Spring 2011

UNIVERSITY OF WASHINGTON
ELECTRICAL ENGINEERING

The Integrator

In This Issue...

Photo by Andrew Karpenko

Quadricopters Take Flight in EE 472 Class

As part of their EE 472 class, undergraduate students were challenged to develop their own remote control system for quadricopter drones last winter quarter. EE 472 "Embedded Microcomputer Systems" is an introductory course to specification, design, development, and testing of real-time embedded system software. Aside from all the fun that the students experienced during their final project demonstration, the main concepts in this class translate to any major embedded systems platform and even to developing on resource-constrained systems.

The students' final project required them to figure out how to control the flight of the drones by writing code and building a joystick type controller device to fly them. The students conducted time trials on an obstacle course in the atrium of the Paul Allen Center. They also had to develop a system to allow the drones to fly autonomously through another obstacle course by using the onboard cameras and sensors. Finally, the students were asked to do anything they wanted with the drones for the creativity part of the project. Examples included the drones dancing to music, playing pong with the drones, and having one drone chase another.

"The students really went beyond what they were required to do for this class," said Assistant Professor Shwetak Patel. "They were very motivated and excited to work with the drones, while still learning a lot about embedded systems."

To watch the drones in action, view pictures and read student interviews about this project, visit the following website: ***www.filikagroup.com/ee472/***

Message from the Chair

During the 2010/2011 academic year students completed some pretty fascinating projects that I would like to highlight. For example, one notable student project developed an electronic sensor to determine when water in a bottle set out in the sun for purification is safe to drink (see page 5). These students won an international contest and took 2nd place in the 2011 UW Environmental Innovation Challenge. They are creating a nonprofit organization to turn their concept into a reality.

Most recently, the final project for undergraduate students in assistant professor Shwetak Patel's Embedded Systems EE 472 course required them to figure out how to control the flight of quadricopter drones by writing code and building a joystick type controller device to fly them. You can read more about this on the front page of this issue.

I'm also thrilled to announce the addition of three new faculty members to EE. Kai-Mei Fu, Daniel Kirschen and Joshua Smith each bring their own expertise to emerging and existing research areas. I'm positive that their contributions will continue to spur even more innovations and excitement among our faculty and students.

As this year comes to a close, we will celebrate the achievements of our students at our graduation ceremony. This year's commencement speaker is alumnus Carl Morgan (MSEE '76), one of the five founders of Heartstream, now part of Philips Medical Systems. He will share his experiences and perspectives with our graduates as they enter the workforce.

Leung Tsang
Professor and Chair

New Faculty

Kai-Mei Fu

Kai-Mei Fu received her PhD from Stanford University in 2007, and will join as an assistant professor of electrical engineering and physics in Fall 2011. Her research focuses on solid state spin systems coupled to optical fields for applications in quantum information processing and magnetic sensing. Particular material systems of interest include shallow impurities in semiconductors, color centers in diamond, and semiconductor quantum dots.

Daniel Kirschen

Daniel Kirschen joins the department as a full professor and holds the Donald W. and Ruth Mary Close Endowed Professorship in Electrical Engineering. His research focuses on how to balance the conflicting requirements for the supply of electrical energy, and in particular how to keep it cheap, reliable and facilitate the integration of renewable energy sources such a wind power. This encompasses the implementation of the communication and control technologies of what is called the "smart grid." He is also very interested in understanding the mechanisms leading to blackouts and what can be done to prevent such catastrophes. Kirschen received his PhD from University of Wisconsin–Madison in 1985.

Joshua Smith

Joshua Smith joined the departments of Electrical Engineering and Computer Science & Engineering as an associate professor in Winter 2011. Smith obtained his PhD from MIT in 1995. As a doctoral candidate at the Massachusetts Institute of Technology, Smith invented an electric-field-based passenger airbag suppression system that is now standard equipment in all Honda cars. Smith leads projects on personal robotics, WREL (wireless resonant energy link), and WISP (wireless identification and sensing platform).

2011 EE Leadership Seminar Series

The EE Leadership Seminar Series (EE 400), now in its sixth year, was designed to demonstrate to current EE students the depth and breadth of a degree in electrical engineering. Since we strive to involve our alumni in the life of the department and provide opportunities for students and alumni to connect, this series achieves a dual goal for us.

We were fortunate to have eight very successful alumni contribute their talent to this year's line-up. Thanks to all who took the time to come back to campus and share their insights with our juniors and seniors. When alums discuss their experiences in their profession, our students gain the opportunity to reflect on how they will use their degree in future career endeavors. The class consistently receives high ratings in student surveys. "One of the most valuable courses I've taken here," wrote one of our undergrads.

We appreciate the contribution our alumni have made to our students' professional development and awareness of career options.

Max Ciccotosto, *MSEE '99*
CEO, Wishpot

Gary Bernard, *BSEE '59, MSEE '60, PhD '64*
UW EE, Affiliate Professor

Gerald McMorrow, *BSEE '74, MSEE '78*
CEO, Verathon

Bing Teng, *BSEE (CSE) '90*
CEO, OneMedNet

Mark Jancola, *BSEE '91*
VP Engineering & Technical Operations, Apptio

Alison Perrin, *BSEE '88*
Surgeon, NW Surgical Specialists

Barna Ibrahim, *BSEE '04, MSEE '05*
Field Application Engineer, Intel

Matt Shanahan, *BSEE '86, MSEE '89*
Senior VP, Marketing & Strategy, Scout Analytics

In Memory of John Schulz

On March 30th, 2011, John C. Schulz passed away following a lingering illness. Schulz worked as an engineering technician at UW EE for 40 years before retiring in 2001. A special memory for Schulz was the opportunity he had to join a UW EE research team that went to Antarctica in 1970. A memorial service was held at the Calvary Baptist Church in Everett on Saturday April 9th. In lieu of flowers, donations can be made to the Undergraduate EE Scholarship Fund by contacting Gloria Heaton at: ***gheaton@u.washington.edu***

2011 Commencement Speaker – Carl Morgan

The department is pleased to announce the selection of Carl Morgan as its 2011 commencement speaker. The graduation ceremony is Friday, June 10, 7-9pm in Kane Hall 130.

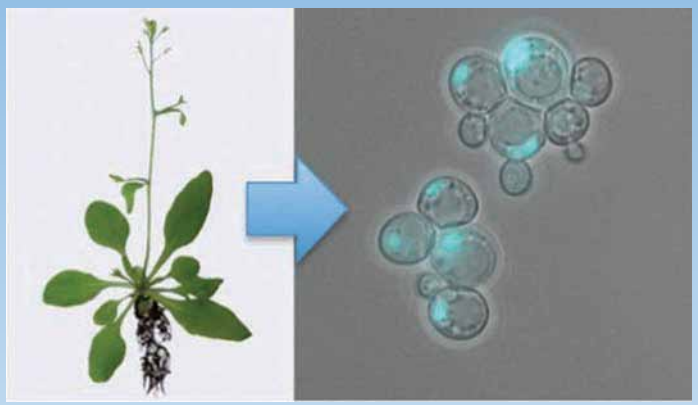
Morgan is one the five founders of Heartstream, now part of Philips Medical Systems. The firm is a pioneer developer of easy-to-use automatic external defibrillators (AEDs) for the rapid treatment of cardiac arrest. He served as its first general manager in 1992. Successive generations of AEDs have become widely available and have saved thousands of lives.

Morgan received a BS in EE from Virginia Tech and an MS in EE from the University of Washington in 1976. He served as an engineer in the U.S. Central Intelligence Agency during the Cold War and is a former Air Force pilot. Morgan developed avionics in Seattle before spending 25 years in medical device research and development. A registered professional engineer in the state of Washington, Morgan is the holder of numerous patents and loves to build things in his basement on Bainbridge Island.

Reverse Engineering the Auxin Pathway

The auxin pathway is central to nearly every aspect of higher plant life and evolution. Professors Eric Klavins of UW EE and Jennifer Nemhauser from the Department of Biology recently received $1.4 million from the Paul Allen Foundation to reverse engineer the auxin pathway using *Saccharomyces cerevisiae* as a testbed. Because different tissues and plants use different combinations of auxin response factors (ARFs) and their inhibitors (Aux/IAAs) for a huge array of purposes, it suggests that the auxin pathway is indeed reprogrammable. "This grant allows us to address the fundamental question: to what extent are genetic components, even ones from different kingdoms of life, interoperable? If we can mix and match entire signaling systems, a whole host of possibilities for engineering emerge," says Klavins.

Together their research labs aim to rebuild the auxin pathway to learn how to program with it. By better understanding individual parts of the pathway, they hope to build entirely new systems capable of producing novel behaviors. In the short term, they intend to reproduce the behaviors of simple multi-celled organisms or tissues in a population of engineered yeast cells. Then, they will port a complete set of signal processing components that could potentially be used in any organism as a modular auxin sensor.



The auxin project aims to port the auxin processing pathway from plants into yeast. Shown are yeast cells expressing a CFP-tagged auxin response factor (ARF).

Perhaps the most intriguing aspect of auxin processing is how plants use auxin while they develop. Development requires (in addition to the pathway these researchers are investigating) auxin transport proteins, synthesis, degradation and sequestration. These systems together allow a developing plant to coordinate the growth patterns of all the cells in the plant to create its ultimate shape. Porting all these systems to yeast could allow them to reprogram non-plant cells to develop into patterns. Understanding development by recapitulating it in a single-celled organism is a truly motivating engineering goal.

New E-Beam Equipment to Advance Research Efforts in Nanophotonics and Optoelectronics

A high-precision electron beam lithography machine, the first of its kind in the Northwest, is now operational in the WTC/NTUF cleanroom facility in Fluke Hall. It will greatly advance UW work across all of nanoscience, including EE's emerging efforts in nanophotonics and optoelectronics.

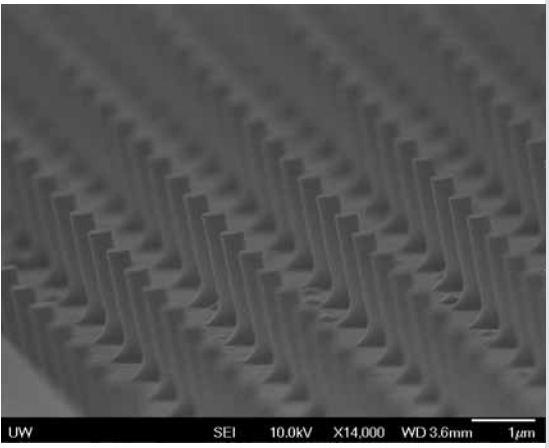
The "e-beam" system writes patterns by scanning a beam of electrons on to the surface of a wafer, which can be a semiconductor such as silicon, or a metal or insulator. These patterns can then be transferred into other materials etching or deposition processes, using other equipment in the shared facilities. With a beam only five billionths of a meter wide, the system can draw circuits and devices down to 6-nanometer resolution and can create 3D structures by building multiple layers.

For EE assistant professor Michael Hochberg, the e-beam is a central technology for his group's work, allowing for the fabrication of advanced photonic devices. Collaborative work on ultrafast nonlinear optics with UW faculty in several engineering departments has produced a silicon-organic electro-optic modulator that greatly lowers the operating voltage and power consumption compared to the previous lowest

energy silicon modulator. Data will move much faster on extremely small chips powered with light rather than electricity. Other groups are using the electron beam system in support of projects in biology and patterned magnetic materials, for example, and several corporate users are currently using the tool to research and prototype commercial devices.

"These new devices could have some pretty exciting potential applications in digital systems such as CPUs," Hochberg said.

The Washington Research Foundation and the Washington Star Researchers Program funded the acquisition and installation costs of the e-beam instrument, which totaled several million dollars. It is currently available for use by researchers in industry and community institutions.



An electron microscope image of an array of silicon nano-pillars, made by e-beam lithography and silicon ICP etching, in the Fluke Hall cleanroom. Silicon nano-structures such as these are used in many research projects at UW, including basic research in materials and physics, optics, and bio-mechanics.

Students' Water-Testing Tool Wins Prize

Nonprofit Launched to Turn Concept into Reality

An interdisciplinary team of UW students invented a device that shows when water is safe to drink. The tool is called PotaVida, and the students were awarded $40,000 from the Rockefeller Foundation to manufacture it. In addition to winning this international contest, the student team took 2nd place at the 2011 UW Environmental Innovation Challenge.

Together the student team built a low cost, reusable and electronic system that is able to detect when the bottle has been exposed to sufficient light to provide the required sterilization of the water inside. "It has all the same components that you'd find inside a dirt-cheap solar calculator, except programmed differently," EE graduate student Charlie Matlack said. The electronics monitor how much light is passing through the bottle and whether a water-filled bottle is present, so the system knows when to stop or start recording data.

Cofounders of PotaVida (L-R): Tyler Davis, doctoral student at The Evans School, Jacqueline Linnes (BioE PhD '10), and Charlie Matlack, EE doctoral student.

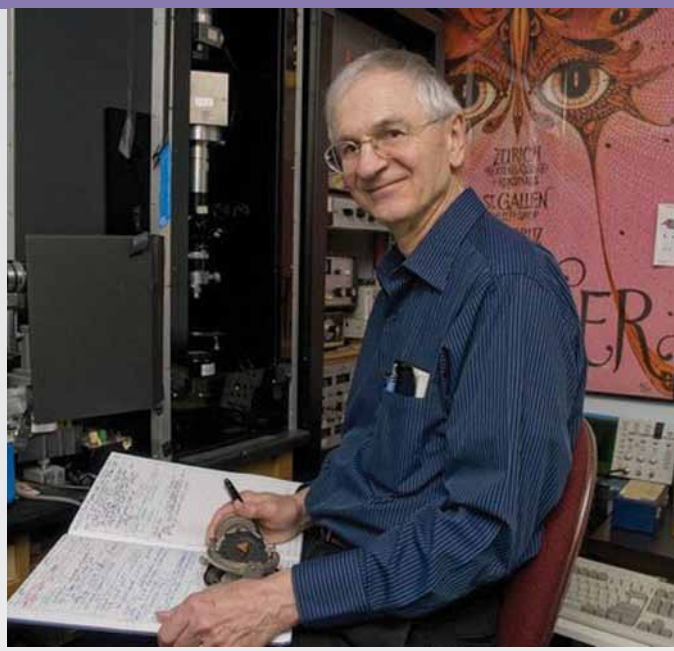
Currently 1.1 billion people do not have access to clean drinking water. People who drink contaminated water are more likely to suffer from diarrhea as a result of consuming pathogens in the water. Approximately 1.5 million children under 5 years old die as a result of this preventable illness, making it the leading cause of death.

This solar disinfection method, known as SODIS, is used all over the world, but adoption rates are low. PotaVida is designed to increase adoption of this method, ensure that the disinfection is done correctly, and notify users when the water is safe to drink.

Winning the contest means the students' efforts may improve the health of children around the world. The challenge called for designs costing less than $10. The UW students estimate their parts would retail for $3.40, and bulk buying could reduce the cost further. "This is part of what engineering education should be," said faculty advisor Howard Chizeck, an EE professor. "It's educating students with the skills and the desire to make things better."

Butterflies and Boeing:

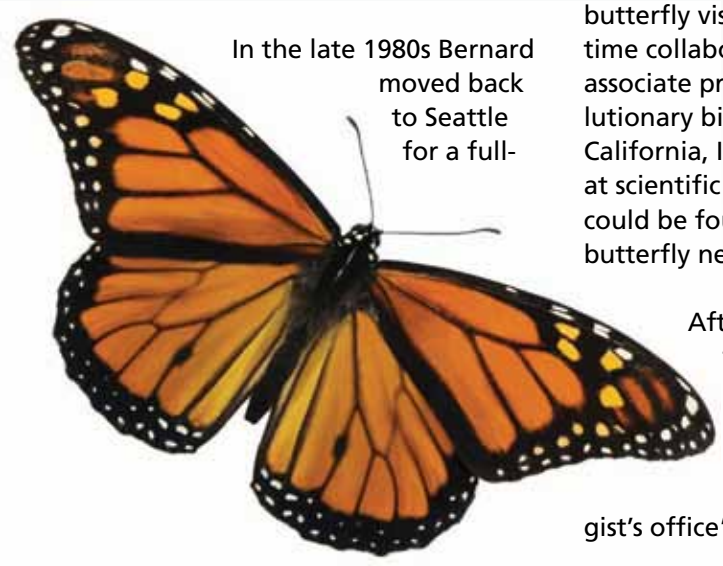
An electrical engineer's unusual odyssey



Gary Bernard's career splits neatly in half, geographically and in engineering applications — 21 years conducting research on insects at Yale University followed by 20 years with Boeing Commercial Airplanes in Auburn. Flight from the micro to mega scale might seem to be the common thread, but Bernard's research passion explores eyes and vision, not wings.

Bernard began his electrical engineering career by completing his undergraduate ('59) through doctoral degrees ('64) at UW EE researching electromagnetic waves. Following a fellowship at the Massachusetts Institute of Technology, he moved to Yale University to collaborate with a physiologist in using electromagnetic waves to study insect vision. Long before cross-disciplinary became a buzz word, he held joint appointments in Yale's departments of engineering and applied science and ophthalmology and visual science.

Over the years he has published scientific papers on bees, houseflies, dragonflies, spiders, beetles, butterflies and moths. One series of publications showed that spiders webs reflect ultraviolet wavelengths to attract prey.



In the late 1980s Bernard moved back to Seattle for a full-time engineering position with Boeing, where he did more traditional EE work looking at ways to process signals to detect wear and tear while machining parts.

His insect research equipment moved with him to the Northwest and found a home in UW EE, where he co-advised graduate students as an affiliate professor. He also helped establish the UW Center for Auditory and Acoustic Research, a multi-university partnership focused on acoustic monitoring.

"He just loved working with the students and with junior faculty," said Les Atlas, a professor of electrical engineering and collaborator of Bernard's.

In his spare time, Bernard kept up his research investigating the evolution of butterfly vision, working with longtime collaborator Adriana Brisco, an associate professor of ecology and evolutionary biology at the University of California, Irvine. Atlas remembers that at scientific meetings his colleague could be found wandering off with a butterfly net in hand.

After retiring three years ago from Boeing, Bernard built a research lab in his Federal Way home, and installed his equipment, a high-tech "opthalmologist's office" for insects, and revved up the third phase of his career. Last year he and Brisco co-authored a paper in the Proceedings of the National Academy of Sciences that may shine light on how some butterflies seek out prospective mates, the latest of nine joint publications.

Heliconius butterflies are famous for having wing colors and patterns that vary with geographic location. As many as a dozen species in one location may look identical to confuse predators.

"Ok, they fool the predators, but how do they avoid fooling themselves?" said Bernard. "How do they recognize butterflies of the same species when they look so similar?"

Butterflies, Bernard discovered in the 1960s, have eyeshine, the property that makes a raccoon's eyes shine in the glare of a car's headlights. A reaction between incoming light and molecules in the eye causes wavelength shifts in eyeshine color. Bernard measures this carefully for each wavelength to learn exactly which ones the insect can see.

In some instances he waits for eight hours in the dark, flashes bright orange light, then measures with

dim flashes in different colors every half-hour to see how the eye responds. He takes advantage of visual molecules in the eye that take many hours to recover. A second technique measures pupil contraction in the insects' compound eyes to verify the results. These painstaking experiments take three days and require middle of the night changes in equipment settings. He then sends the results and the specimens to Briscoe's lab for the genetic analysis.

According to the new results, *Heliconius erato* has evolved a second receptor for ultraviolet light so these butterflies are sensitive to small variations in the UV range. What's more, the UC Irvine researchers found ultraviolet blotches on *Heliconius erato's* wings that are not found on other species. The ultraviolet spectrum could be a "private channel" that this species uses to communicate.

"Gary does really unusual work. He does physiology on living butterflies. It's an extremely technically challenging, computationally challenging kind of experimental work," Briscoe said.

This study's implications are still speculative, the authors caution, because they have not yet tested whether birds and other predators can also see the ultraviolet wing patterns. But there's a follow-up paper in the works and other exciting projects in the pipeline.

"It's really cool for me, as an old guy, retired, to be still active and working with a young group that's pushing the limits," Bernard said.

More on the butterfly vision research can be found at:

http://visiongene.bio.uci.edu/

Alumni on the Radar - EE Class Notes

We'd like to hear from you! Check out our Alumni Connections web page to read a complete list of updates from your former classmates, or to provide your own:

www.ee.washington.edu/people/alumni/index.html

Christopher K. Ho, *MSEE '11*
Bellevue, WA – Ho has worked for seven years as a flight test engineer at The Boeing Company. The EE Professional Master's Program improved his background knowledge about some of the problems he has encountered (e.g., signal processing, electromagnetic interferences, computer and communication networks) during his professional career. It also covered research methods and trends in the EE field. In all, the courses were thought provoking and inspiring for his work and research.

Shailesh Rai, *PhD '10*
San Diego, CA – Rai works at Qualcomm and lives in San Diego with his wife and one-year-old. They love the city, its sun and amazing landscape, but still miss the Seattle rain, friends, lab mates, long nights in the lab, talking to the EE faculty in corridors, and last but not least—working with Brian Otis. What he learned while in Seattle has helped shape his present and future.

Pierre-Henry Marbot, *PhD '05*
Brussels, Belgium – After UW, Marbot worked for industrial companies. He started with four months in the robotics department of EdF, the French power generation company that uses robots to service nuclear plants. He then moved to a logistics service company where his EE training came in handy to improve the use of PCs to automate and record operator activities. After an MBA at Insead, he moved on to work for Tenneco, where they operate a large number of robots and CNC machines. His training from UW has helped him in Logistics and Operations to push the limit and improve performance to unheard of levels. Last summer, he took his family to the US and to UW; doing so helped him make the point to his kids that in the US, more is possible, and such an environment can push back the limits of the possible.

Agniezska Miguel, *PhD '01*
Seattle, WA – Miguel recently received tenure and promotion to associate professor at Seattle University. She was also selected to be the next chair of Electrical and Computer Engineering at SU (starting in the summer).

Richard Adams, *PhD '99*
Charlottesville, VA – Following graduation, Adams continued to serve as an Air Force officer, directing advanced research, development, and engineering efforts at the Pentagon and Air Force Space Command. He finished active duty at the US Air Force Academy as assistant professor in the Department of Astronautics and deputy director of the Space Systems Research Center. Since 2009, Adams has been with Barron Associates, Inc. of Charlottesville, Va, conducting robotics and automatic controls-related research for various defense, NASA, National Institutes of Health, and corporate clients. His most recent project collaborates with the BioRobotics Lab on a tactile data entry system for NASA. Outside of work, his passions remain his family and fly fishing.

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Ishimaru Wins College of Engineering Diamond Award

Congratulations to Professor Emeritus Akira Ishimaru for receiving the College of Engineering's 2011 Diamond Award for Distinguished Achievement in Academia. The Diamond Awards honor outstanding alumni and friends who have made significant contributions to the field of engineering. The award ceremony and dinner is Friday, May 13, at the Don James Center in Husky Stadium.

Ishimaru is one of the world's top experts in wave propagation and scattering in random and turbulent media. His research has affected every aspect of modern life, from health care to communications to national defense.

Ishimaru received a bachelor's degree from the University of Tokyo and worked at Electrotechnical Laboratory and Bell Laboratories before arriving at the UW to pursue his doctorate. His distinguished academic career began in 1958 when he completed the first PhD at UW EE. He was immediately hired as an EE professor and adjunct professor of applied mathematics.

He is the author of a classic two-volume treatise on random media, more than 190 journal papers and over 250 conference papers. Among his many distinguished awards, Ishimaru is a member of the National Academy of Engineering, and an IEEE Fellow with a number of prestigious IEEE awards. Perhaps his greatest legacy is the lives he's influenced and the careers he's shaped as an educator. Ishimaru has advised over 40 PhD students, and more than ten years after retiring, he has active research grants and continues to graduate one or two PhD students per year.