### Newsletter Fall 2014

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**MICROSYSTEMS**

**A MAJOR RESEARCH AREA**
Alumni gifts provide critical financial assistance for our students. In today’s economy, more students and their families are faced with economic hardships. We remain unwavering in our commitment to admit outstanding students who demonstrate intellectual potential, strength of character, and a love of learning, regardless of their ability to pay. We endeavor to make a Cornell education affordable to all admitted students. It is alumni like you who help to make this possible.

Alumni gifts also help us attract the finest faculty. We must compete with other top engineering schools to attract and retain these outstanding individuals. Your gifts help to equip modern research labs and support our outstanding graduate students, making Cornell a top contender when competing for the best and brightest faculty.

Alumni gifts are essential in providing top-notch facilities. The importance of well-equipped labs for teaching cannot be underestimated. Such labs are where students gain their hands-on experience, giving them an edge in the job market. Every little bit matters—even a few hundred dollars can put a piece of equipment on a lab bench featuring the donor’s name. Likewise, ECE faculty and students depend upon technology to enable effectiveness and efficiency, as well as adequate meeting spaces, which facilitate collaboration to generate and grow ideas. For example, we now offer our students an M.Eng lounge which fosters key interactions, and other meeting places for students are being designed. You, our ECE alumni, are critical in supporting these facilities.

Whether you are able to make a large gift or a small one, we need your support for our students, faculty, and facilities. Every gift matters. Individually and collectively, you are instrumental in making Cornell ECE a strong, vibrant school that produces fine engineers and essential knowledge.

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I feel like a dinosaur. Recently, I’ve been teaching one semester of our basic circuits course ECE 2100, likely called EE 210 when you were here. Covering Kirchoff’s laws and the systematic methods for analyzing a circuit, I took a version of this course as a student 40 years ago in 1973. I went into this, my first EE course with great anticipation—finally, I hoped, I would learn how to design a stereo amplifier! As you probably know, however, this didn’t happen. Instead, I was bored out of my mind with things called Kirchoff’s voltage law and current law, and techniques like node and mesh analysis. The professor told us, “You have to eat your vegetables to grow strong,” and indeed, we grew strong that term.

These days, I start 2100 warning that it will definitely be a boring course. This seems to shock our students, but at least my conscience is clear as we march through mesh and node analysis. The professor told us, “You have to eat your vegetables to grow strong,” and indeed, we grew strong that term.

In electrical and computer engineering there always has been, and always will be, a tension between teaching fundamental knowledge and teaching the dynamic advances in current technology. In the past 40 years, electronics has arguably had a bigger impact on everyday life than any other technology—just think of the personal computer. As a student, I sat in front of an IBM 360 in a large machine room on campus learning Fortran using punch cards. Such instruction would be a failure today. Now, our students design and build computers in their sophomore labs, utilizing them throughout the curriculum.

Since the time to degree hasn’t changed, the growing impact of digital electronics has driven us to displace material. Each time new technology develops, we have lively faculty discussions: “Should we replace chemistry with biology?” “Electromagnetics? Can’t that be done by a good software program now?” And cynically, “How long before calculus is simply an app on the phone?” It often boils down to the “eat your vegetables first” discussion—should we teach a rigorous set of fundamentals first and leave the applications to the end, or should we use today’s technology to continuously motivate the critical learning of fundamentals? Fortunately, students seem a lot smarter today than I was (perhaps you’ve heard of the Flynn Effect?) and Cornell students still rank among the most sought-after. In the end, we seem to be doing things right.

In last May’s commencement address, I showed a photo of Dr. Spock and Captain Kirk from “Star Trek” using a communicator as an example of an early cell phone. Most of the students didn’t have a clue who Spock and Kirk were. They were all still talking about the commencement address they had just heard by actor Ed Helms. “Ed Helms? Who’s that?” I asked, as I felt my bones fossilize a little more, not knowing he was a star of the TV show “The Office.” I watch Star Trek reruns, they watch current shows. No surprise there.

In the next 40 years, our field will continue to change dramatically, but I have no doubt that our Cornell engineers will still receive one of the best educations out there, based on a solid foundation of knowledge that will carry them throughout their career. While we may have to adapt with technology, the culture here won’t let us relax that critical standard.

Sincerely,

Clif Pollock
In June, a California judge ruled that teacher tenure laws in that state deprive students of their fundamental right to an education as guaranteed in the California State Constitution. The judge also ruled that the same teacher tenure laws violate the civil rights of students. The decision could dramatically change hiring and firing practices in California schools and could encourage challenges to teacher tenure laws in other states. The lawsuit challenging California’s tenure laws was funded by David Welch ’85.

Judge Rolf M. Treu’s ruling came in the case of Vergara vs. California. A group of student plaintiffs argued that California’s public school teacher tenure laws deprived them of a decent education by protecting the jobs of bad teachers. The student plaintiffs received financial support in their case from a nonprofit group called Students Matter.

Students Matter was started by Cornell Engineering alumnus David Welch, who received his Ph.D. from the School of Electrical and Computer Engineering. Welch holds more than 130 patents, has authored more than 300 technical publications, and in 2001, co-founded Infinera, which manufactures optical telecommunications systems.

Welch, (in an e-mail interview with ECE Connections), says he started Students Matter in 2010 because, “the public education system is one of the cornerstones of our democracy and when our education system fails our most vulnerable, then our society suffers.” With the financial support of Students Matter, the plaintiffs in the case were able to hire a team of high-profile lawyers, including Theodore J. Boutrous, Jr. and former United States Solicitor General Ted Olson.

In his decision, Judge Treu agreed with the students’ arguments that current rules regarding tenure and lay-offs in California combine to disproportionately affect poor and/or minority students. Treu wrote, “The evidence is compelling. Indeed, it shocks the conscience.” David Welch says, “After working to develop strategies for the improvement of public education, I eventually realized that these laws that inhibit the best teachers from teaching our children are criminal and that the laws must be an infringement of the rights of our children.”

Teachers’ unions in California are planning to appeal the decision. “We believe the judge fell victim to the anti-union, anti-teacher rhetoric and one of America’s finest corporate law firms that set out to scapegoat teachers for the real problems that exist in public education,” says Joshua Pechthalt, president of the California Federation of Teachers. “There are real problems in our schools, but this decision in no way helps to move the ball forward.”

“BECAUSE TEACHERS ARE THE KEY DETERMINANT OF EDUCATION QUALITY, OUR LAWS MUST MAKE EVERY STUDENT HAVING AN EFFECTIVE TEACHER IN EVERY CLASSROOM THE NUMBER ONE PRIORITY.”

— David Welch

Welch disagrees strongly. “Time and again, research has shown that teacher quality is the number one in-school determinant of educational effectiveness—not class size, not per-pupil spending,” says Welch. “Because teachers are the key determinant of education quality, our laws must make every student having an effective teacher in every classroom the number one priority.”

California State Attorney General Kamala D. Harris said she was reviewing the ruling with state education officials and with Governor Jerry Brown before deciding whether to appeal the judge’s decision.
**Debdeep Jena**  
**Professor**  
- B.Tech. (Electrical Engineering), Indian Institute of Technology, 1998  
- Ph.D. (Electrical and Computer Engineering), University of California, 2003

Electronic devices have become ubiquitous—they are in our clothes, our houses, and our cars. As these devices have shrunk to near their ultimate size and speed limits, many are wondering if we are reaching an end to the scaling described by Moore’s Law. Professor Debdeep Jena believes this looming technological wall is not a wall at all. It is an opportunity.

Jena, who will soon join the faculties of the School of Electrical and Computer Engineering and the Department of Materials Science, thinks now is the perfect moment to develop new nanoelectric materials and devices. “I am excited to explore the physics of new classes of materials for unconventional electronic and photonic device applications,” says Jena. “I chose to move to Cornell ECE to work with excellent colleagues who share some of my dreams for the future. My joint appointment with MSE is another strong pull—along with the excellent Physics and Applied Physics programs at Cornell. My research work increasingly needs expertise in these areas and strong experimental facilities.”

Jena’s research and teaching interests are in the material growth and device applications of quantum semiconductor heterostructures, investigation of charge transport physics in nanostructured semiconducting materials, and their device applications.

Jena received his undergraduate B. Tech. degree in electrical engineering, (with a minor in physics), from the Indian Institute of Technology Kanpur in 1998. He then earned a Ph.D. from the University of California at Santa Barbara in electrical materials science and engineering.

In 2004, Xing joined the faculty at the University of Notre Dame, where her lab began developing her expertise in gallium nitride materials and devices as well as high-speed high-performance electronics in general.

In 2004, Xing joined the faculty at the University of Notre Dame, where her lab developed a reputation for leading-edge research into electronic nanomaterials—specifically the gallium nitride family and two-dimensional crystals. One focus of Xing’s research has been to develop gallium nitride components to make power delivery hardware more efficient and computer engineering in 2003. He joined the electrical engineering faculty at the University of Notre Dame, where he has taught for eleven years. In 2007, Jena won an NSF CAREER Award. In 2010, he won the Joyce Award for Excellence in Undergraduate Teaching. In 2012, he was awarded the ISCS Young Scientist Award and the IBM Faculty Award, and in 2014, he won the MBE Young Investigator Award.

“While I am going to miss my colleagues at Notre Dame very much,” says Jena, “I am excited to forge new research directions with my new colleagues. I am also looking forward to teaching and doing research with exceptional undergraduate and graduate students.”

In his free time, Jena says he likes “to hang out and try to relearn to be a child with my son. He is learning more everyday than I do in a year!” Jena will join the faculty of Cornell Engineering in the spring of 2015.

**Huili (Grace) Xing**  
**Professor**  
- B.S. (Physics), Peking University, 1996  
- M.S. (Materials Science), Lehigh University, 1998  
- Ph.D. (Electrical Engineering), University of California, 2003

Silicon-based semiconductors have been of primary importance to the electronics revolution of the past 50 years. Professor Grace Xing is working on what comes next. She is one of the leading experts on gallium nitride components and their many uses in a wide array of applications and she will soon be joining the faculty of Cornell Engineering. Xing will have a dual appointment in both the School of Electrical and Computer Engineering and the Department of Materials Science and Engineering.

Xing received her bachelor’s degree in physics from Peking University. She earned a master’s degree in materials science and engineering from Lehigh University in Pennsylvania. She then went on for a Ph.D. in electrical engineering from the University of California at Santa Barbara. It was at Santa Barbara that Xing began developing her expertise in gallium nitride materials and devices as well as high-speed high-performance electronics in general.

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Richard L. Liboff, Cornell professor of electrical and computer engineering, whose classes and books taught physics to thousands around the world—and to one cinematic superhero in particular—died March 9, 2013, in New York City. He was 82.

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Born December 30, 1931, in Brooklyn, New York, and educated at Brooklyn College (Bachelor of Arts, 1953) and New York University (Ph.D., physics, 1961), Liboff was teaching physics at NYU and working as a research associate at the Courant Institute of Mathematics when Cornell began recruiting.

At Cornell, Liboff specialized in plasma physics, kinetic theory, and electrodynamics, co-chairing the first International Symposium on Kinetic Equations here in 1969. He was the principal investigator on federal grants to study plasma physics, a member of the American Physical Society and of Sigma Xi, the science fraternity. Liboff was promoted to professor of electrical engineering and of applied and engineering physics in 1970.

Clif Pollock, director of the School of Electrical and Computer Engineering and the Ilda and Charles Lee Professor of Engineering, was “just a rookie assistant professor when I first met [Liboff] in 1983. I was working on lasers and he was all excited about a patent he had received for a gamma-ray laser. He also liked to ask everyone, ‘Do you play chess?’ I don’t think many people got through Phillips Hall without being asked. Students liked to play tricks on him; he seemed to enjoy them and was a popular professor. He was always upbeat and spent most of his creative energy on committing his scholarship to textbooks.”

The first of five texts was Introduction to the Theory of Kinetic Equations (1969). By 2004, the then-retired Liboff had a certified best-seller with Introductory Quantum Mechanics.

That was the book (fourth edition, 2003) nerdy physics student Peter Parker (aka Spider-Man) dropped when he stumbled while rushing to class at Columbia, 10 minutes into the blockbuster film “Spider-Man 2.”

Fifty million moviegoers had already seen that literary placement when Liboff’s publisher, the San Francisco-based Addison-Wesley, called with the news. Hardly Spider-Man fans, Liboff and his wife, Myra, received comp tickets to the film at a local theater.

He stayed just long enough to see his book dropped—and trampled by a movie extra—then left the theater. Liboff’s 15 minutes of fame lasted “just about one microsecond,” he proclaimed with his customary precision.

Instead Liboff preferred to defend the topic of the text, which by then had sold more than 100,000 copies and was translated into several languages, saying: “Quantum mechanics is the science of very small particles and systems, where classical physics breaks down and you have to use the Schrödinger equation. Most people don’t know who Schrödinger is, but what he did relates to everything you do: automobiles, TV, surgery, radios... everywhere. That’s quantum mechanics.”

Simpson (Sam) Linke

ECE Professor Simpson (Sam) Linke passed away on Friday, December 27, 2013, at the age of 96. Professor Linke joined the School of Electrical Engineering as an assistant professor in 1949. He was promoted to associate professor in 1953 and full professor in 1963. His research areas included electric
Linke organized and conducted the first International Symposium on the Hydrogen Economy. He also conducted a Symposium on Superconducting Magnetic Energy Storage as well as a Symposium on Research in Electric Transmission and Distribution.

Professor Linke was the editor of ECE Connections from 1992 to 2005. He retired from Cornell in 1986.

**Norman M. Vrana**

ECE Professor Norman M. Vrana, passed away peacefully at home on November 9, 2013. He was born February 16, 1920, the eldest son of Rudolf and Barbara Heindel Vrana in Hudson Heights, N.J. Norman prided himself on his work ethic; actually, he knew no other way.

As a teenager, he helped build structures for the 1939 New York World’s Fair and worked as a messenger on Wall Street, just two of the many jobs he took to get ahead. He then worked for ADT while going to night school at New York University (NYU) studying math and science.

Professor Vrana moved his young family to Ithaca in 1949, to pursue a master’s degree in electrical engineering at Cornell. He taught laboratory courses for more than 40 years and never missed teaching a summer school session.

The courses he taught started with DC machinery and ended with microprocessor systems. In 1973, he designed a laboratory course where students assembled computers from chips integrated into a briefcase, which became known as the “Vrana Box” on campus.

As a family they enjoyed numerous camping trips to the Adirondacks, Maine, and Canada. As a father and grandfather he passed his love of camping and skiing on to the future generations of Vranas. In 1992, he married Ethel Heila Vrana. They enjoyed 21 years together, traveling, and continuing to enjoy camping in the Adirondacks. He was active in the Ellis Hollow Community and helped create the Ellis Hollow Ski Slope. After retirement he joined the Ithaca Community Chorus and The City Club.
Microsystems A Major Research Area

With the ubiquity of handheld devices and the advent of the Internet of Things—networking everything from cars to light bulbs—microsystems, which bring together functionalities such as sensing, actuation, information processing, and communication at chip-scale, has become a major area of research in electrical and computer engineering.

“A revolution of innovation is poised to be unleashed in the coming years,” says Amit Lal, a professor at Cornell ECE. It is not only driven by the “gee whiz” appeal of adding functionality to devices that allow users to sense and respond to the surrounding environment. “To a significant extent, the GDP of our country is dependent on the productivity we get out of these products as we use the devices all the time to do work,” said Lal. “In the future, cell phones are going to continue to be even more capable because the information they provide is a central engine for creativity.”

The leading information technology research firms IBM and Google agree that by 2020 there will be approximately 27 billion devices connected to the Internet. Many of these devices do not yet exist, and each will require small, efficient, and reliable microsystems to keep them connected as they provide seamless benefits—ranging from health monitoring to security—based on voice and fingerprint recognition.

Like revolutions in other areas of computing, the increasing use of microsystems will require parallel innovation in more traditional areas of research. “Because you have so many things connected, you need technological revolutionary ideas to increase the speed at which you can process and store this information,” said Lal. “All these handhelds are going to generate so much data that it’s going to end up somewhere and you need to process it all in large quantities.”

Smart phones, already a collection of microsystems—a camera, a microphone, a few accelerometers and gyroscopes—are obvious platforms, and the addition of...

“IN THE FUTURE, CELL PHONES ARE GOING TO CONTINUE TO BE EVEN MORE CAPABLE BECAUSE THE INFORMATION THEY PROVIDE IS A CENTRAL ENGINE FOR CREATIVITY.”

— Amit Lal
new functionality to smart mobile and spatially-bound electronics is likely to further change people’s relationship with devices that already give them positive feedback in the form of “likes” on social networks such as Facebook.

“Much like pets provide psychological comfort and healthier living through undivided attention and unconditional affection, I think in 15 years, it’s very possible that the cell phone will become pet-like, becoming a source of unconditional dedication,” said Lal. Using motion body detection, personal devices could figure out your feelings. Your cell phone might take advantage of the integrated inertial sensors you might have on your body and see how you are reacting to things in terms of your physical posture. Your cell phone may take that data, process it, and it might say, ‘Why are you fidgety?’”

“The concept of what constitutes a microsystem has evolved since the 1970s, when the focus was on microcontrollers, microprocessors, and microelectromechanical systems or MEMS,” said Lal. Today the definition has broadened to include any chip with the ability to interact with the environment beyond bits going in and out.

“Today a microsystem is a chip in which there are transistors, there is some way of communicating with the world other than using wires—with photons, sound, mechanical, or chemical signals,” said Lal. “The prototypical microsystem that the MEMS field is going after is a tiny robot that can sense, compute, and move intelligently with integrated power sources.” The technology that can implement these functions could form the basis for miniaturizing many systems to microsystems.

For example, says Lal, you could put several different types of microscopes—scanning electron microscope, ultrasonic sonars, and terahertz radars—now all very large, on one chip. “You could imagine putting these in the fingertips of a latex glove and then the doctor wearing that glove. Wherever he touches, he can image...
what is happening,” he said. “One type of microscope by itself may not be sufficient to tell you what’s going on, but when you have them all, the synergistic output from all is more than the sum of what each microscope can provide individually, and you can see what it is conclusively.”

An atomic clock, another bulky technology, has already been miniaturized to chip size. “By using micromachining, you can shrink it down to about a cubic centimeter and it’s commercially available now. That’s an example of a successful microsystem,” he said. “This example adds merit to the mantra that anything is shrinkable.”

The challenges in miniaturization, however, can be formidable. “Sometimes making things smaller improves performance. It takes less energy to heat objects as they get smaller, such as heating a smaller blood sample for DNA analysis. But in many other cases, you have to invent new ways to improve performance at small scales, as exemplified by the large numbers of challenges facing further shrinking of the transistor.”

Cornell Engineering has long played a pivotal role in the area of microsystems. Cornell graduates founded Kionix, one of the first and most successful MEMS manufacturers in the world. Kionix has guided the development of products for inertial sensing with a majority of manufacturing in Ithaca—proving that Ithaca can be a global manufacturing town. The success of Kionix in Ithaca has led to spinoff companies in optical microsystems (Calient) and microfluidic microsystems (Rheonix). Cornell has helped develop Ithaca as a powerhouse of MEMS R&D and industry.

One of the reasons Cornell Engineering was a natural place for MEMS research to take hold early on is the institutional commitment to collaboration across interdisciplinary fields. Another reason was the presence of the National Science Foundation-funded Cornell NanoScale Science & Technology Facility, which coupled with expert staff, supported a broad range of nanoscale science and technology projects by providing state-of-the-art resources.

“MEMS and microsystems tends to bring people together,” says Lal. He mentions the work of fellow Cornell

“BY USING MICROMACHINING, YOU CAN SHRINK IT DOWN TO ABOUT A CUBIC CENTIMETER AND IT’S COMMERCIALLY AVAILABLE NOW. THAT’S AN EXAMPLE OF A SUCCESSFUL MICROSYSTEM. THIS EXAMPLE ADDS MERIT TO THE MANTRA THAT ANYTHING IS SHRINKABLE.”

— Amit Lal
ECE professors Michal Lipson, Rajit Manohar, Edwin Kan, Sunil Bhave, Farhan Rana, Alyssa Apsel, Ehsan Afshari, and Al Molnar. “Interdisciplinary colleagues are very important to MEMS because they provide expertise in optics, electromagnetics, circuits, algorithms, and complementary devices. Without advanced circuits and algorithms you can include all the sensors you want, but if you can’t make them work together, they are not very valuable,” says Lal. Not only does each component need to work in miniaturized form, but they also must be integrated so they don’t interfere with each other. And they need to be designed for production at high volumes to be affordable.

“Foundries make money by maximizing the number of wafers they process per week for a paying customer,” said Lal. “For integrated circuit (IC) foundries to make money they need to push more wafers through, and continued increase in microsystem demand could be crucial to continued profitability in the semiconductor industry.”

Currently, only a handful of foundries produce most of the silicon chips used in the world. And they work hard to reduce cost with competition and offer higher value with higher capability and process differentiation.

As the technology becomes less expensive, it’s possible to imagine silicon becoming as pervasive as steel or brick. “It’s not so crazy to think of everything made of silicon circuits—everything as in our architectural structures and automobiles. Especially if we learn to make silicon stronger than steel,” said Lal. “If you have a thousand foundries pumping out silicon at extremely low cost, you can start functionalizing everything around you with electronics.”

Lal does not know what the future of microsystems holds, but he knows it is wide open. “Have I thought about all the possible applications? No,” says Lal. “But that is what’s driving the future of electrical engineering—the idea that the more functionality we can put on the chip, the more likely that vision of functionalizing everything might come true.” In his own lab, this sense of the future being wide open is highlighted by the many lines of research Lal pursues. He directs the SonicMEMS Laboratory at Cornell ECE, which works on topics such as linear and nonlinear effects of ultrasound for microfluidics, applications of radioactive thin films for powering the “Internet of Things.” His group has also developed radioisotope-powered large-area nanolithography. The SonicMEMS Lab has also developed ultrasonic microprobes for surgery and bioinstrumentation, nanoelectromechanical analog switches and computation, hybrid insect cyborg microsystems, micromechanical solar energy, and chip-scale high-energy particle accelerators.

Whatever the future of microsystems holds, research and innovation done at Cornell Engineering will play a big role.

FIND OUT MORE ABOUT PROFESSOR LAL’S MICROSYSTEM RESEARCH AT:
www.sonicmems.ece.cornell.edu

Piezoelectrically-driven silicon horns concentrate ultrasonic energy to increase displacement to 100s of microns. This large displacement causes less damage to tissue compared to direct penetration, leading to less damaging neural probe insertion.

Early Metamorphosis Insertion Technology (EMIT): insertion of electronics and MEMS structures into the insects undergoing metamorphosis. Wounds are auto-repaired and tissue adopts to the artificial structures, if insertions are done at the right time. The cyborg moths with electrodes are able to fly and function naturally. This process is a new pathway enabling cyborg microsystems for drug discovery and for studying the fundamentals of insect development, in addition to micro-UAVs.
ECE INNOVATION AWARDS

For some students, creating a new product and bringing it to market are distant goals. For Teams Saund and Pulso, winners of the 2014 Electrical and Computer Engineering Innovation Award Competition, these goals are now much closer to reality.

Charged with designing and developing an innovative technology based on the principles of electrical and computer engineering while addressing a practical business or societal challenge, teams pitched their ideas to a panel of judges this past May. The two winning teams each netted a $10,000 prize.

Eileen Liu, ECE ’14, M.Eng ’15 and her partner Shane Soh, ECE ’14 developed Pulso, a hand-mounted mobility device enabling visually impaired individuals to navigate their surroundings and perform day-to-day tasks by “feeling” their way around. Using both ultrasonic and infrared sensors, Pulso discerns nearby objects and translates this information to the user through intuitive vibrational pulses.

“We had the opportunity to speak with and test out prototypes with the elderly at a care center in Ithaca, as well as visually impaired students at Cornell,” said Eileen. “The response was overwhelmingly positive—users not only responded with excitement, but engaged in lively discussions for features they wanted to see in future iterations.”

According to the team’s research, in the U.S. alone, an estimated 6.6 million people suffer from significant vision loss. Visually impaired individuals depend upon their sense of touch, and the range of traditional mobility aides such as white canes and guide dogs is limited. Pulso would make it possible to move beyond these conventional aides, allowing the visually impaired to perceive their environment in new ways through an integrated, intuitive, and reliable device.

Like a conventional white cane, the user sweeps the device side-to-side, checking for obstacles in his or her path, improving obstacle detection and allowing him or her to recognize various common hazards such as approaching obstacles and changes in elevation. Pulso is hoping to extend the product to include navigational guidance as well.

When used on nearby objects, Pulso draws on an infrared-based ranging technique, allowing the user to detect edges and distances accurately and efficiently. By sweeping their hands across a table for instance, the user can create a mental map of the location of various items. The user can also “feel” his or her surroundings in a non-intrusive and safe manner, making crowded and cramped places like public transportation more accessible and comfortable.

“It’s been a crazy ride seeing Pulso evolve from a classroom idea to a working product with the potential to aid millions of visually impaired individuals worldwide,” said Liu.

Liu and Soh completed the first prototype of Pulso during the fall 2013 semester in ECE 4760, Designing with

Pulso uses ultrasonic and infrared sensors to help visually impaired individuals “feel” their way around.

The next iteration of Pulso.
Microcontrollers. The course deals with microcontrollers as components in electronic design and embedded control, empowering students to develop, design, and build their own project.

“ECE 4760 gives students a place to develop their ideas into real projects,” said ECE Senior Lecturer Bruce Land who teaches the course. “It is amazing to see what they do with the projects, both in the class and after.”

Team Saund—Kelsey Kruse, ECE ’16; Andrew Bryan, ECE ’16; Vitchyr Pong, ECE/CS ’16; and Sue-Jean Sung, Hotel ’15—is using brain computer interface technology to create a direct pathway between the brain and a device, developing wireless headphones that can be controlled with the mind.

While music often helps runners and fitness enthusiasts get into the zone or otherwise focus during a workout, and performance-based headphones do exist, the team found that some people gave up listening to music entirely because of frustrations with current technology limits. Many found existing hardware disruptive to the running experience, with ear buds that fall out, wires that get in the way, and controls that are awkward to manipulate on music players.

Challenging this, Saund is making what you think happen, bypassing the hardware interface and giving users direct control over features like play, pause, volume, and next or previous song. These actions would be controlled directly by thought, creating a robust user-interface for listening to music.

Though targeted at runners, Saund believes anyone who wants to really focus and avoid these distractions during a workout would benefit from the ability to operate their device using this Brain Control Interference technology.

“We originally thought that our product would only appeal to elite athletes, but we are beginning to see a greater demand for our technology outside of this initial niche,” said Kelsey Kruse, Saund founder. “We are thankful and feel honored to have won the competition.”

Founded at Cornell’s 3-Day Startup in November 2013, the team designed and created a working prototype with a concentration-based interface, conducted research, and pitched their product to venture capitalists at the culmination of the event. More research and investigation into the interface and technology followed, as did a second prototype based on eye movement, and in January 2014, Saund was chosen as a finalist for the Johnson School’s Shark Tank. Media attention came from the Cornell Daily Sun, and the team participated in Microsoft’s Startup Trek at Cornell in February. They continue research and development of further prototypes of the device, including potentially expanding in the direction of brain computer interface for sports medicine and training.

“This competition was very exciting and is indicative of the vibrant spirit of entrepreneurship that is flourishing at Cornell ECE,” said Amit Lal, ECE Professor and Innovation Award Competition Judge. “I look forward to a new batch of great ideas for the next competition to be run in Spring 2015.”

The Electrical and Computer Engineering Innovation Award Competition challenges students to design and develop an innovative technology based on electrical and computer engineering, and to demonstrate the potential of the idea to address a practical business and/or social challenge. Two winning teams each receive $10,000, which they can spend as they choose, with periodic progress updates to the ECE committee. Supported in part by a generous gift from Michele (’85 ORIE) and Burt Kaliski, judges also include ECE alums Dan Simpkins B.S. ’80 EE, M.Eng ’81 and Rich Caccappolo ’87 ORIE, as well as ECE Director Clif Pollock, Professor Amit Lal, and Senior Lecturer Bruce Land.
Professor C. Richard Johnson, Jr. has changed his career focus several times by bridging gaps and figuring out what people need—and then making it happen. He recently met with ECE Director Clif Pollock to explain how he has progressed from adaptive control to telecommunications to art history, and how he succeeds as an electrical engineer in the art world.

Pollock – Your teaching and research have always been distinguished by the level of interaction with experts and by the dexterity in which you change research directions. You started your career in control and today are working with art museums. How did this evolution start?

Johnson – This whole idea about transferring between two areas started when I was in graduate school. A classmate, Tom Mitchell, and I arrived at the same time and served as TAs in electronics for a circuits course. Tom was doing artificial intelligence (AI) and machine learning systems and I was working on signal processing. We hung out together and I noticed a lot of similarity in our fields. I have one of the early publications with him pointing out how AI has a lot of the same structure as signal processing.

Pollock – So you recognize similarities between fields and then zero in on these.

Johnson – Yes, and it’s because I’m connecting two things that I know something about. The thing is at some point you need an expert to help you finish. Sometimes it’s the person inside the application. Sometimes it’s the theory wiz who is a hundred times better than you. I’ve always thought and I’ve always told my students that sometimes the easiest thing is to put together two things that you are familiar with.

Pollock – But this seems to come naturally for you. Is there something that motivates your changes?

Johnson – With me, it really comes down to circumstance. With adaptive control, everyone looked up and realized that the theory was done. I could no longer attract the best students to my research group, or even some of the best—they didn’t want to do control anymore, they all wanted to do telecommunications.

I saw opportunities in telecom to combine control and signal processing, and with the help of another college friend, I built a research and teaching program in communications.

The next thing came along and the physical layer communications course collapsed. Again, the best students weren’t available anymore and I thought, “For once I’m going to work on a problem that I care about instead of just using it as a vehicle for doing what I really enjoy—doing fun things with images, interacting with Ph.D. students, and teaching them how to do research.”

Pollock – So is this how you got started in the art world?

Johnson – Yes. For years Tom Mitchell and I had been trying to find a way to work together. I called him up and said, “Hey Tom, I’ve got this idea. When we were in grad school, I did that art history stuff. All of the art exams are about attribution: the professor puts a slide on the wall and you have to give its name, date, and the artist that painted it, and write a short essay.

“So I thought, with a little bit of machine learning or even a little bit of image processing, I should be able to somehow put this authentication or artist identification on some sort of steroids. Wouldn’t that be fun?”

He said, “I know someone in the Netherlands who’s actually trying to do something like that with the Van Gogh museum.” So I contacted this guy and told him I have a real interest in the problem area they’re working on, trying to identify brush strokes for fakes and such. I was in a good place because I can speak the language of engineering and I can speak to the museum because I have some background and an interest in art history.

Pollock – Did you feel uncomfortable stepping so far away from traditional electrical engineering subjects? How did your colleagues feel?

Johnson – As academics, our rewards are traditionally based on specializing narrow and deep. That’s where research support comes from, that’s what attracts students, that’s what generates results that are considered typical for publication. But that’s not what motivated me—I wanted to do something I was passionate about. I was lucky to be at Cornell, where people
appreciate cross-disciplinary work. On every side, I was supported in moving in this direction.

Cornell has a culture of attempting to lower every potential barrier to cross-disciplinary research. That’s just part of the philosophy here, and everything’s in place to do that. And because of this environment, I feel emboldened.

Pollock – So, you were an electrical engineer knocking on the door of an art museum. How did you gain traction in the field?

Johnson – In the last 15 years or so, a subfield has emerged called technical art history that needs forensic evidence to support the work. An object can tell you an enormous range of things—how it was handled, where it came from, what it was intended for—and these things can be pieced together. However, most of the evidence is based on chemistry because that’s the background of most conservationists. There’s no injection of computation to speak of. So now, we’ve written software programs that assist conservationists with this type of evidence collecting.

Pollock – Cool! Are you turning conservationists into geeks?!?

Johnson – I teach conservationists how to use these programs and we’re trying to get them to establish a procedure, a standard format—this is completely foreign to the field. For instance, I’ll ask a group of conservationists what standards they follow and they readily admit that everybody does it differently. But no one knows why, really. We’re learning about the culture of the field so when we do find these cultural gaps we can say, “Well, if you did it like this, then this other thing would happen, and you’ll get this extra bonus. How great would that be?”

Pollock – How is your research process different now than it was when your focus was control or telecommunications?

Johnson – What’s interesting is the way research is done in museums. They mount exhibitions and do things to bring in visitors, but they also do research because that’s what maintains their status in the museum world. And research at museums usually happens by the curator saying, “I’m doing something on this particular thing. It has a theme of this, so I need five examples of this.”

I come in saying, “Give me the X-rays for everything. Can we get all 700 of them tomorrow?!” And they look at me and ask, “Why would we ever do that?” As engineers, we have a way of measuring everything, then seeing what we have, and only then figuring it all out. And the museum conservators are just horrified by this! I often get asked, “Why would you waste all of your time on that? You’re looking for this, so you just need to look at the three examples of this.” So the process completely changes.

Now both methods are needed because if you’re not paying attention you’ll miss the thing you need most. With almost every experimental thing I’ve ever been involved with, halfway through we said, “We should have connected this over here as well.”

Pollock – How do you envision the future connection between engineering and the humanities?

Johnson – Honestly, I think digital humanities is going to be huge, another one of these gigantic things that we can play a role in. And it’s not just in art history—there are many more opportunities we haven’t thought of yet.

Johnson – It’s a whole lot easier if you can find the part of the orchard with low-hanging fruit. You don’t need a ladder, but you’ve got to look a little bit.

I fully expected this to go nowhere, I just thought it would be a great ride—if I had a chance to be inside the museum, to learn this world, then it would have been enough. But it’s turned into a big deal now. Everyone that has ever been involved, especially those first green-lighted at the Van Gogh museum, they all agree that it’s gone beyond anything we would have imagined in terms of the reach, the success, and the impact.

It’s been a great ride and I’ve learned a lot. Their world is different, but there are many things that are similar.
Here is what you told us...

CLASS YEARS REPRESENTED 1959-2013

Top 3 reasons respondents read *ECE Connections*
1. Keeps them connected to what is happening in ECE
2. Not your typical school magazine/not just asking for money
3. They are impressed with the balanced coverage

Awareness of the *ECE Connections* webpage
Although respondents all have the Internet,
1. Only 29% knew there was an *ECE Connections* webpage online
2. Only 21% have been to *ECE Connections* online

Rate coverage of these areas in ECE
85% of the respondents felt that these areas were covered well, very well, or excellently
1. Alumni News
2. Alumni Achievements
3. Faculty
4. Research
5. Student Achievements
6. Teaching

Which sections do you read?
91% said they read parts of each section
1. Director’s Message
2. Awards
3. Faculty News
4. Features/Cover Story
5. Student News
6. Director’s Dialogue
7. Alumni Spotlight

Degrees Represented
- Bachelor’s: 15%
- Master’s: 35%
- Ph.D.: 50%

How often do you read *ECE Connections*?
- Every time it comes out: 11%
- Most issues: 33%
- Occasionally: 23%
- Do not read: 31%

How much of the newsletter do you read?
- All: 12%
- Most: 31%
- Portions: 42%
- None: 15%

What topics do you like most?

- Faculty Profiles
- Alumni Accomplishments & Alumni News
- Cornell Engineering News
- Research
- ECE History
- Teaching
- Community Involvement/Outreach
- Student Life
- Gifts to ECE

Scale of 1-7

0 1 2 3 4 5 6 7
Senior Lecturer Bruce Land has been teaching Electrical and Computer Engineering students at Cornell since 1997. He began when the professor who had been teaching a microcontroller class retired. Land took over the class, revamped it as a design course, and has not looked back since. Sixteen years later, he now teaches three classes in ECE, and all of them are focused on design.

When Land talks about his ECE 4760 Designing With Microcontrollers course, it is clear that this is his baby. “This class is the culminating design experience for seniors and M.Eng students,” says Land. “Much of what they decide to make grows out of their personal interests and I just love seeing what they come up with each year.”

Land has taught more than a thousand students the basics of integrating microcontrollers into their designs and for him, it never gets old. “We ask undergraduates here to do astonishingly complicated things,” says Land, “and they just do it.”

Visit the link below and you too can see what the students come up with each year.

http://people.ece.cornell.edu/land/courses/ece4760/FinalProjects/

“SEEING THE CREATIVITY OF THE STUDENTS IS THE BEST PART OF TEACHING.”

“I CAN TALK ALL DAY ABOUT POLARITY, BUT IT DOESN’T MAKE SENSE UNTIL THEY BURN THEIR FINGERS.”

“All photos by Robyn Wishna

“WATCHING A STUDENT’S IDEA GO FROM ZERO TO EXISTING IN THE REAL WORLD IS SUCH A RUSH.”
**TEACHING/ADVISING AWARDS**

### 2013

**Christopher Batten**  
Michael Tien ‘72 Excellence in Teaching Award and  
James M. and Marsha D. McCormick Award for Outstanding Advising of First-Year Engineering Students

**Tsuhan Chen**  
Michael Tien ‘72 Excellence in Teaching Award

**Alyosha Molnar**  
James and Mary Tien Excellence in Teaching Award

**José Martínez**  
Kenneth A. Goldman ‘71 Excellence in Teaching Award

### 2014

**David Albonesi**  
Ruth and Joel Spira Award for Excellence in Teaching in the School of Electrical and Computer Engineering

**Eilyan Bitar**  
National Science Foundation Early CAREER Award

**Xiling Shen**  
National Science Foundation Young Investigator Award

**G. Edward Suh**  
ASPLOS Most Influential Paper Award

**Sunil Bhave**  
Ultrasonics Young Investigator Award, IEEE International Ultrasonics Symposium

**RESEARCH AWARDS**
PROMOTIONS TO EMERITUS STATUS

Michael C. Kelley
Promoted to emeritus status as the James A. Friend and Family Distinguished Professor Engineering Emeritus, July 2013

Zygmunt Haas
Promoted to emeritus status, October 2013

OTHER RECOGNITIONS

Alyssa Apsel
Elected to Board of Governors of the IEEE Circuits and Systems Society

GRADUATE STUDENT AWARDS

2013

Biswajeet Guha (Advisor: Michal Lipson)
Intel Ph.D. Fellowship

2014

Ruonan Han (Advisor: Ehsan Afshari)
Director’s Thesis Research Award
IEEE Microwave Theory and Technique Society Graduate Fellowship

Enrique Mallada (Advisor: Kevin Tang)
Director’s Thesis Research Award

Maia Kelner (Advisor: David Albonesi)
Director’s Ph.D. Teaching Assistant Award

All photos by Cornell University Photography unless otherwise noted.