Software Engineer	Able Lending	Austin, Texas
Matthew C. Valenti F BSEE '92, Ph.D. '99	Professor	West Virginia University	Morgantown, W.Va.
Michael Gordon Vondrak S BSCPE '05	Software Engineer	Medical Simulation Corporation	Denver, Colo.
Wesley T. Wade S BSEE '93	Senior Systems Engineer	Oracle Financial Services Software	Fairfax, Va.
Kristin Weary S BSEE '03	Electrical Engineer	Bechtel - Knolls Atomic Power Laboratory	Niskayuna, N.Y.
Michael Lee Webber F BSEE '02, MSEE '04	Technical Director	United States Air Force	Wiesbaden, Germany
Paul C. Weinwurm F BSEE '03	Protection and Control Engineer	DiGioia, Gray and Associates	Roanoke, Va.
Matt Welch S BSEE '09	Lead Test Engineer, Fleet and Prototype Test Engineering	GE Power and Water	Greenville, S.C.
Jason S.K. Wienke S BSEE '02	Technical Analyst	Systems Enginering Group	Blacksburg, Va.
William Worek S BSCPE '99, MSCPE '02	Senior Engineer	SAIC	Arlington, Va.
Kai Xu S BSEE '95	International Products Leader	Houzz	Palo Alto, Calif.
Matthew A. Yaconis S BSEE '97	Senior Software Engineer	Rockwell Collins	Sterling, Va.
Jason Yoho F MSEE '98, Ph.D. '01	Design Engineer	Tektronix	Louisville, Colo.
Ben York F MSEE '10, Ph.D. '13	Senior Project Engineer	Electric Power Research Institute	Iowa City, Iowa
Phillip Andrew Zellner F BSEE '07, MSEE '12, Ph.D. '13			
Richard Zimmermann S BSCPE '07	Applications Programmer	Virginia Tech Transportation Institute	Blacksburg, Va.
Gregory A. Zvonar S/F BSEE '90, MSEE '91	Principal Member of the Staff	The Charles Stark Draper Laboratory	Cambridge, Mass.
	Temporary Assignment	Missile Defense Agency	Huntsville, Ala.

The following Fellows are completing their graduate degrees at Virginia Tech:

Matthew Bailey
Thaddeus Czauski
Christina DiMarino
Chris Jelesnianski
Virginia Li
Hunter Long
Andrew Love
Robert Lyerly
Elliott Mitchell-Colgan
Derek O'Connor

Every effort has been made to ensure the accuracy of this listing. If your name was missing or incorrect, please send corrections to ebaumann@vt.edu.

CORPORATE & INDUSTRIAL *AFFILIATES*

Center for Power Electronics Systems (CPES)

Principal Plus Members
3M Company
ABB Inc.
Altera – Enpirion Power
Chicony Power Technology Co. Ltd.
CRRC Zhuzhou Institute Co. Ltd.
Delta Electronics
Dialog Semiconductor
Dowa Metaltech Co. Ltd.
Eltek
GE Global Research
General Motors Company
Groupe SAFRAN
Huawei Technologies Co. Ltd.
Infineon + International Rectifier
Integrated Device Technology Inc.
Inventronics (Hangzhou) INC.
Linear Technology
Lockheed Martin Corporation
Murata Manufacturing Co. Ltd.
Navitas Semiconductor
NextEV
Nissan Motor Co. Ltd.
NXP Semiconductors
ON Semiconductor
Panasonic Corporation
Rockwell Automation
Siemens Corporate Technology
Silergy Corporation
Sumitomo Electric Industries Ltd.
Texas Instruments
United Technologies Research Center
VERTIV

Principal Members
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LG Electronics
Macroblock Inc.
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NR Electric Co. Ltd.
Toshiba Corporation
ZTE Corporation

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Calsonic Kansei Corporation
China National Electric Apparatus Research Institute
Crown International
Cummins Inc.
Dell
Dyson Technology Ltd.
Efficient Power Conversion
Ford Motor Company
Fuji Electric Co. Ltd.
Halliburton Energy Services Inc.
Lite-On Technology Corporation
Maxim Integrated Products
Microsoft Corporation
Richtek Technology Corporation
Robert Bosch GmbH
Shindengen Electric Mfg. Co. Ltd.
Tesla Motors
Toyota Motor Corporation
United Silicon Carbide Inc.

Affiliate Members
ANSYS, Inc.
CISSOID
EGSTON GmbH
Electronic Concepts Inc.
Mentor Graphics Corporation
NEC TOKIN Corporation
OPAL-RT Technologies
Plexim GmbH
Powersim Inc.
Rohde & Schwarz
Simplis Technologies Inc.
Synopsys Inc.
Taiyo Yuden Co. Ltd.
Tektronix Inc.
Transphorm Inc.
Vesta System
VPT Inc.

Center for High-Performance Reconfigurable Computing (CHREC)

Altera
Cisco Systems
NASA
NSA

Multifunctional Integrated Circuits and Systems Group (MICS)

Principal Members
Amcom Communications
FSP-Powerland
Lockheed Martin

Associate Member
BAE Systems

WIRELESS@VT

L-3 Communications
Raytheon Company
Zeta Associates Inc

Broadband Wireless Access and Applications Center (BWAC)

L-3 Communications
Motorola Solutions
n~ask Incorporated
Office of the Secretary of Defense
Raytheon Corporation

Security and Software Engineering Research Center (S²ERC)

CACI
Department of Defense
Harris Corporation
LGS Innovations
Northrop Grumman Mission Systems
Office of the Secretary of Defense
SAIC

STUDENT *AWARDS*

Bradley Fellow **Markus Kusano** (BSCPE '14) was selected for the NSF Graduate Research Fellowship Program. Kusano, a doctoral student, is currently working in software engineering/formal methods with his advisor, Chao Wang.

Graduate students **Seungmo Kim** and **Junsung Choi** and ECE Research Associate Professor Carl Dietrich received a best paper award in the 2nd IEEE WCNC 2016 International Workshop on Smart Spectrum, held April 3-6 in Doha, Qatar, for the paper "Coexistence Between OFDM and Pulsed Radars in the 3.5 GHz Band with Imperfect Sensing."

David Evans (BSEE '17) and his team were awarded the People's Choice Award of $5,000 in scholarships at the VT KnowledgeWorks Global Entrepreneurship Challenge Semifinals. Their invention, Yard Mapper, is designed to track trailers and shipping containers at distribution centers.

COURTESY FAROOQ AMIN

FAROOQ AMIN won Best Student Paper Award at IEEE Microwave Symposium.

Sebastiano Peluso, an ECE research assistant professor, received the William C. Carter Ph.D. Dissertation Award in Dependability for his dissertation entitled "Efficient Protocols for Replicated Transactional Systems." The award is given annually for a significant contribution to dependable computing.

Farooq Amin, an ECE doctoral candidate advised by Kwang-Jin Koh and Sanjay Raman, won the Best Student Paper Award at the 2016 IEEE International Microwave Symposium. His paper, "A High Dynamic range 4th-order 4-8 GHz Q-Enhanced LC Band-Pass Filter with 2-25% Tunable Fractional Bandwidth," presented an integrated circuit filter in silicon technology for interference rejection applications.

Ph.D. *DEGREES AWARDED* 2015 2016

Abdallah AbouSheaisha, Abdallah Sabry
Crosslayer Optimal Control for Adaptive Video Streaming Using the FINS Framework
Committee Chair: MacKenzie, A.B.

Abdelraheem, Mohamed Medhat Tawfik
Spectrum-efficient Cooperation and Bargaining-based Resource Allocation for Secondary Users in Cognitive Radio Networks
Committee Chair: Midkiff, S.F.

Akbar, Muhammad
Chip-Scale Gas Chromatography
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Amuru, Saidhiraj
Intelligent Approaches for Communication Denial
Committee Chair: Buehrer, R.M.

Bitaraf, Hamideh
Mitigating Challenges of Utilities with High Wind Energy Penetration through Energy Storage and Demand Response
Committee Chair: Rahman, S.

Chen, Baifeng
High-efficiency Transformerless PV Inverter Circuits
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Chen, Xi
Bayesian Integration and Modeling for Next Generation Sequencing Data Analysis
Committee Chair: Xuan, J.

Couch, Jacob D.
Investigation of Non Traditional Applications of the Physical Level in Reconfigurable Computing
Committee Chair: Athanas, P.M.

Danilovic, Milisav
Active Source Management to Maintain High Efficiency in Resonant Conversion Over Wide Load Range
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Dobson, Kelly Katherine
Reconstruction Enhancements with Optical Scanning Holography
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Global Energy Conservation in Large Data Networks
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Constraint Based Program Synthesis for Embedded Software
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Fraser, Michael John
Optical Fiber Microstructures for Self Contained Whispering Gallery Mode Excitation
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Frissell, Nathaniel A.
Ionospheric Disturbances: Radio Blackouts, Midlatitude Pi2 Magnetospheric ULF Pulsations, and Medium Scale Traveling Ionospheric Disturbances
Committee Chair: Baker, J.B.

Ghorbanzadeh, Mohammad
Resource Allocation and End-to-End Quality of Service in Cellular Communications Systems Under Congested and Contested Environments
Committee Chair: Clancy, T.C.

Hassan, Ahmed Mohamed Elsayed
Designing, Modeling, and Optimizing Transactional Data Structures
Committee Chair: Ravindran, B.

Hirve, Sachin
On the Fault-tolerance and High Performance of Replicated Transactional Systems
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Hosseini, Seyed Yahya
3-D Bio-inspired Microenvironments for In Vitro Cell Migration
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An Agent Based Platform for Customer Centric Demand Response Implementation in Smart Buildings
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Spectrum Sharing between Radar and Communication Systems
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Efficiency Improvement Strategies and Control of Permanent Magnet Motor Drives
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Adaptive Control of Waveguide Modes in Two Mode Fiber
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Mohamedin, Mohamed Ahmed Mahmoud
On Optimizing Transactional Memory: Transaction Splitting, Scheduling, NUMA Optimization, and Fine-grain Lock Fallback
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Morrell, Christopher Frank
Improving the Security, Privacy, and Anonymity of a Client Server Network through the Application of a Moving Target Defense
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Nounagnon, Jeannette Donan
Using Kullback Leibler Divergence to Analyze the Performance of Collaborative Positioning
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Design Optimization of Hybrid Switch Soft-Switching Inverters using Electro-Thermal Simulation
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Load Modeling and Improved Contingency Analysis using Synchrophasor Data
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ModelCentric Interdependent Critical Infrastructure System Recovery Analysis and Metrics
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Fundamental Analyses of Collaborative and Noncollaborative Positioning
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Resilient Waveform Design for OFDM-MIMO Communication Systems
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Shajaiah, Haya Jamal
Resource Allocation with Carrier Aggregation for Spectrum Sharing in Cellular Networks
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Srinivasaraghavan, Vaishnavi
Bioimpedance Spectroscopy of Breast Cancer Cells: A Microsystems Approach
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Tamburello, Philip Michael
Iterative Memoryless Non-linear Estimators of Correlation for Complex-Valued Gaussian Processes that Exhibit Robustness to Impulsive Noise
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Uzair Gilani, Syed
Biodiversity and Dynamics of Direction Finding Accuracy in Bat Biosonar
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GaN-Based High-Efficiency, High-Density, High-Frequency Battery Charger for Plug-in Hybrid - Electric Vehicle
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Youssef, Bassant El Sayed
Models for the Generation of Heterogeneous Complex Networks
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Yuan, Xu
Modeling and Optimization for Spectrum Sharing and Coexistence
Committee Chair: Hou, Y.T.

Zahid, Zaka Ullah
Design, Modeling and Control of Bidirectional Resonant Converter for Vehicle-to-Grid (V2G) Applications
Committee Chair: Lai, J.-S.

Zeng, Kevin
An Exploration of Circuit Similarity for Discovering and Predicting Reusable Hardware
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KEYNOTE ADDRESSES

Dushan Boroyevich was the keynote speaker at the 2016 International Conference on Electrical Systems for Aircraft, Railway, Ship Propulsion and Road Vehicles & International Transportation Electrification Conference (ESARS-ITEC), Toulouse, France, Nov. 2016.

T. Charles Clancy was the keynote speaker at the GNU Radio Annual Conference (GRcon), Boulder, Colo., Sept. 2016

Y. Thomas Hou was the plenary keynote speaker at The 19th International Symposium on Wireless Personal Multimedia Communications (WPMC 2016), Shenzhen, China, Nov. 2016. He was also the keynote speaker at the 9th EAI International Conference on Mobile Multimedia Communications, Xi'an, China, June 2016.

Fred C. Lee was the keynote speaker at the International Forum on Wide Bandgap Semiconductors (IFWS 2016), Beijing, China, Nov. 2016.

T.-C. Poon was the keynote speaker at the Conference on Three Dimensional Image Acquisition and Display Technology, Jinhua, China, Oct./Nov. 2016.

Sanjay Raman was the keynote speaker at the 12th Annual IEEE Dallas Circuits and Systems Conference, Arlington, Texas, Oct. 2016.

Editorships

IEEE Journal of Selected Topics in Quantum Electronics	Luke F. Lester	*editor-in-chief*
IEEE/KICS Journal of Communications and Networks	Jung-Min (Jerry) Park	*editor*
IEEE Transactions on Cognitive Communications and Networks	T. Charles Clancy	*editor*
IEEE Transactions on Green Communications and Networking	Harpreet S. Dhillon	*editor*
IEEE Transactions on Mobile Computing	Jung-Min (Jerry) Park	*editor*
IEEE Wireless Communications Letters	Harpreet S. Dhillon	*editor*
Journal of Semiconductor Technology and Science	Dong Ha	*editor*

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Area/Associate Editorships

Chinese Optics Letters	T.-C. Poon	*associate editor-in-chief*
IEEE Transactions of Industrial Informatics	T.-C. Poon	*associate editor-in-chief*
IEEE Transactions on Cognitive Communications and Networking	Allen B. MacKenzie	*associate editor*
IEEE Transactions on Communications	Allen B. MacKenzie	*area editor*
IEEE Transactions on Computers and ACM Transactions on Embedded Computing Systems	Patrick R. Schaumont	*associate editor*
IEEE Transactions on Wireless Communications	Harpreet S. Dhillon	*area editor*
IEEE Transactions on Wireless Communications	Jung-Min (Jerry) Park	*area editor*
Radio Science and Radio Science Bulletin	Amir I. Zaghloul	*associate editor*

Conference Chairs

Peter M. Athanas was program chair of the 2016 International Conference on Reconfigurable Computing and FPGAs (Reconfig16), Cancun, Mexico, Dec. 2016.

R. Michael Buehrer and **Harpreet S. Dhillon** served as co-chairs of the IEEE International Workshop on Localization and Tracking: Indoors, Outdoors, and Emerging Networks (IEEE LION), IEEE Globecom, Washington, D.C., Dec. 2016.

Harpreet S. Dhillon served as co-chair of the Workshop on Green Wireless Communications and Networks (GREENNET), WiOpt 2016, Phoenix, Ariz., May 2016.

Tom Hou is serving as chair of the IEEE INFOCOM Steering Committee. He is also chairing the IEEE Communications Society GLOBECOM conference and the ICC Technical Committee (GITC). He also co-chaired the Technical Program Committee, Wireless Personal Multimedia Communications (WPMC 2016), Shenzhen, China, Nov. 2016.

Vassilis Kekatos was technical chair for the Symposium on Signal and Information Processing for Smart Grid Infrastructures under the IEEE Global Conference on Signal and Information Processing 2016, Washington, D.C., Dec. 2016.

Fred C. Lee was general chair of the IEEE 8th International Power Electronics and Motion Control Conference (IPEMC 2016 ECCE-Asia), Hefei, China, May 2016. He served as international chair of the Subforum on GaN Power Electronic Devices, International Forum on Wide Bandgap Semiconductors (IFWS 2016), Beijing, China, Nov. 2016.

T.-C. Poon served as general chair of the Conference on Three-Dimensional Image Acquisition and Display Technology 2016, Jinhua, China, Oct./Nov. 2016.

Walid Saad and **Harpreet S. Dhillon** served as co-chairs of the IEEE Globecom 2016 First International Workshop on the Internet of Everything (IoE), IEEE Globecom, Washington, D.C., Dec. 2016.

Patrick K. Schaumont served as co-organizer of Dagstuhl Seminar 16342 on the Foundations of Secure Scaling, Dagstuhl, Germany, Aug. 2016.

IEEE Fellows

Ed Fox, professor of computer science and professor of ECE by courtesy, was named IEEE Fellow for leadership in digital libraries and information retrieval.

Jung-Min (Jerry) Park was named IEEE Fellow for his contributions to dynamic spectrum sharing, cognitive radio networks, and security issues.

Theresa Mayer was named IEEE Fellow for her contributions to nano materials integrations and directed assembly.

R. Michael Buehrer was named IEEE Fellow for his contributions to wideband signal processing in communications and geolocation.

T.-C. Poon was named IEEE Fellow for his contributions to optical image processing and digital holography. He also received the SPIE Dennis Gabor Award for pioneering contributions to optical scanning holography, which have contributed significantly to the development of novel digital holography and 3-D Imaging.

Awards & Distinctions

Harpreet S. Dhillon received the IEEE Communications Society Heinrich Hertz Award for the best manuscript in a journal sponsored by the society during the previous three calendar years.

Dushan Boroyevich received the 2016 Outstanding Achievement Award from the European Power Electronics Association (EPE). He also received the IEEE Power Electronics Society Harry A. Owen Distinguished Service Award.

Qiang Li won an NSF CAREER Award to conduct research on high frequency integrated voltage regulator to support dynamic voltage and frequency scaling for mobile devices.

Peter M. Athanas, with **K. Zeng,** won a Best Paper Award for "A q-gram Birthmarking Approach to Predicting Reusable Hardware," in the Proceedings of the 2016 Design, Automation & Test in Europe Conference & Exhibition, Dresden, Germany, March 2016. With R. Marlow, S. Ma, K. Lee and A. Love, he won a Best Paper Award for "Incorporating Rapid Design Assembly into a Virtual Prototyping Environment," 2016 International Conference on Embedded Computer Systems: Architectures, Modeling and Simulation (SAMOS), Agios Konstantinos, Greece, July 2016.

Amir I. Zagloul was named a Fellow of the Army Research Laboratory.

Y. Thomas Hou was named an IEEE Communications Society Distinguished Lecturer.

Luke F. Lester was named the Roanoke Electric Steel Professor of Engineering.

Qiang Li and **Walid Saad** were named Outstanding New Assistant Professors by the College of Engineering.

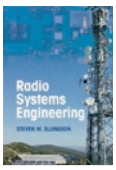
Yaling Yang was awarded a College of Engineering Faculty Fellowship.

Tom Martin was awarded a Certificate of Teaching Excellence.

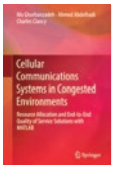
Joseph G. Tront and **Randy Marchany** were named Inventors of the Month by the Virginia Tech Office of the Vice President for Research and Innovation for their Method for Dynamically Obscuring Internet Addresses.

Books Published

Charles W. Bostian co-authored Cognitive Radio Engineering (SciTech Publishing 2016).



Steven W. Ellingson authored Radio Systems Engineering (Cambridge University Press 2016).



T. Charles Clancy, with Mohammad Ghorbanzadeh (Ph.D. '15) and Ahmed Abdelhadi co-authored Cellular Communications Systems in Congested Environments: Resource Allocation and End-to-End Quality of Service (Springer 2017).

Arun G. Phadke and **James S. Thorp** co-authored the second edition of Synchronized Phasor Measurements and Their Applications (Springer 2017).

Sanjay Raman co-authored mm-Wave Silicon Power Amplifiers and Transmitters (Cambridge University Press 2016).

T. Charles Clancy, with Awais Khawar (Ph.D. '15) and Ahmed Abdelhadi co-authored MIMO Radar Waveform Design for Spectrum Sharing with Cellular Systems: A MATLAB Based Approach (Springer 2016).

EXCEPTIONAL national & international SERVICE

Paul Ampadu served on the Board of Governors of the IEEE Circuits & Systems Society.

Dushan Boroyevich serves as the Kwoh-Ting Li Chair Professor of National Cheng Kung University, Tainan, Taiwan.

Y. Thomas Hou is a member of the IEEE Communications Society Board of Governors and the IEEE Computer Society Fellow Evaluation Committee. He also serves as a steering committee member of the IEEE Transactions on Mobile Computing. He is a member of the IEEE Communications Society Conference Council Leadership Team and the IEEE Conference on Communications and Network Security (CNS) Steering Committee.

Fred C. Lee serves as Chair Professor of National Jiao Tong University, Taiwan.

Allen B. MacKenzie has been appointed to a two-year term on the Department of Commerce's Commerce Spectrum Management Advisory Committee (CSMAC).

Jung-Min (Jerry) Park is an Executive Committee Member of the National Spectrum Consortium, which oversees more than $1 billion in research and development of advanced spectrum access technologies.

Sanjay Raman is an elected member of the IEEE Microwave Theory and Techniques Society Administrative Committee.

Walid Saad was elected Vice Chair of the Americas for the IEEE Communications Society Technical Committee of Cognitive Networks for a two-year term.

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TENURE & PROMOTION

Scott M. Bailey was promoted from Associate Professor to Professor.

Patrick R. Schaumont was promoted from Associate Professor to Professor.

Jason Jianhua Xuan was promoted from Associate Professor to Professor.

Sedki Riad was named Professor Emeritus.

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