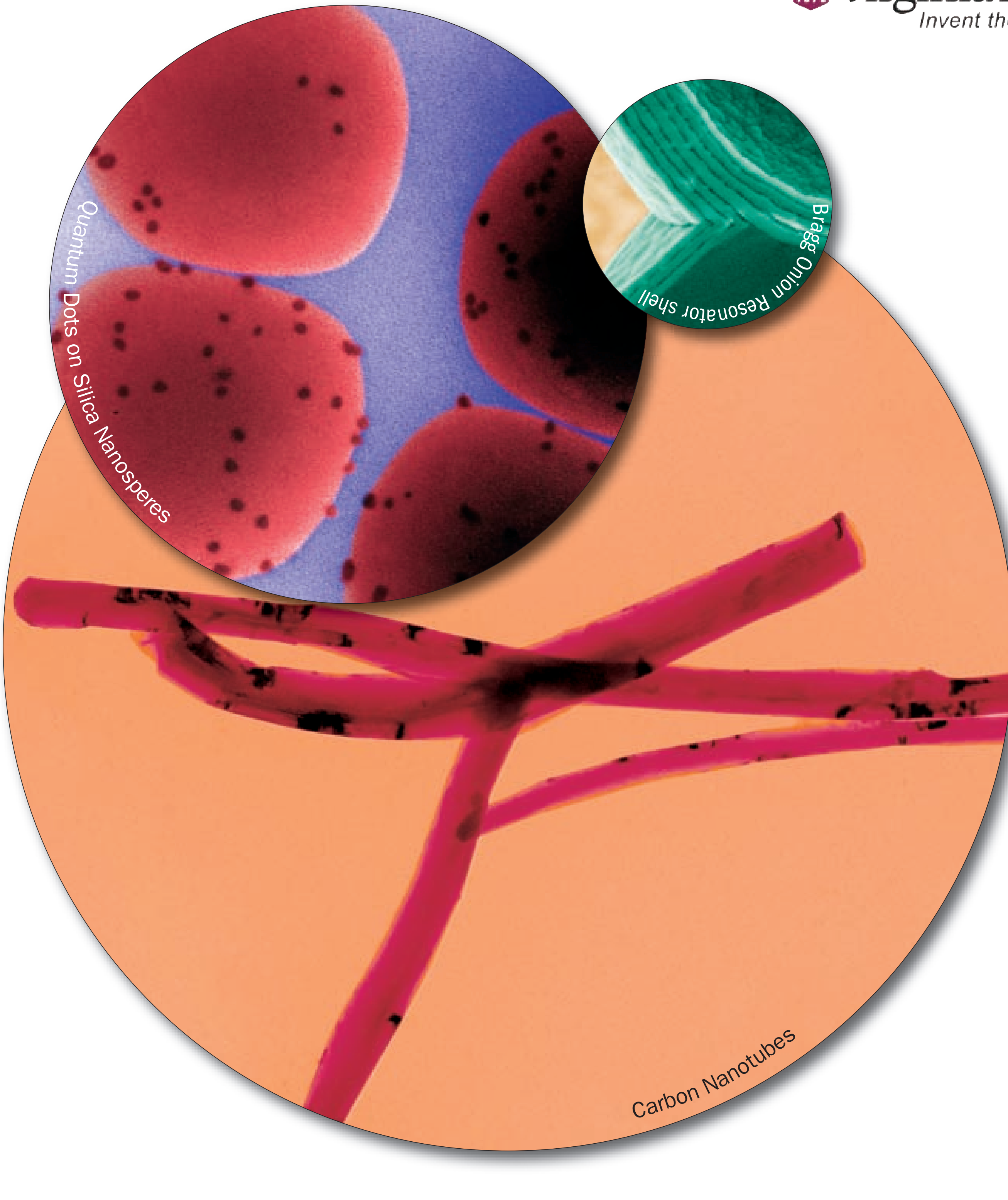
VirginiaTech
Invent the Future



Making the smallest things visible

ECE 2007

The Bradley Department of Electrical and Computer Engineering

Captured by a tangent

One day, early in my college career, my Circuit Analysis professor, an enthusiastic man prone to tangents, managed to turn some ho-hum circuit analysis review into a half-hour explanation of the obstacles faced in current microelectronics research.

"Electronic components are getting small enough that quantum mechanical effects are beginning to dominate, and devices no longer behave the way they're supposed to," he announced. Then he told us that in order to continue producing smaller, faster computers at the current breakneck pace, researchers must develop a technology that is completely new—probably based on the same quantum mechanical effects that cause the current technology to flounder.

Until then, I had thought of computer engineering as my career path and physics as my hobby: never the twain will meet. Suddenly, here was Dr. Hendricks telling me that they had not only met; they had met, married, and started a family. "It will be a paradigm shift," he continued, "and you'll be the ones to shape it."

Today, I can't remember if I shivered my way to class under two jackets and a sweater or ambled, sweating under the hot sun. I can't remember if it was late morning and I was eager for lunch, or if it was late afternoon and I was ready to go home. I can't remember if I was a bright and eager freshman or a self-assured and all-knowing sophomore. The details of that class and that day are lost in murky memories of the Far Distant Past, but I can remember with absolute clarity listening raptly to my professor's words and thinking to myself, "*That's* what I want to do."

My Linh Pham, CPE/Physics '07
Minors: Microelectronics, Mathematics
Bradley Scholar

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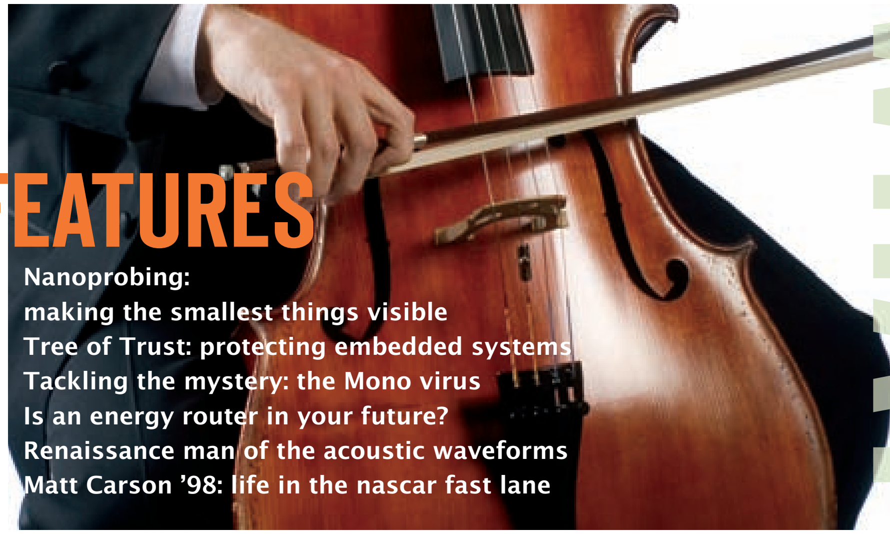
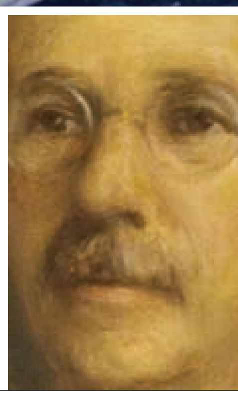
WHAT'S INSIDE

FEATURES



RESEARCH



ECE PEOPLE

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unless noted otherwise.
Josh Armstrong: pp. 1, 2, 3, 4,
8, 9, 13, 14, 20, 21, 22, 26, 31
Rick Griffiths: pp. 1, 2, 16, 40-44
John McCormick: pp. 3, 36, 40-44
Michael Kiernan: p. 27

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PERSPECTIVES

FROM THE
Department Head

After three years of hiring, we have become one of the largest ECE departments in the country. We are in the top 10 in terms of total number of faculty and in a comparable position in terms of both undergraduate and graduate students.

Since January of 2005, we have added 17 faculty members in ECE and are recruiting for three more this year. We currently have a record high of 75 tenured and tenure-track faculty members in the department.

In 2006, eight more new faculty members joined us. They are Leyla Nazhandali, assistant professor in computer engineering; Khai Ngo, professor in power electronics; Scott Bailey, assistant professor in space sciences; Bob Clauer, professor in space sciences; Brent Ledvina, assistant professor in space sciences; Ming Xu, assistant professor in power electronics; Jason Xuan, associate professor in imaging; and Yaling Yang, assistant professor in computer engineering. The eight have Ph.D.s from Caltech, Colorado, Cornell, Illinois, Maryland, Michigan, UCLA, and Virginia Tech.

We have added three faculty members in the space sciences area due to the NSF grant to Wayne Scales and colleagues mentioned in previous years. The Virginia Tech Industry/University Partnership for Space Science (IUPSS) has been formed and received initial support from VPT, Inc. A Space Science Center at Virginia Tech encompassing: ground based analysis of GPS signals, development of scientific instruments for sounding rockets and satellites, and leadership of major satellite programs is planned.

Governor Timothy Kaine cut the ribbon to open the new ECE Micron Technology Semiconductor Processing Laboratory on October 4th. The lab is a renovation of a teaching laboratory that opened in 2001. It has new and improved capabilities that will be used for both teaching and research. Micron Technology made a $750,000 gift that provided the final funds to complete the laboratory.

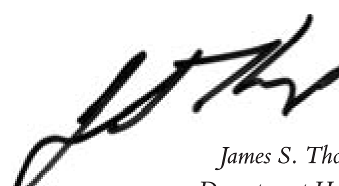
The Microelectronics, Optoelectronics and Nano-technology (MicrON) group, which involves more than 10 faculty members in four departments, will be conducting research in the new lab, and Bob Hendricks will be teaching ECE's semiconductor processing course.

Notable faculty awards include: Arun Phadke was one of four professors honored with the Docteur Honoris Causa di I'INP Grenoble; Daan Van Wyck received the IEEE power Electronics Society 2006 Distinguished Service Award; Jason Lai was named a Fellow of the IEEE; Dushan Boroyevich was named the American Electric Power Professor of ECE; and Anbo Wang was named the Clayton Ayer Professor of ECE.

Our young faculty members continue to garner national recognition in research: Tom Martin received a Presidential Early Career Award for Scientists and Engineers (PECASE), and Patrick Schaumont and Yong Xu received NSF CAREER Awards. With Martin, Schaumont, and Xu, we now have three faculty members who have won PECASE awards and an even dozen CAREER awardees. Congratulations to all!

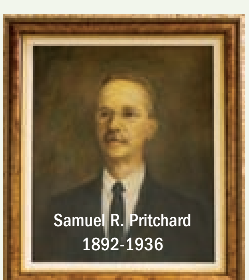
My many thanks to Dan Sable, who is the chair of the advisory board. Dan and the board have been extremely helpful in supporting the initiative in space sciences.

We had a ceremony March 9th to honor past and present ECE department heads. Oil paintings of many of the department heads are now on a stone wall in Whittemore 302. The painting of Samuel Pritchard (1892-1935) was rescued from Pritchard dormitory during a renovation. The more recent paintings are from photographs. Portraits of W.A. Murray 1935-56 and B.M. Widener (1956-58) are the only missing. If you have a good photo of either that you could part with for a while, we would appreciate your help in completing the wall. Debbie Hallstead, Jaime De La Ree, and Kathy Atkins deserve all the credit for the ceremony and the wall.

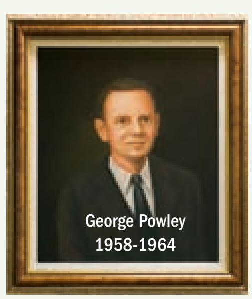


James S. Thorp
Department Head

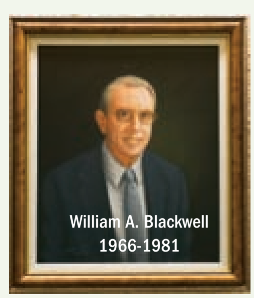
Heads of ECE



Samuel R. Pritchard
1892-1936



George Powley
1958-1964



William A. Blackwell
1966-1981

Daniel B. Hodge
1981-1989

FROM THE

Advisory Board Chair

It is an honor and a privilege to have been elected chairman of the ECE Department Industrial Advisory Board (IAB). I have been associated with ECE for almost 25 years in various capacities including as a master's student, a Ph.D student, a research scientist, and the founder and president of a VPT Inc., a Virginia Tech spin-off company initially located in the Corporate Research Center and now located in the Blacksburg Industrial Park.

The Virginia Tech ECE department has truly outstanding undergraduate and graduate programs with excellent faculty world-renowned for its teaching and research. I can still remember when I was a master's student listening to a truly fascinating guest lecture by Professor Charles Bostian on satellite communications. After his researchers had received anomalous signals from the satellite dishes on the top of Whittemore Hall, they began to develop new theories of RF wave propagation only to later determine that the cause was a dead fly in the wave guide.

Virginia Tech has always been a leader in the application of technology directly in the classroom. It was not too long ago that Virginia Tech became the first engineering college in a land-grant university to require all incoming students to possess a personal computer. The state-of-the-art model at the time was an IBM PC with a whopping 640K of memory. This tradition continues with today's application of wireless tablet PCs in the classroom.

ECE department excellence does not stop at great teaching. During my association with Tech I have witnessed ECE develop internationally recognized research programs in power electronics, fiber optics and sensors, wireless communications, microelectronics, computers, and others. The future challenges for the department are to establish leadership positions in a variety of emerging fields including nanomaterials, biomedical engineering, energy and the environment, and space science.

As alumni and members of the IAB, it is in our own interest to see the ECE department prosper and gain higher reputation. At VPT Inc., 100 percent of our engineers received a bachelor's or master's or Ph.D. from Virginia Tech. At Orbital Sciences Corp., which is also represented on the IAB, there are about 100 engineers with a Tech degree. My vision for the IAB is to encourage an active role for the members in several ways:

1. Alumni and IAB member companies can encourage practical experience by sponsoring undergraduate and graduate student interns. At VPT, we have had an active intern program for 12 years. This is a mutually beneficial relationship as VPT often hires the students full-time upon graduation.

2. Alumni and IAB member companies can participate directly in the classroom through guest lectures. Relating practical problems encountered in industry to the classroom theory goes a long way with student understanding of course material.

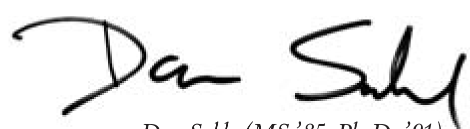
3. Alumni and IAB member companies can sponsor research in areas of concern to them. VPT has been active in promoting the emerging space science group in the ECE Department and is also a member of Center for Power Electronic Systems (CPES) Industry-University Partnership Program.

4. Alumni and IAB member companies can take an active role in being advocates for the ECE department at the college and university level. ECE has been a traditional strength of the university. It is critical that it continues to receive appropriate priority.

5. Finally, alumni and IAB member companies can support the ECE department through generous financial donations.

Jim Thorp has demonstrated remarkable leadership in focusing the department, and the IAB fully supports his efforts. The university is fortunate to have person of his stature, integrity, caliber, and vision as the ECE department head.

Great teaching, great research, great students, great alumni, great leadership–what more can one ask?

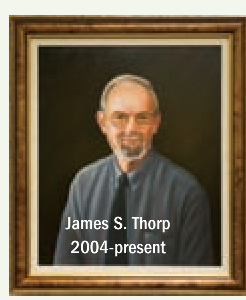


Dan Sable (MS '85, Ph.D. '91)
Chair, ECE Advisory Board


F. William Stephenson
1990-1994


Leonard A. Ferrari
1995-2000

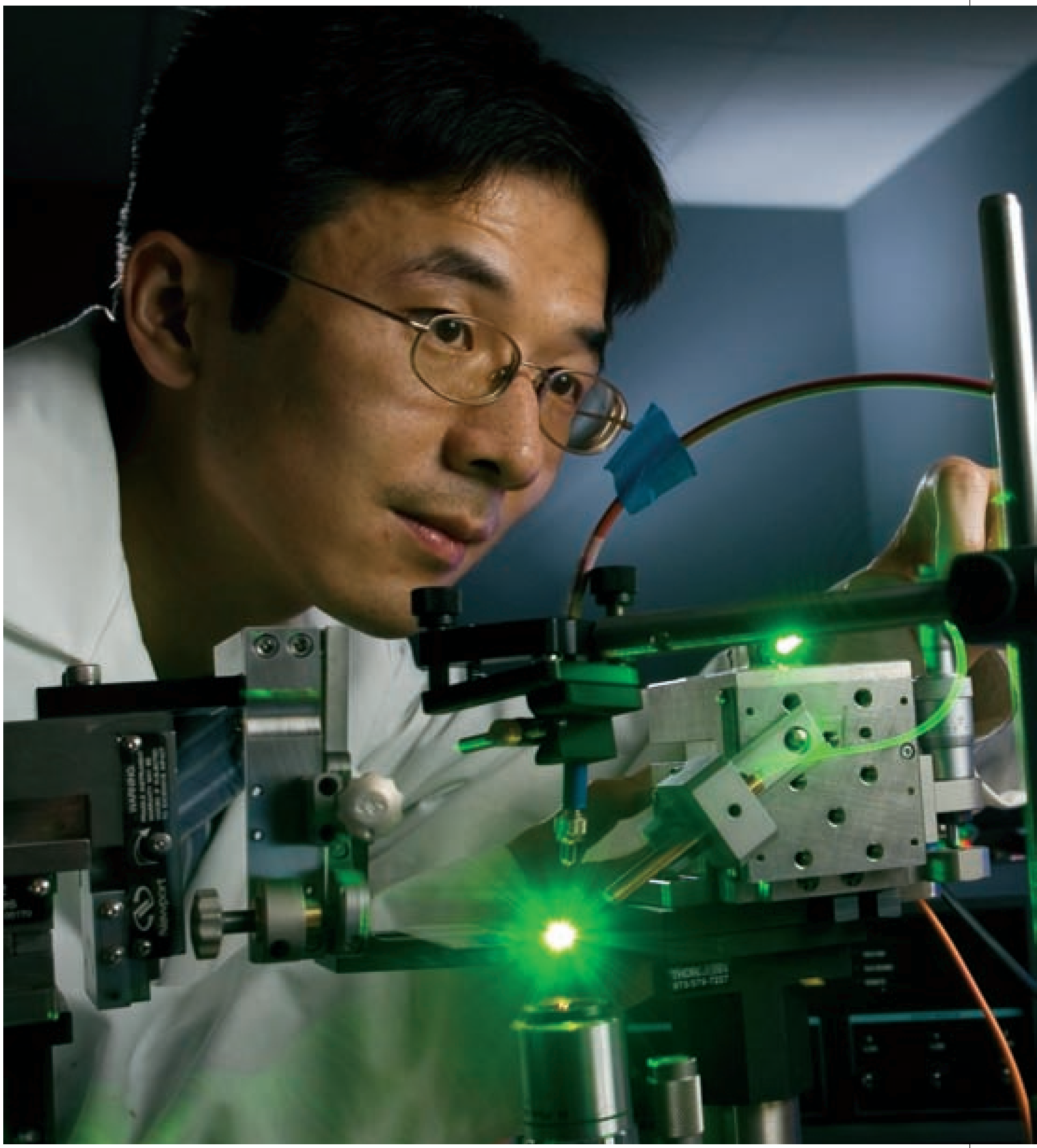

Robert J. Trew
2001-2002


James S. Thorp
2004-present

In March, ECE began displaying portraits of the department heads who have served since ECE was established in 1892. We are seeking photos of W.A. Murray (1935-56) and M.M. Widener (1956-1958).

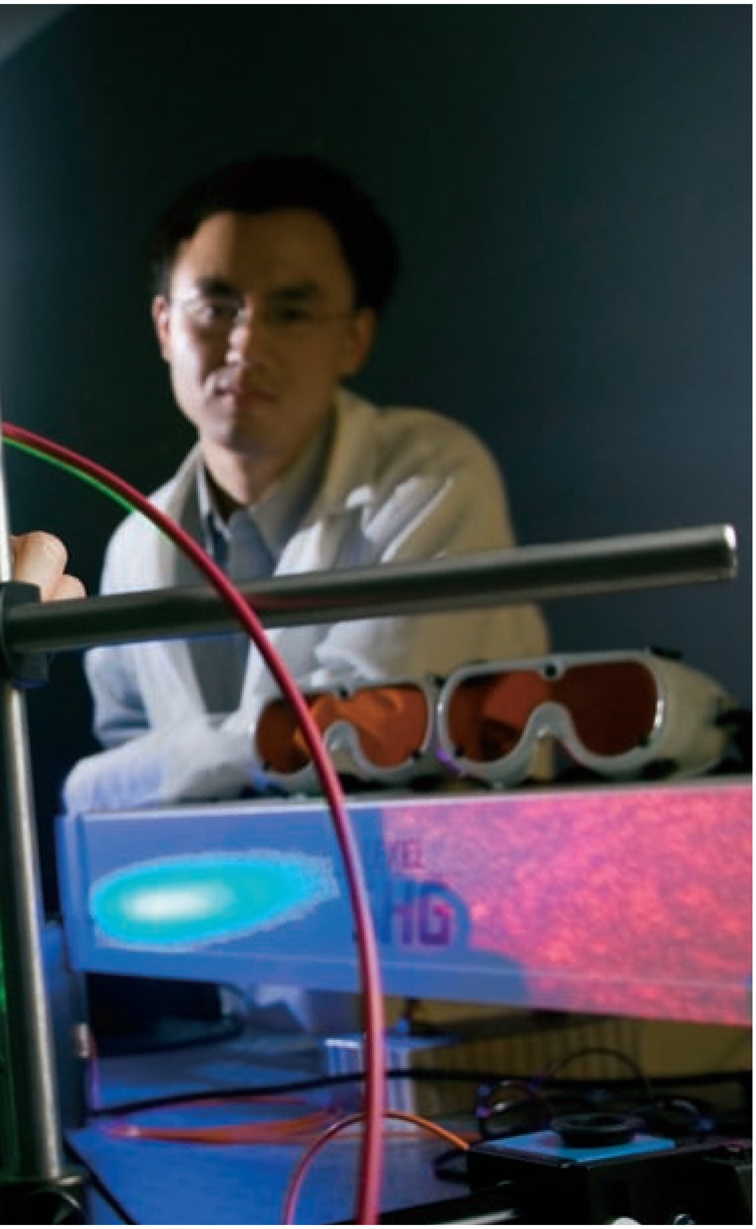
Making the smallest things visible

NANOPROBING



Yong Xu (left) is developing technology that employs a nanotube on the end of a fiber to achieve an optical imaging resolution of 1nm. His team uses a laser imaging system in order to “see” and manipulate the nanotubes. Graduate student Yaoshun Jia observes from the right.

Nanoprobe technology could achieve ultimate optical imaging resolution, while helping explore one of the last mysteries of quantum electrodynamics



Yong Xu, an assistant professor of electrical engineering, is developing an active nanoprobe technology that could enable significant breakthroughs in optics, physics, and communications.

Optically, his nanoprobe technology can break the diffraction limit and achieve the ultimate optical imaging resolution of 1 nanometer. Furthermore, he hopes to use the nanoprobes to measure one of the few remaining mysteries of quantum electrodynamics—vacuum field fluctuations. The probe could also be configured as a single-photon emitter, enabling quantum cryptography and the ultimate secure communications link.

Xu has received a National Science Foundation (NSF) Faculty Early Career Development Program (CAREER) Award to support his efforts. CAREER grants are NSF's most prestigious awards for creative junior faculty members who are considered likely to become academic leaders.

A tube and a dot

The potential of Xu's technology seems inversely proportional to its size—that of a single carbon nanotube. A carbon nanotube is a single-atom-thick sheet, shaped as a cylinder, that can have a diameter of about 3 nm. Its length can reach tens of microns. Like many nanoscale molecules, carbon nanotubes have novel properties, including great strength and numerous intriguing electrical properties.

While a nanotube will serve as the body of the probe, the tip of an optical nanoprobe will be a single 1-3 nm quantum dot and the whole assembly attached to an optical fiber. Also called nanocrystals, quantum dots are nanometer-scale pieces of semiconductor that can emit light (fluoresce). "We needed an emitter with a size as small as possible," Xu explains. "We also needed a fluorescent element that is bright, stable, commercially available, and can cover a broad wavelength range."

Xu expects it may take up to two years to perfect the fabrication techniques and develop working prototypes of the appropriate size and strength. Once the fabrication is proven, his team will apply the nanoprobes in near-field imaging, vacuum-field imaging, and single-photon generation.

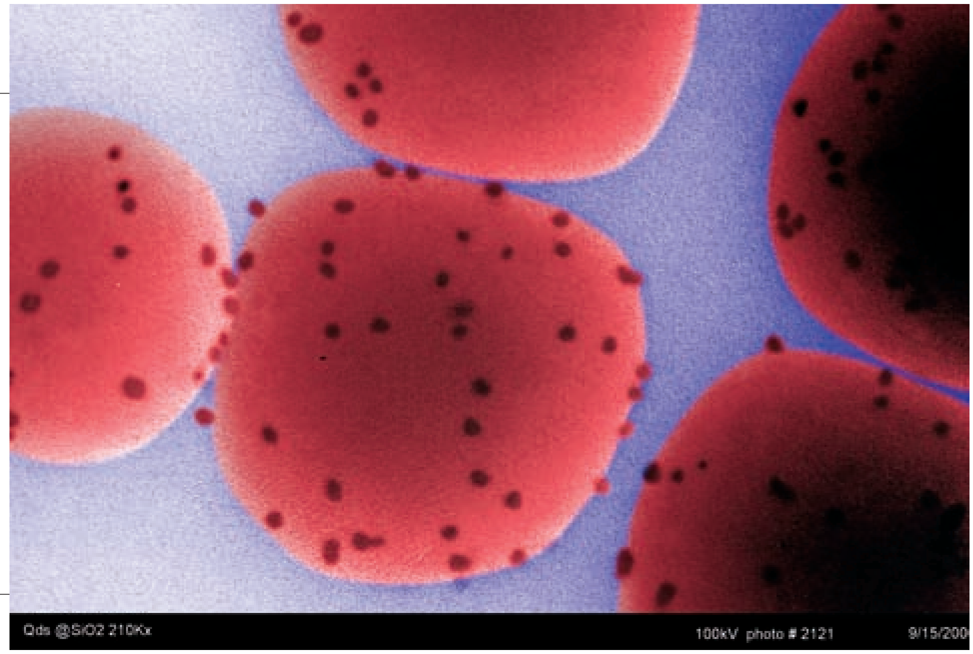
Improving the optical microscope

"Improving resolution is critical to the advance of nanotechnology," Xu says. "We need to be able to image optical

Colorized images of nanotechnology
From the left: Quantum dots (dark spots, ~3nm in diameter) on silicon nanospheres (red).

Center: An army of Bragg onion resonators, similar to the ones Yong Xu plans to use to demonstrate and map vacuum field fluctuations—which have been proven, but never mapped.

Far right: a close-up of the resonator shows the layers of "shell," which make it possible to isolate a vacuum field fluctuation.



structures and observe physical phenomena at ever smaller sizes."

Most optical microscopes are restricted by the diffraction limit and cannot produce optical images with resolutions better than a few hundred nanometers. To overcome the diffraction limit, the current approach relies on a nanoscale fiber aperture to obtain higher imaging resolution, as in the case of near field scanning optical microscopes (NSOM). However, even in the most advanced NSOM systems, the imaging resolution is limited to about 50 nm resolution. In addition, NSOM technology relies on metal-coated tips, which creates a large perturbation of the original optical field, Xu explains.

Since the ultimate resolution limit of nanoprobe imaging is determined by the size of the fluorescent element, Xu's nanoprobe should enable optical imaging at a resolution of 1-3 nm, he says. The probe can generate images by scanning the position of the quantum dot and detecting the fluorescence into the silica fiber. "Using a single carbon nanotube, the nanoprobe can achieve for the first time non-perturbing imaging at this resolution," he says.

Viewing a quantum mystery

With a nanoprobe of such small scale, Xu hopes to demonstrate a 3-dimensional vacuum field imaging for the first time. Modern physics has determined that a vacuum is not a complete void, as many people believe, he says.

"By definition, there is always something there, even in the absence of all particles. We call this tiniest level of physical existence of electromagnetic field 'vacuum field fluctuation.' Light, contrary to what you might imagine, comes as waves of tiniest energy bundles called 'photons.' And a photon is emitted when an atom or a molecule jumps from a high energy level to a low level," he explains.

"If there is no electromagnetic vacuum field, then they won't jump. There is a perturbation that in essence tries to trick them into jumping from high to low. Our most precise theory of nature predicts this and we know it must be there because otherwise our devices would not work. We have verified vacuum fields by countless experiments. We have a theory to calculate it, but we have not been able to measure what is going on and how it is distributed," he says.

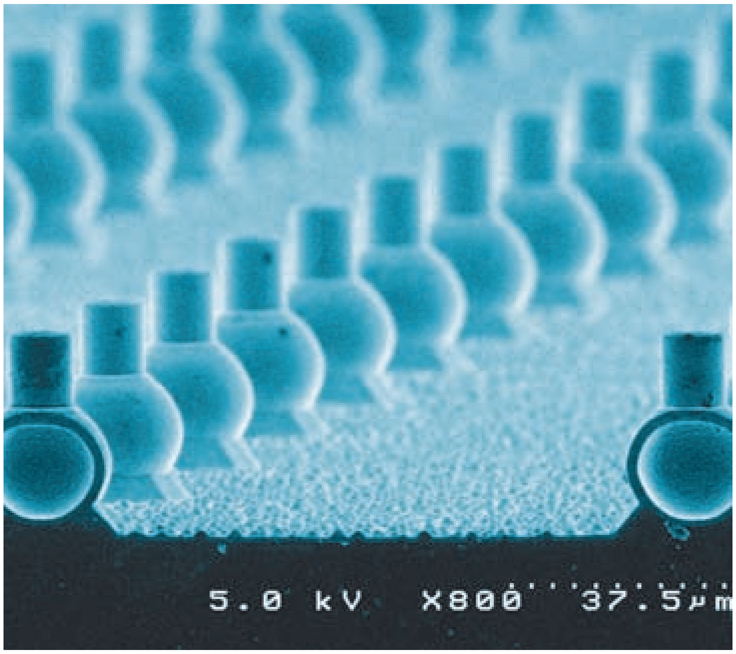
Xu plans to analyze the decay of the quantum dot to measure a vacuum field. "The decay of the light emitting process indicates there is a field. By measuring how it decays or how quickly a photon is emitted, we can infer the distribution of the field."

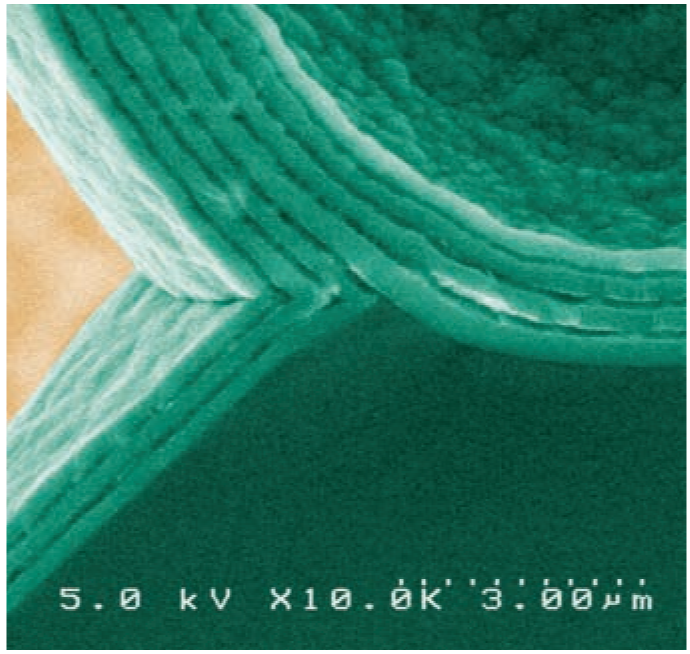
The nanoprobes in this application will have a tip of multiple quantum dots. In addition, an integral part of the 3-D vacuum field imaging is the use of silicon-based Bragg onion resonators he helped develop while he was a postdoctoral scholar at Caltech.

New, single photon emitters

The third application of the nanoprobes is to convert them into single-photon emitters, which can be used in quantum cryptography

"We need to detect something so incredibly weak and still isolate it from the noise. We spend a lot of time in a dark room."





and quantum information processing.

"In our approach, we use a nanoprobe to achieve optimal coupling between a single quantum dot and a cavity, so that single photons can be triggered as needed," he says. "We can engineer the cavity so that all the photons generated by the quantum dot will go into the cavity. In the end, we can create a 'push button' device that can generate one, and only one, photon at a time, i.e., single photon on demand."

A reliable, constant source of single photons will enable the development of quantum cryptography, where the security of communications is guaranteed by one of the most basic laws of nature. "A photon cannot be split in two, which is a wonderful gift of life." Xu says. "A photon is either detected or not detected. It is a signal of one. It is either received or stolen by an eavesdropper." If sidetracked by an eavesdropper, the recipient knows the data or message is compromised.

The trouble with tiny

Xu's nanoprobe technology in imaging, computing, measurement, and communications, may find future use in physics, biology, chemistry, and even quantum teleportation, he suggests. However, in the near-term, his team faces challenges related to the small size of the technology.

"We deal with structures with dimensions of a few nanometers, so we must make sure everything is perfectly stable and nanostructures are precisely manipulated," he explains. "We are also working with one photon at a time. That is a very weak signal. We need to detect something so incredibly weak and still isolate it from the noise. We spend a lot of time in a dark room."

Calling on an army of onion resonators

For Yong Xu, 3-D vacuum field imaging is one of the most important aspects of his research. "It is a great challenge and great fun to be able to measure something that has never been measured before to the precision of a few nanometers," he says.

Not only would success reflect the first time vacuum field imaging is demonstrated, but Xu's work may also lead to the creation of a silicon laser, which is the most critical missing component in the race towards silicon-based integrated optics.

Xu's team plans to demonstrate vacuum fields by using Bragg onion resonators he and his colleagues at Caltech and Sandia National Laboratories developed in 2004. Each resonator is a hollow cavity encased in a shell made of alternating layers of high-index silicon and low index silicon dioxide (SiO_2). Each resonator has a "stem" opening so that a nanoprobe can be inserted.

The shell is a very thin 250 nm and each resonator is 10 to 15 microns in diameter. Due to the large index contrast between silicon and SiO_2, the shell can behave as a perfect conductor and provide 100 percent reflection for any incident light. This can effectively isolate the vacuum field in the hollow core from outside field.

Xu's team has developed a theoretical model and demonstrated that onion resonators can both enhance and inhibit spontaneous emission by more than one order of magnitude. "This tells us we can funnel most of the spontaneous emission into the desired mode, which is important for both single photon sources, and for laser applications," he says.

TREE OF TRUST

GROWING THE TREE OF TRUST STARTS BY PROTECTING THE ROOT-OF-TRUST IN EMBEDDED SYSTEMS

Pengyan Yu (left) and Eric Simpson demonstrate SAM (secure authenticated mode). Unauthorized devices see only the noise on the right, while the authorized device sees the magic word.

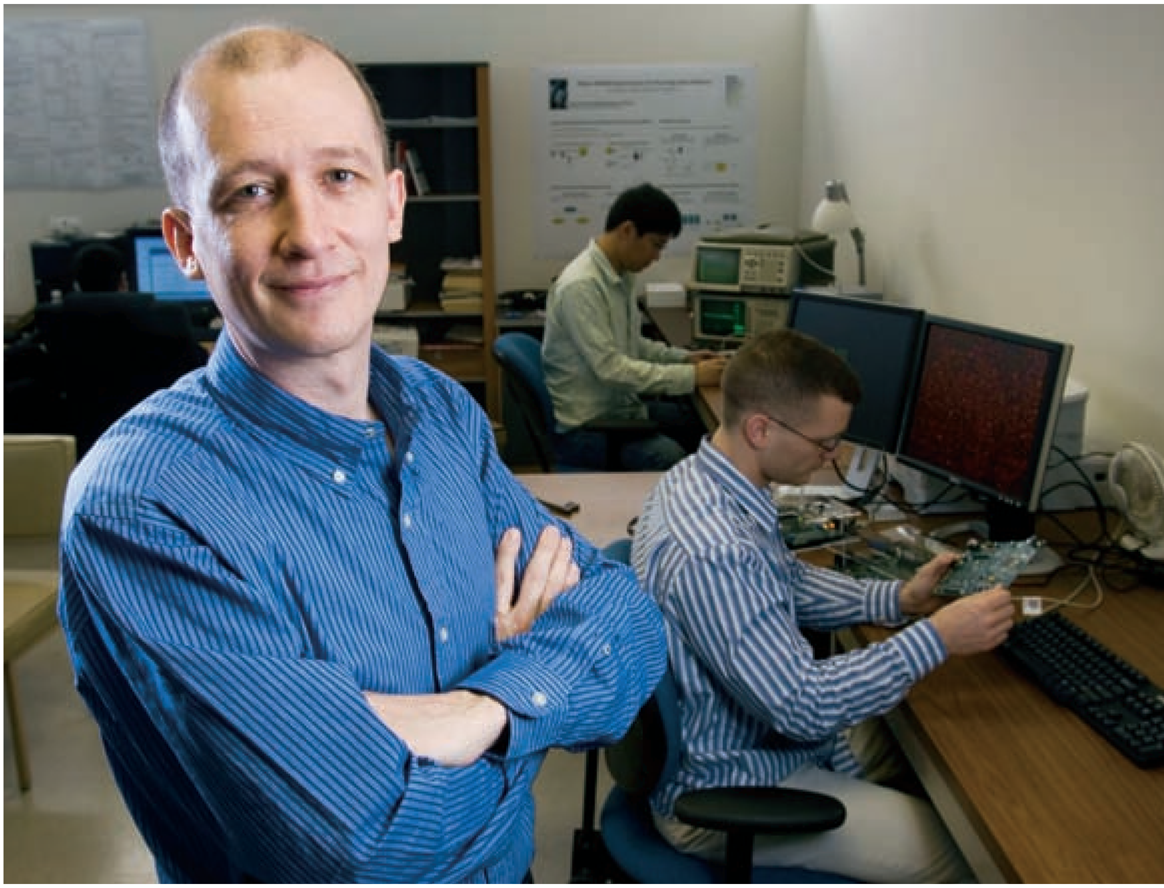
While hackers and viruses grab headlines in computing security, Patrick Schaumont's team is working to protect data from a newer, growing threat—a threat from the loss and theft of embedded computers that store personal and private information.

"Today's computers are so small that we can carry them around and lose them," he says. "Who among us can claim never to have lost a credit card, a cell phone, a PDA, a laptop?"

Medical records, high-resolution pictures of pen-drawn signatures, and codes to unlock electronic car locks are just some of the examples of information now stored on smart cards, key fobs, and other embedded computers. The problem in keeping the information safe, Schaumont says, is that conventional computer security and cryptography focuses on protecting data during transmission, but once thieves have possession of the computer, transmission is not an issue and the data is vulnerable.

The solution is to carefully design security into the hardware and software of a computer, but engineers commonly add protection only as an afterthought. Schaumont is working to develop a methodology for embedded systems engineers to follow in designing both

“We could break the code in just three minutes by measuring the power.”



Patrick Schaumont received an NSF CAREER Award for his work on protecting embedded systems from side-channel attacks.

hardware and software for security.

His team is seeking answers to questions, including: How can we systematically deal with private information processing in a portable computer? How can we implement cost-effective encryption mechanisms that are energy-efficient and secure? How can we store secrets in a reliable way in a portable system?

“Securing secrets is not part of the typical engineer’s toolbox,” he says. “We want to change that.”

Schaumont has received funding for his effort from a National Science Foundation (NSF) Faculty Career Development Program (CAREER) award. The CAREER grant is worth $400,000 over five years and is NSF’s most prestigious award for junior faculty members. Schaumont joined ECE in 2005 as an assistant professor.

Greatest hazards are side channel attacks

“As in any kind of security, a secure embedded system is only as safe as its weakest link,” Schaumont says. Once thieves have possession of an embedded computer, secrets can be easily probed out, and the thief doesn’t need to know the password to do that. For example, a cryptographic chip can often be analyzed with a side channel attack by measurement of only its power consumption pattern.

“You don’t need to open the chip to do this,” Schaumont explains. “It’s a systematic problem, much like a communications problem. You can filter out the noise and detect the code you seek.” He was on a team in the Secure Embedded Systems Group at the University of California at Los Angeles (UCLA) that demonstrated such a side-channel attack on a standard encryption chip. “We could break the code in just three minutes by measuring the power,” he says.

Side-channel attacks have been recognized as a security issue only in the past decade, according to Schaumont. “Most people are familiar with software attacks and physical attacks, but not side-channel attacks,” he says. (*Continued on p. 10*.)

Software attacks often arrive via virus or spyware and involve a complicated process that requires expert knowledge, Schaumont explains. "Logical attacks require brains, but they are cheap. All an attacker needs is patience." Classical security software is designed to thwart these attacks.

Physical attacks, often used in reverse engineering, require disassembly and are costly. "Physical attacks require expensive, specialized equipment, such as microscopes and chemicals to get down to the chip layer," he says. "It's expensive, but it's not hard. Using a systematic approach, it can be done."

Side-channel attacks are ideal for embedded systems from an attackers perspective. "You don't need to open a chip and don't need expensive hardware. Plus, it is systematic." Protecting against these attacks is very challenging, Schaumont says. "There are many abstraction layers—all of them exposed. Current countermeasures are all point solutions, implemented only in software or hardware. They offer no guarantees for the overall system."

Hardware/Software Codesign

The solution to designing secure embedded systems is to pay attention to all abstraction layers, and this requires hardware/software codesign, he says. "The flexibility of software supports complex crypto-algorithms. On the other hand, hardware can provide side-channel countermeasures that are hard to implement with software, such as constant-power execution. A combination of the two will enable flexible and secure system design."

"Securing secrets is not part of the typical engineer's toolbox. We want to change that."

Tree of Trust

Schaumont wants to develop a systematic approach to side-channel-resistant embedded system design. "Security is hard to optimize, hard to quantify," he explains. He is proposing a systematic approach to side-channel-resistant embedded system design he calls "The Tree of Trust."

With the Tree of Trust, a designer can systematically partition a system into a secure-critical and a non-critical part. A designer needs to be able to systematically shield those secrets. Secrets go into the critical part. A completely isolated secret is meaningless, however. All these protected secrets are only useful if they can interact. The Tree of Trust makes sure that secrets are integrated into the system with a secure interface.

"You are trying to defend your root of trust," he says, explaining that the root of trust is the element that is implicitly trusted, such as the key of an encryption algorithm. "Implementing the root of trust is always expensive, so the smaller you can make this, the cheaper your system is. Indeed, the non-trusted elements can use standard components or software."

The embedded system contains several abstraction levels, including the protocol, the algorithm, the architecture, hardware, and circuit levels. "If you partition the system correctly at every level, you will obtain a very small root-of-trust which can be protected with cost-effective countermeasures across the hardware/software boundaries," he explains.

Building With Secrets

His goal, he says, is "to come up with a way in which people can systematically deal with the design of secrets when designing a system …We are trying to find a canned sequence of operations that a designer of secure hardware and software could use."

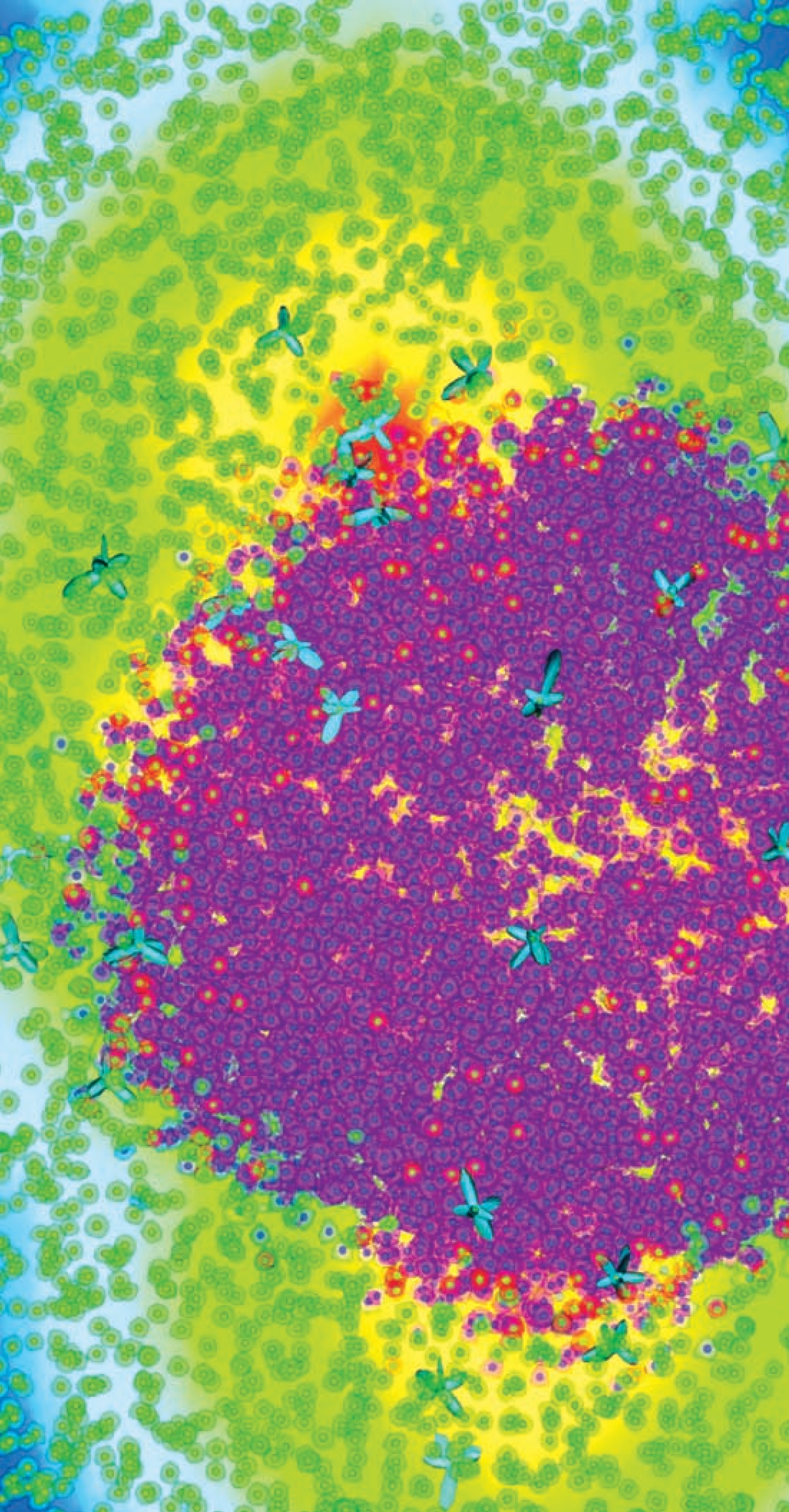
His team is applying the Tree of Trust concept to different embedded-system implementations. One ongoing application involves protecting content using "Secure Authenticated Mode," or SAM for short. Using SAM, a video message can be created that can be displayed only on a unique and single device. Another project is the development of protection mechanisms for DSP software in sensor nodes that remain active in the field for several years. "The sensor nodes contain highly advanced signal processing to gather information on activities in their environment. The software represents an important amount of intellectual property," he says.

Targeting the Engineers

A critical part of Schaumont's plan is educating the engineers who design embedded systems. He has involved undergraduate students in the research project and introduced a new undergraduate course last fall called Hardware/Software Codesign. He is also working on a team that is developing a freely available CD-ROM for undergraduates that includes a codesign environment and tools.

"Hardware/software codesign has typically been a graduate-level topic, however we want our undergraduates to be able to compete on a global scale and be capable of designing complex embedded systems," he says. Schaumont plans to develop an additional course at the graduate level focusing specifically on secure embedded systems.

"We want engineers to develop a sense about how to build secure embedded systems and to understand what is breakable and what is not."



TACKLING THE MYSTERY:

THE MONO VIRUS

Many people know infectious mononucleosis (mono) as the disease of fevers, sore throats, and fatigue that can rob students of entire semesters. Medical researchers know mono as the disease caused by the Epstein-Barr virus (EBV)—one of the oldest, most common human viruses.

By age 45, about 95 percent of all adults have been infected, according the U.S. National Center for Infectious Diseases. EBV is a tenacious virus that can maintain a lifelong, persistent infection in healthy people. Researchers know it 'hides out' in healthy people, but what triggers it to go from 'sleeper agent' to an infection that spreads to other individuals is still unknown. (*Continued on p. 12.*)

ECE's Paul Plassmann—along with Mark Jones and a team of graduate students—is working with researchers from Tufts University to understand the dynamics of EBV; how it interacts with human cells and organs over time. Using supercomputers, they are developing a simulation that researchers hope to use to model the behavior of the virus at the cellular level in a human body.

"We just can't watch cells interacting over time in a human body," Plassmann says. Given the impossibility of observing the virus infecting people, a simulation testbed is the only solution for such situations, he says, adding that biologists have coined a term for it. "They call experiments in living tissue 'in vivo,' experiments in the laboratory 'in vitro,' and now, experiments using computer simulations, 'in silico.'"

> *"The more we can do with simulation, the more we can help to find ways to improve people's health."*

The mystery

Viruses typically target certain kinds of cells and particular organs, he explains. "EBV hangs out in the tonsils." Specifically, EBV targets naïve B-cells, which are part of the body's adaptive immune response system. An EBV-infected naïve B-cell then goes through the "germinal center process" and fools the body's immune system into thinking that the infected cell is real memory B-cell. "It then hides out in the adaptive immune system's memory compartment. For unknown reasons, these infected B-cells occasionally are activated and become 'lytic.' In the lytic phase, the virus reproduces, destroying the original cell and producing free virus, which can infect other B-cells or leave in the saliva to infect other people."

After the initial acute phase of the infection, EBV survives in the body at a constant rate of about 5 in a million cells. The mystery, Plassmann says, is how EBV cells remain at a constant population under the radar of the body's immune system. "Biologists do not know how long an infected B-cell lives," he explains. "It could be as short as a week. At some point, the cell has to reproduce or go lytic and infect other cells." When people develop mono, as much as 50 percent of their memory B-cells become infected and destroyed by the immune system, causing the familiar symptoms.

Simulating extraordinary complexity

Simulating a live biological process is extraordinarily complex. The simulation models cells, viruses, and other biological objects as agents and simulates their motion and interaction through the solution of stochastic differential equations. Each agent has an internal state, which can be modeled as a finite state machine or ultimately by chemical pathways that will involve hundreds of states and thousands of transitions. The real computational challenge, however, is with the number of cells. "We are modeling hundreds of millions to billions of cells," Plassmann explains. "The time step for the simulations is on the order of minutes, but we want to see what happens over a span of months or years." The simulations easily get into the teraflop to petaflop range (greater than 10^{12} to 10^{15} floating point operations per second), which is the edge of what is possible with today's fastest machines, he says.

Such simulations typically require supercomputers, or parallel computers, he says. Plassmann uses machines with between 200 and 400 processors. An interesting new development in computer engineering is that number of cores per chip is rising quickly, "so we will have to develop the algorithms and software that can take advantage of these massively multi-core architectures," he says.

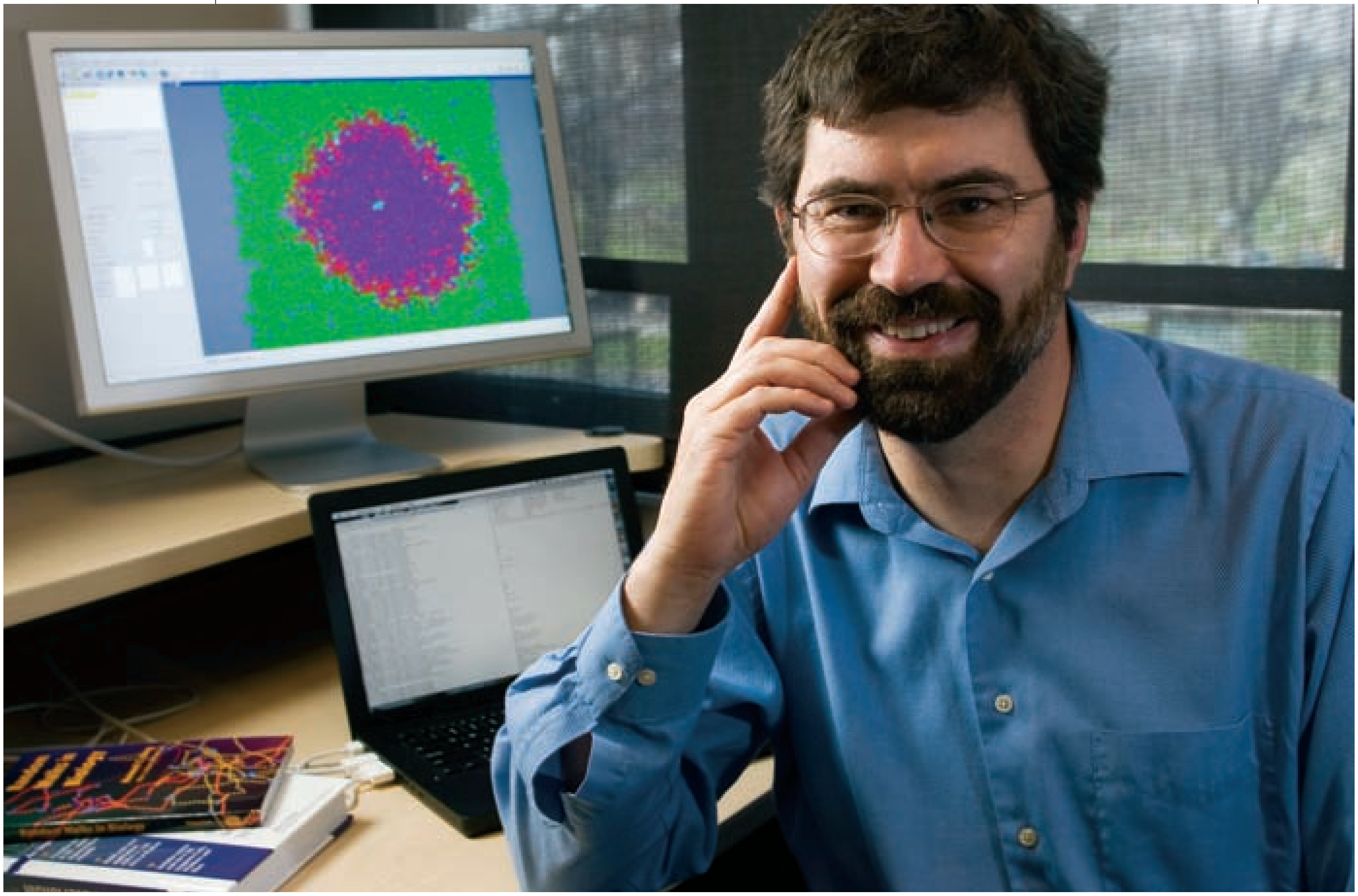
Another complicating factor is that the reactions and dynamics involve different time scales, creating a multi-scale problem. "There is a slower time scale where we model the motion and interaction between cells," Plassmann explains. "However, where we model the chemical pathways inside a cell, things happen on a much faster time scale. The trick is to have the simulation move at the longer time scale of the cells, while accurately representing what is happening at the shorter time scales," he says.

Borrowing from combustion

The team is using some ideas from their experience in combustion modeling. In combustion, the fluid mechanics happens at the slow time scale (millisecond time scale) and the chemistry happens at the fast time scale (nanoseconds). "The observation is that similar chemistry calculations are done repeatedly. So, rather than redoing them, we store the results of these calculations in a 'scientific database' and approximate subsequent chemistry calculations based queries to this database. This approach has enabled speedups in combustion simulations of 100 to 1000 times, Plassmann says.

While Plassmann enjoys the challenge of multi-scale simulations, he says the most fun is working with people in other fields on predictive capabilities. "In my work on EBV, I'm working with experimentalists. Their experiments look at understanding the specifics of particular cellular transitions, interactions, or properties. However, the simulation is the 'whole picture' and gives an experimental biologist a chance to see how these specific properties affect the

Paul Plassmann is developing simulations to help solve the mystery of the latent infection of the Epstein-Barr virus that causes mono. The screen behind him, and the image on page 11, show a cross section of a simulation of a germinal center—an active area of the tonsils used by the adaptive immune system to develop memory B-cells.



complete biological system. In the predictive mode, a biologist can now ask the question, 'if I can experimentally change a specific interaction (by, for example the use of a drug) how will that affect the entire system?'"

The give-and-take between biologists and engineers is fun, he says. "There are many things we discover that they don't know, but are necessary for an accurate simulation. For example, how long does a memory B-cell live? Where does it divide? They don't know. And you can't track a memory B-cell around the body in vivo. You might have a picture of the germinal center, but that's just a snapshot." Germinal centers are areas of activity that develop dynamically after the immune system activates B-cells. And ultimately one has to be able to understand these dynamics to get to the bottom of latent EBV infection.

"Together, we design experiments to get the information we need. Then we see how the results map to what they already know … The neat thing about this is once we figure out how the germinal center works, we have a model that can be used for predictive purposes. There is no way they can get that without our simulations."

The team is discussing similar models for other biological systems, he says, such as modeling influenza infections of the lungs. They are in discussions with one group about developing models for H5N1, the bird-flu virus. Another potential project involves modeling the T-cell response to dioxin in the environment.

Plassmann says the hope is to develop a general simulation framework that can make big contributions to research in systems biology. In biology, for example, "the more we can do with simulation, the more we can help to find ways to improve people's health."

IS AN ENERGY ROUTER in your future?

Imagine a device that automatically detects demand for power and delivers processed electricity in the required form (AC or DC) at the correct voltage and frequency. Energy routers, analogous to the familiar data and communications routers, could improve reliability, efficiency, and safety at every level of the electrical power system.

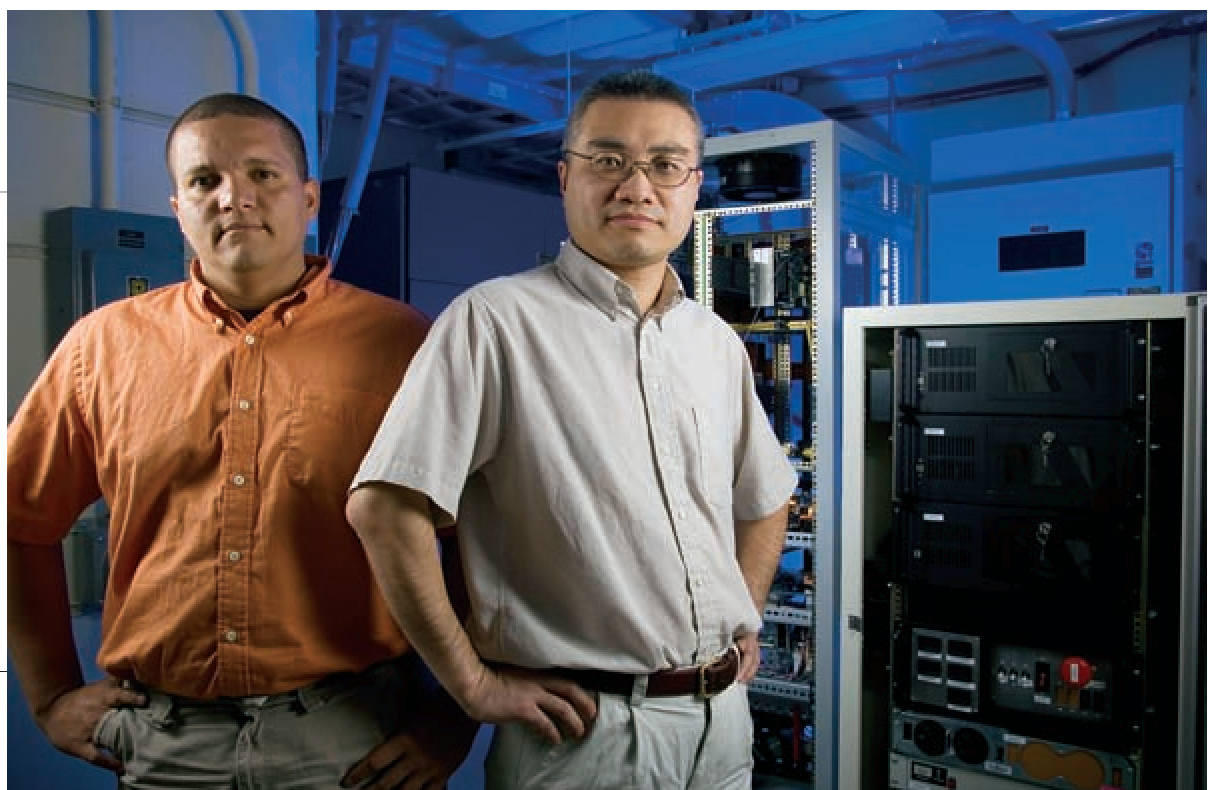
Ships, aircraft, and land vehicles could be made smaller, lighter, and more fuel-efficient. Businesses, factories, and even homes could better use greener and more efficient energy sources and loads, such as different equipment and appliances with variable-speed motors. The power grid could employ intelligent energy routers to quickly isolate problems while still providing necessary power.

Energy routers are still a concept, and their true realizations may be years in the future, but they are a dream of many power electronics researchers today. According to Fei (Fred) Wang, an associate professor of electrical engineering, at the heart of the concept are the electronic power distribution systems promoted by the Center for Power Electronics (CPES), an NSF Engineering Research Center led by Virginia Tech.

"It's a long-term goal, but in the end, your power electronic converter will be an energy router," he says.

Smaller, lighter high-power

Wang's interest in the concept evolved from his work in high-power electronics—developing electronic circuits to convert and control electricity in systems that range from tens of kW to megawatts of power.



Luis Arnedo (left) and Fei (Fred) Wang in the High Power Laboratory at the Center for Power Electronics Systems. Behind them is a "plug-and-play" modular converter and beside them is a converter system testbed.

The team led by him and his colleagues at CPES is currently focused on improving the power systems of jets, ships, land vehicles, mini-grids, and even oil rigs. The team is not only engineering high-density power converters, but also designing the architecture and concepts that will help control and operate the high-power electrical systems of the future.

In high-power applications, the motivation for developing higher density power converters springs from a drive toward greater fuel efficiency, a desire to use less materials, and a need for increased usable space, Wang says. For example, the team is working with Boeing on an advanced motor drive system for potential aircraft use. "The goal is that it be lightweight and compact," he says. "To make these systems smaller, we must use advanced technology, like better semiconductor and magnetic materials, better capacitors, better cooling and packaging, new circuits, and new controllers."

"The problem is that everybody is hand waving, but nobody has an analytical tool."

Part of the solution was using advanced silicon carbide (SiC) switches that are not yet commercially available. "SiC can operate at 300°C, whereas silicon can only work up to 150°C. That is a big difference and means we need less cooling and a smaller heat sink." SiC also has lower loss and allows very fast switching enabling the design to reduce other components, such as capacitors and inductors, he says. "Every component we eliminate equals a savings in space and weight."

CPES is working on a variety of projects with other aircraft firms, including Rolls Royce, General Electric (GE), and SAFRAN. Much of the focus involves technology for the more-electric aircraft. The aircraft retain their fuel engines, but from that point onward, the goal is for all the subsystems to be electrical. Power density and reliability are key requirements for such a system.

The U.S. Navy has similar goals for its ships. "The Office of Naval Research (ONR) has been funding research on the all-electric ship, for, among other things, the reduced size and weight," Wang says. "We are looking at everything after the generating plant. This means we are trying to get rid of bulky, inefficient mechanical and hydraulic equipment. To do that, however, we need a family of high density power converters as large as 100 MW." Because the goals are also to reduce size and weight, the CPES team is collaborating with industry and national labs and studying the potential use of SiC devices for these converters, he says.

Transforming the entire system

Developing the individual electronic components—no matter how large—is only part of the story, Wang says. "When we put all these converters together, how can we make sure they work together in an optimal way?"

Conventional high-power systems employ generators, motors, transformers, and mechanical devices to process electricity, he says. "Now, we are talking about systems with a high penetration of electronic power converters. Power converters have much faster dynamics than traditional equipment. They are also highly nonlinear. This is good and bad."

Electronic converters are intelligent and fast, but they generate a lot of noise. This can result in poor power quality and electromagnetic noise interference. "We are now studying these system issues. We need to understand the interactions for systems to work in an optimal way," Wang says. Although the research is still at an early stage, he is already talking about "getting rid of the bulky stuff," like mechanical protection devices and breakers.

CPES has conducted power architecture studies for server, data center, aircraft and ship power systems, and is currently investigating a power system for offshore oil drilling. "Traditionally, these oil rigs use pneumatic power, but they want to use electric. How do you design that?"

Another project, for the NSF, involves designing a distributed generation microgrid for electric utilities. "Today the grid is slow and based on electromechanical inertia. There is so much inertia that it doesn't crash easily," Wang explains. "Once we have electronic converters, they will operate so fast that we will no longer have inertia in the system. We will maximize utilization, but we need to make sure that while working fast, our system can also react fast."

Whether for offshore drilling, vehicles, or power grids, the questions can be as basic as whether to use AC or DC power, and at what voltage, he says. "The problem is that everybody is hand waving, but nobody has an analytical tool." CPES wants to develop a fundamental tool that uses scientific evaluation and provides engineers with the ability to model, analyze, and control the power in the most efficient manner possible.

Once we have a raw form of electricity, how do we convert it to what we need? Wang and his CPES colleagues believe that future systems will be electronic power distribution systems, consisting of three types of power converters: source converters tied to the generating source, distribution converters for power delivery, and load converters for the dedicated use. The ultimate answers to getting the right form of power when needed may transform the whole system. One of those changes may be energy routers. Imagine life without wall warts …

RENAISSANCE MAN of the acoustic waveforms

David Gagnon (EE '07) came to Virginia Tech in 2002 intending to major in electrical engineering. But his diverse interests kept complicating his academic life. He will graduate this May with a double major in EE and music and a minor in mathematics, with a load of research projects on his resume. He's also principal cellist with the New River Valley Symphony.

For graduate school, Gagnon may add another subject area to the mix. He's being courted by two graduate programs—architecture at Rensselaer Polytechnic Institute and physical acoustics at the University of Texas at Austin.

"I love learning," he says. "A lot of topics intrigue me."

Gagnon added the mathematics minor because he enjoys it. He added music because he loves it and has played with the New River Valley Symphony for five years. An honors student, Gagnon started pulling his interests together with the Horton Honors Scholarship, which financed a trip to study the acoustics of European concert halls. Attending performances in Salzburg, Austria's 2,179-seat Festspielhaus during Salzburg Festival trained his ear in a way that performance never had, Gagnon says.

"When I'm on stage, I don't get to hear a lot of what goes on in the concert hall," he says. "In Europe, I compared venues

David Gagnon (EE '07) is also a music major and has a mathematics minor. He is interested in music acoustics—analyzing and characterizing the sounds of music.

and noticed how the dimensions of the building effect sound clarity and echo."

Now he's thinking about a career designing concert halls and achieving good acoustics for various types of performances. His senior honors thesis also involves music—analyzing and characterizing sound waves of music. He's investigating how the sound changes as it bounces off materials of different absorptive values and how echoes show up in the audio signal. He's also interested in characterizing music waveforms so music genres can be automatically catalogued and retrieved by computer.

"Our brains are so complex; it's a challenging task to have the computer listen to notes and figure out what type of music it is," he says. "The beat histogram, for instance, can give a lot of information about the type of song. Classical music can be speedy or slow, and the beat is not strong; it produces a blurry histogram. A techno song, on the other hand, has a strong rhythm."

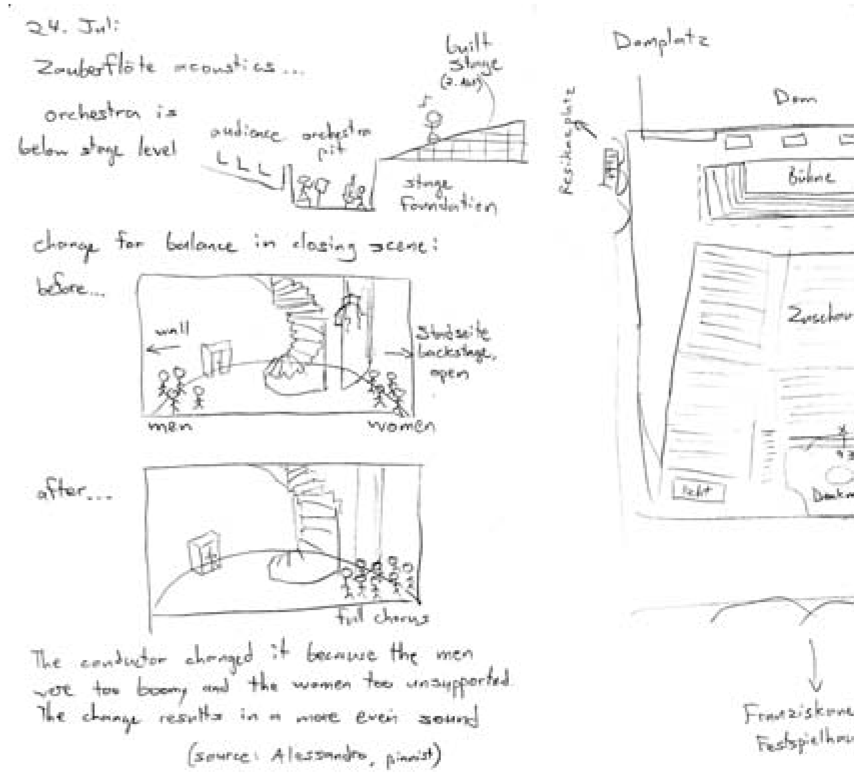
Gagnon is also looking at the timbre of different musical instruments—the tonal character and changes over time—and analyzing the waveform. In one test, he will play his cello in a studio with a friend on a euphonium, which has a different range, to determine whether his characterization program is only good for one instrument.

His engineering experience will have a major role in the study as well. Gagnon is using MATLAB to analyze the wave file of the music.

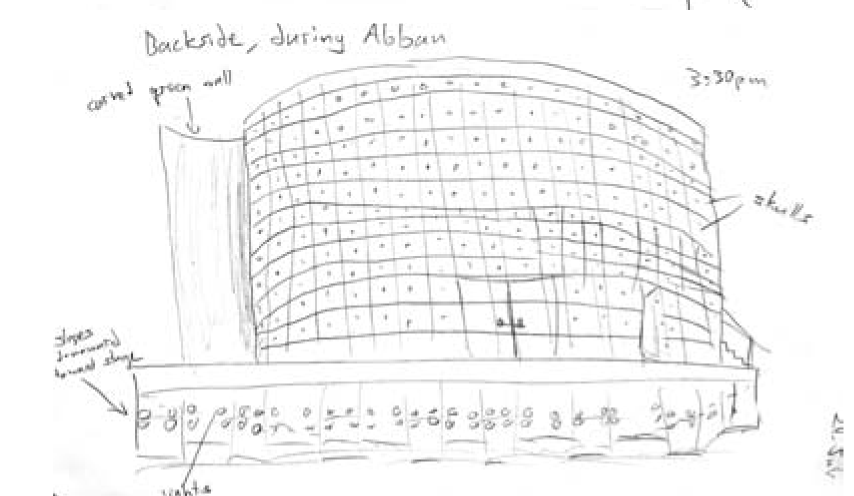
Gagnon is familiar with the data acquisition involved in research projects; he has participated in two separate REU (Research Experience for Undergrads) programs under the auspices of the National Science Foundation. In the first, at Central Florida University, he worked with ultra fast lasers. Gagnon spent last summer at Penn State, where he was involved with testing the conductivity of "graphene" thin carbon films, which have "cool, unusual properties" and the ability to conduct electricity well.

"I've just picked things that interested me during my college career," he says. "I have a lot of things I want to learn. That means I go from musical theory class over to the engineering building for antenna design. Electromagnetic waves are similar to those in acoustics. These things are very exciting to me."

—By Su Clauson-Wicker



Gagnon spent the summer of 2005 visiting and sketching the acoustic environments of Europe's major concert halls.



BIOMEDICAL APPLICATIONS

FACULTY

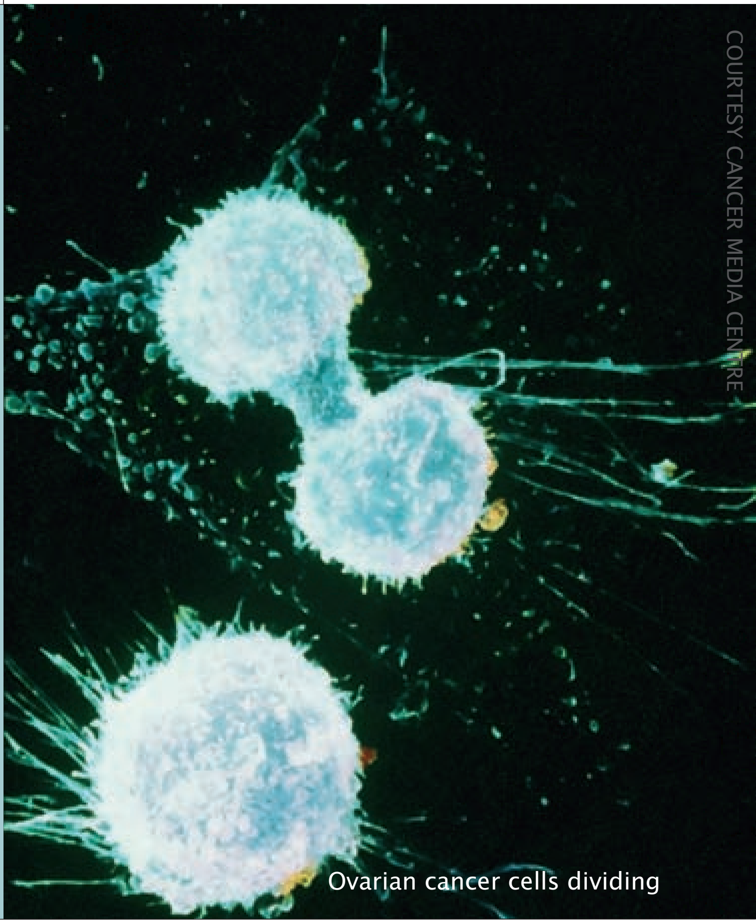
Masoud Agah
Peter Athanas
William Baumann
Amy Bell
Louis Beex
Gary Brown
Michael Buehrer
Richard Claus
William Davis
Mark Jones
G.Q. Lu
Tom Martin
Kathleen Meehan
Paul Plassmann
T.-C. Poon
Joseph Tront
Anbo Wang
Yue (Joseph) Wang
Chris Wyatt

Understanding ovarian cancer drug resistance

ECE researchers are collaborating with researchers from Johns Hopkins University School of Medicine to develop an integrated systems biology approach to study ovarian cancer drug resistance. Ovarian cancer is the fifth leading cause of cancer death among women in the United States and up to 80 percent of patients diagnosed at advanced stages die within five years.

In many cases, the patients initially respond to chemotherapy but later relapse with recurrent tumors that are resistant to the therapy. The Johns Hopkins researchers have produced a cell line model for which they can reversibly turn on and off the cell's drug resistance.

Stimulating this simple biological system with relevant inputs and observing the dynamic response of the protein levels within the cells will provide data that the ECE team will use to build models of the signaling and regulatory networks that are responsible for drug resistance. These models will then be validated experimentally and ultimately used to more precisely target drugs to improve the long-term survival of patients.



COURTESY CANCER MEDIA CENTRE

Ovarian cancer cells dividing

The key risk factors in cardiovascular disease

The Computational Bioinformatics & Bio-imaging Laboratory, in collaboration with the medical team at the Wake Forest University School of Medicine, is working on a genome-wide association study to identify an individual's risk of cardiovascular disease from the joint effects of multiple genetic factors.

Although there are a number of studies underway to collect genetic data from individuals with cardiovascular diseases, the analysis of these massive data sets to identify the key risk factors and their interactions is a critical but unsolved problem. The staggering number of possible combinations of factors that must be considered, coupled with the probable nonlinear nature of these interactions, makes this problem immensely complex.

Using recent advances in machine learning, such as support-vector machines, conditional mutual information, and cluster computing, Joseph Wang and his colleagues expect to make significant advances over conventional techniques that rely on linear models and simple interaction terms. Ultimately, this work will enhance the ability to predict, treat, and prevent cardiovascular disease.

The ability to identify individuals with a genetic predisposition for disease will allow for more effective preventive interventions, including modifying environmental exposures that have been shown to interact with the genetic predisposition to increased disease risk.

WINDOWS to the brain

Does changing white matter in the aging brain affect cognitive function? Do the effects of alcohol abuse on the brain begin early in the abuse process? Does childhood exposure to stimulants such as methylphenidate (Ritalin) predispose adolescents to developing substance abuse disorders?

These questions are being investigated using image analysis tools developed by researchers in the Bioimaging Systems Laboratory. The laboratory is a joint effort between ECE and the Virginia Tech/Wake Forest School of Biomedical Engineering and Sciences to accelerate the use of imaging and image analysis in biomedicine. Much of the work is done in collaboration with clinical and basic science researchers at the Wake Forest School of Medicine and the Virginia-Maryland Regional College of Veterinary Medicine.

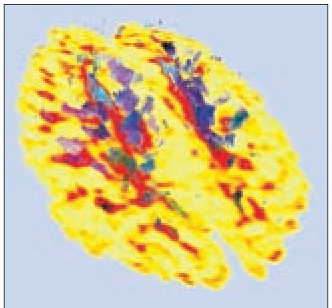


Image estimate of density and direction of white matter connections in a brain.

The nerve fibers that transmit signals long distances within the brain constitute the white matter. As adults age, they can develop patchy white matter lesions, which are referred to as leukoaraiosis (LA). These lesions appear as hyperintensities—or higher contrast spots—in radiologic imaging. LA lesions create a problem for researchers studying how the brain changes with age, as current image registration methods do not perform effectively in regions where tissue contrast has changed.

ECE's Chris Wyatt is developing a new registration approach that can accommodate contrast changes and determine whether the LA changes in white matter correlate with changes in cognitive function. The project is funded by UCLA's Center for Computational Biology (CCB) and the U.S. National Institutes of Health (NIH).

Investigations into the effects of alcohol and stimulants on the brain are underway in conjunction with research at Wake Forest; also funded by the NIH. The ECE team will apply cutting-edge image analysis techniques used in humans to primates, such as macaques or Rhesus monkeys.

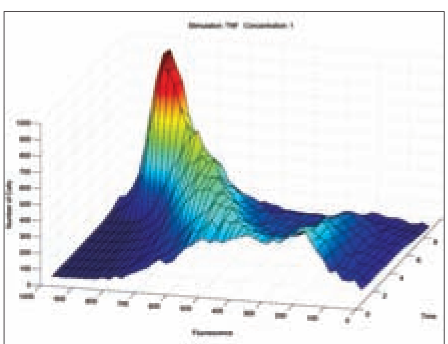
The alcohol abuse study seeks to understand whether the effects of abuse begin early in the process. Most of what is known of alcohol's effects on the brain is based on studies of individuals who have abused for a long time. Human studies are also complicated by factors including non-alcohol drug abuse, poor nutritional states and other medical conditions.

Although most studies of children and adults with ADHD have suggested that medication with methylphenidate or amphetamine has either no effect or can be protective from substance abuse, it is impossible to distinguish between the effects of the stimulants and the ADHD itself, according to Linda Porrino, professor of physiology and pharmacology at Wake Forest. "Given that these stimulants can produce dramatic changes in the brain's dopamine system, the question of long-term adverse consequences still remains," she says. The studies on non-human models are designed specifically to answer whether or not stimulant exposure can predispose adolescents to developing substance abuse disorders.

Applying system identification to biology

The successful sequencing of the genome for humans and other organisms has provided a "parts list" for these cells, but how these parts function and interact is largely unknown. Understanding these networks in human cells will help us better understand the nature of many diseases and point the way to more effective medical interventions. In microbes, this knowledge can aid in engineering designer bugs that can help with waste remediation or energy production.

Deducing the structure and dynamics of the biochemical networks that control life at the cellular level is of the major goals of systems biology. From an engineering perspective, this work falls into the area known as system identification.



The probability over time of an HIV response to a transcription stimulation.

What makes system identification of biological systems so difficult is the sheer complexity of the systems, the fact that they are highly nonlinear, and the difficulty of providing inputs and measuring outputs of the system. Researchers cannot just hook up a function generator and an oscilloscope, as they might to analyze a radio circuit.

ECE's William Baumann, is working in collaboration with Jean Peccoud of the Virginia BioInformatics Institute, John Tyson of biology and Joseph Wang (ECE) on methods to identify these systems. To understand the basics of this problem, they are measuring the responses of synthetic gene networks engineered in bacteria. In this case, where the network can be built up and measured step-by-step, it is possible to verify our techniques and understand the limits of our models. At the next level of complexity, they are looking at stochastic modeling of the cell cycle in yeast and the incorporation of new data from measurements of protein levels in single-cell organisms. At the highest level of complexity, they are investigating the use of gene and protein expression data to model networks of genes involved in diseases such as breast cancer and muscular dystrophy.

COMPUTER SYSTEMS

FACULTY

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Michael Hsiao
Chao Huang
Mark Jones
Tom Martin
Leyla Nazhandali
Jung-Min Park
Cameron Patterson
JoAnn Paul
Paul Plassmann
Binoy Ravindran
Patrick Schaumont
Sandeep Shukla
Joseph Tront
Chris Wyatt
Yaling Yang

FPGAs can finally adapt without external control

Ever since the introduction of Field-Programmable Gate Array (FPGA) technology in the mid 80's, people have imagined computers that could evolve and adapt to changing conditions without requiring external assistance. That dream has come closer to reality as ECE researchers have demonstrated the first known instance of a system changing its own hardware in a non-trivial fashion while continuing to run.

A team in the Configurable Computing Laboratory (CCM) has demonstrated an embedded system that is able to interactively implement new circuits inside itself or remove or reconnect existing circuits. The system was developed by Neil Steiner, a Bradley Fellow and Ph.D. candidate, working with his advisor, Peter Athanas.

By folding low-level design tools into a demonstration system, the team has made it possible for computers to participate in their own design. "If our system finds defects within itself, it can simply avoid using the damaged resources," Steiner said. "This capability is much more cost-effective than throwing away large, but imperfect chips."

Internal modeling and design tools also allow the system to function at a higher level of abstraction than previous FPGA systems. Instead of requiring a configuration bitstream that supports a specific FPGA model, the proof-of-concept system can accept circuit netlists in the widely popular EDIF format. These circuits are then placed, routed, configured, and connected to other circuits inside the system, without interrupting its operation. The same EDIF netlists can be used for any device in the same FPGA family, which ensures that designs remain more portable.

The current research falls within a proposed roadmap for autonomous computing systems—systems that are able to function more independently and assume responsibility for their own resources and operation, according to Steiner. The next step is to include a synthesizer within the system, so that it can accept behavioral circuit descriptions in high-level languages like VHDL or Verilog. "The most ambitious levels on the autonomy roadmap describe systems that can adapt to changing conditions and even learn from experience, a prospect that is not as far-fetched as it sounds," he said.

Steiner credits his Bradley Fellowship and support from Xilinx, the leading FPGA manufacturer, in enabling his research to push the envelope to show what can be accomplished with current technology. "FPGAs have taken on important and well-deserved roles in modern systems, but we have shown that the early dreams are still viable," he said.

Wires on Demand: AIDING THE USE OF FPGAS IN SDR

A CpE team is creating middleware that allows software applications to easily use a dynamically loaded library of functions implemented in FPGA hardware. The "Wires on Demand" technology will enable greater use of FPGAs in software-defined radio (SDR) applications.

"FPGAs are ideally suited to the DSP requirements of software radios," said Cameron Patterson, who, with Peter Athanas, serves as a faculty member on the project. "However, it is difficult to change SDR waveforms at run time," he said. In current reconfigurable approaches, the inter-module communication structure usually remains fixed, which in software-defined radio applications, limits logic and routing resource efficiency.

Reconfigurable applications development is daunting for software radio designers, largely because inter-module communication requires low-level physical design, he said. "The designers must learn more about the FPGA architecture and tools than they ever want to know. Run-time reconfigurable application design would be much easier if module communication circuitry was automatically synthesized." Routing should be optimized between modules as much as within a module and avoid the use of buses, on-chip networks and crossbar switches with their significant latency, area and power overheads, he said.

With the team's approach, choosing the module's coordinates and completing connections to other modules are run-time operations. A library of relocatable partial bitstreams is created, which is used by the run-time system to complete application requests for instancing and connecting modules.

Bradley Fellow alumni Mark Bucciero and Jonathan Graf, both of Luna Innovations, are on the project, along with graduate students Kipp Bowen, Tim Dunham, Matt Shelburne, Jorge Suris, and Bradley Fellow Justin Rice. The project is sponsored by the Air Force Research Laboratory.

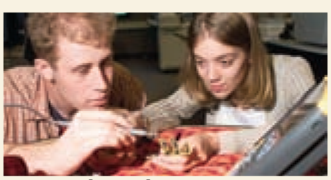
ECE joins new NSF center for reconfigurable computing

ECE's Configurable Computing Laboratory, directed by Peter Athanas, is part of a new NSF Center for High-Performance Reconfigurable Computing (CHREC, pronounced "shreck").

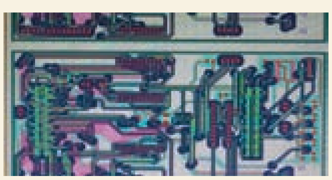
The new center, headed by the University of Florida, includes The George Washington University, Virginia Tech, and Brigham Young University. CHREC is the nation's first multidisciplinary research center in reconfigurable high-performance computing and is part of the NSF Industry /University Cooperative Research Centers (I/CURC) program.

Including the university partners, about two dozen organizations comprise CHREC, ranging from the Air Force Research Laboratory to the Aerospace Corporation. Shawn Bohner of computer science is the Virginia Tech lead and co-director of the Center. Joining Bohner and Athanas are computer science faculty members Wu-Chun Feng and Francis Quek.

e-Rug: The e-Textile Laboratory is incorporating electronics into large surface areas, such as rugs and draperies. The rug prototype shown here was made with readily available electronic yarns and is being used as a testbed for tracking human gait. The rug lights up when the sensors are activated and has potential uses such as tracking people in low-visibility situations or directing traffic during evacuations.



e-Textile Laboratory
Contacts: Mark Jones,
Tom Martin
www.ccm.ece.vt.edu/etextiles/



Configurable Computing Laboratory
Director: Peter Athanas
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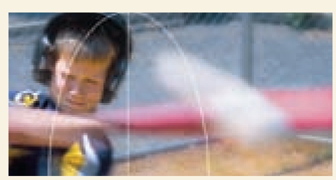
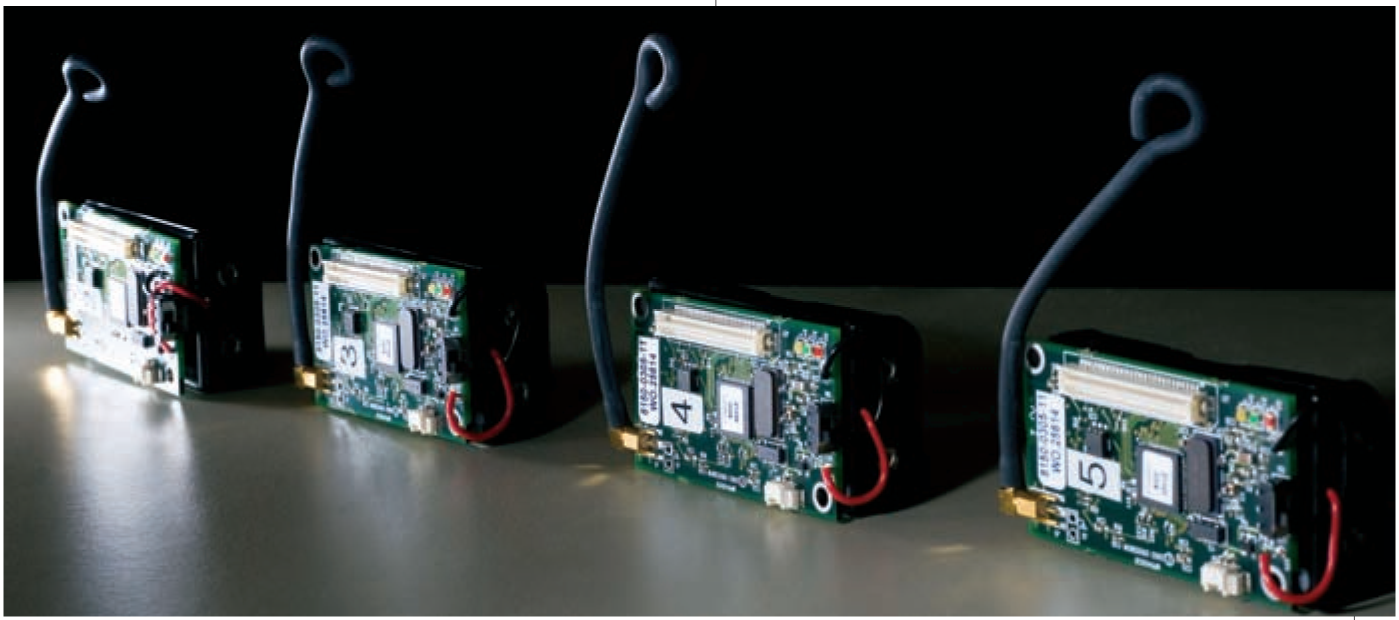


Real Time Systems Laboratory
Director: Binoy Ravindran
www.real-time.ece.vt.edu

NETWORKING

FACULTY

Luiz DaSilva
Mohamed Eltoweissy
Thomas Hou
Yao Liang
Allen MacKenzie
Scott Midkiff
Amitabh Mishra
Leyla Nazhandali
Jung-Min Park
Binoy Ravindran
Yaling Yang



Motes—test platforms for low-power, limited resource systems—in the Laboratory for Advanced Networking (LAN) are used to test network vulnerabilities.

Wireless sensor nets vulnerable to denial-of-sleep

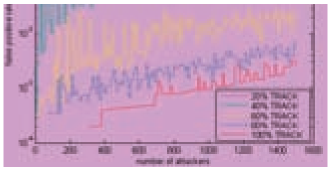
According to research in ECE's Laboratory for Advanced Networking (LAN), the medium access control (MAC) protocols of state-of-the-art wireless sensor networks (WSN) are susceptible to denial-of-sleep attacks that can reduce network lifetime from years to days.

"Like other networks, sensor networks are vulnerable to malicious attacks," said Ph.D. candidate Lt. Col. David Raymond (U.S. Army), who conducted the study with his advisor, Scott Midkiff. "However, their limited resources make these devices particularly vulnerable to denial-of-sleep attacks."

The sensor platforms typically use 8-bit processors, less than 8 kb of RAM, and 100 kb of program memory. "Not only are they more sensitive, but because of their hardware simplicity, defense mechanisms designed for traditional networks are not feasible," he said. The team identified features of WSN MAC protocols that increase vulnerability to denial-of-sleep attacks, then analyzed the impact of attacks tailored to these vulnerabilities.

"With full protocol knowledge and an ability to penetrate link-layer encryption, all WSN MAC protocols examined are susceptible to a full domination attack, which reduces network lifetime to the minimum possible by maximizing the power consumption of the nodes' radio subsystem," he said. "Even without the ability to penetrate encryption, subtle attacks can be launched that reduce network lifetime by orders of magnitude."

The team is working to design and implement mechanisms to prevent or mitigate the impact of these attacks. As WSNs grow less expensive, the potential for widespread use in applications from health monitoring to military sensing continues to rise, he said.



Advanced Research in Information Assurance and Security
Director: Jung-Min Park
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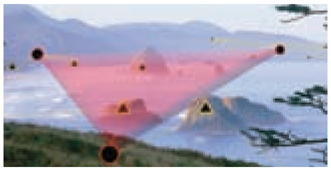


Complex Network and System Research Group
Director: Thomas Hou
www.ece.vt.edu/thou/CNSR

Laboratory for Advanced Networking
Director: Luiz A. DaSilva
www.irean.vt.edu/lan

1st-ever ad hoc networking contest set

In November, Virginia Tech is launching a first-of-its kind competition for students and researchers in mobile ad hoc networking. Called the MANIAC Challenge (Mobile Ad Hoc Networking Interoperability and Cooperation), the competition will be held in conjunction with IEEE's Globecom 2007, November 25-26 in Washington, D.C.

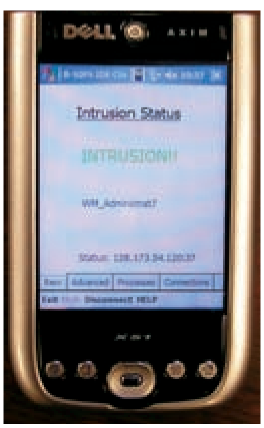
Competing teams will come together to form a large (estimated 30-50 node) ad hoc network. The organizers will create and send traffic to each team. Teams will be judged based on how much of the traffic destined to them makes it through the network, how little energy they consume in forwarding traffic, and a subjective evaluation of the quality of their solution's design. To get their traffic across the network, each team must rely on other teams' willingness to forward traffic for them, according to Luiz DaSilva, who with Allen MacKenzie is organizing the project with funding from the NSF.

The two-in-one effort is aimed at meeting educational and research goals of improving network throughput, deepening understanding of overall network behavior, and motivating students in the field. For more information, see www.maniacchallenge.org.

Battery-sensing intrusion system for mobile computers

Using a dynamic threshold calculation algorithm, a CpE team has developed an attack-detection system for mobile computers, which alerts users when battery power changes are detected on handheld wireless devices, such as PDAs and smart phones.

Hosts enabled with the battery-sensing intrusion protection systems (B-SIPS) are employed as sensors in a wireless network and form the basis of the intrusion-detection system (IDS). "When a small mobile device is kept in a high activity state for extended periods of time, the battery resources are depleted faster than normal, decreasing its charge life," explained Timothy Buennemeyer, a Ph.D. candidate on the project. "Our system not only alerts the user, but it also provides security administrators with a nontraditional detection capability that is scalable and complementary in a network environment with existing commercial and open system IDSs." Irregular and attack activity is detected and reported to the intrusion detection engine for correlation with existing signatures and further investigation.



TIM BUENNEMEYER

An analytic model was developed to examine the smart battery characteristics to support the theoretical intrusion-detection limits and capabilities of B-SIPS. The dynamic polling rate algorithm allowed the smart battery to gauge the network's illicit attack density and adjust its polling rate to more efficiently detect attacks and conserve battery charge.

The team is currently developing a device-profiling and attack matching capability, and a usability study is being conducted. Buennemeyer is working on the project with fellow graduate student Theresa Nelson, Professor Joe Tront, and Randy Marchany, director of Virginia Tech's IT Security Laboratory.


U.S. Air Force

AIRBORNE NETWORKS
Creating a mesh in the sky

Researchers in electrical and computer engineering are designing routing protocols for airborne networks, a technology that provides reliable communication between aircraft, unmanned aerial vehicles (UAVs), and other airborne assets.

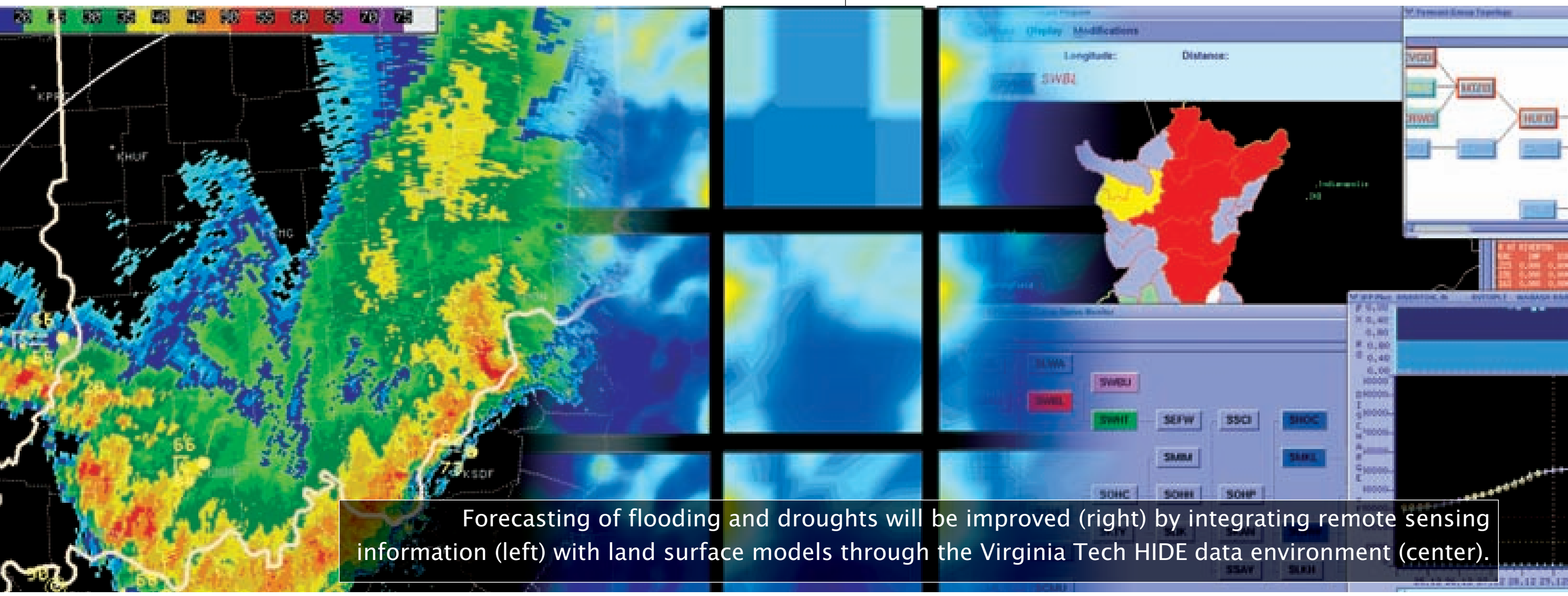
Airborne networks arise naturally in military scenarios, search-and-rescue operations, and even potentially in civil aviation. Ensuring that airborne platforms can communicate effectively without necessarily relying on ground relays is a major objective in this area.

Luiz DaSilva and graduate student Bo Fu are working with a team from SCA Technica, Inc. as part of an Air Force Research Lab SBIR project. The team is developing mechanisms that will overcome routing challenges in networks of high-speed nodes through the use of location awareness and disruption tolerant network techniques. Inspired by the idea of mesh networks, wireless networks of ground nodes that sometimes cover an entire city. They are proposing to opportunistically create a mesh in the sky, with underlying robust mechanisms that address the particular challenges of airborne platforms.

SOFTWARE & MACHINE INTELLIGENCE

FACULTY

Lynn Abbott
Robert Broadwater
Mark Jones
Pushkin Kachroo
Yao Liang
Cameron Patterson
Paul Plassmann
Binoy Ravindran
Sandeep Shukla
Yue Wang
Chris Wyatt
Jason Xuan



Forecasting of flooding and droughts will be improved (right) by integrating remote sensing information (left) with land surface models through the Virginia Tech HIDE data environment (center).

Hydro-informatics for floods, droughts

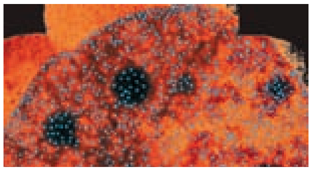
Technology developed in ECE laboratories is serving as the foundation of a new effort to improve flood and drought forecasting in the Ohio River Basin.

"Floods and droughts are two major natural hazards in the Ohio River Basin, and they have major impacts on the region's agriculture, industries, commercial navigation, and residential communities," said Yao Liang, an assistant ECE professor at the Advanced Research Institute (ARI) and principal investigator (PI) on the effort. "There are data and models available from different sources and different systems, that, if integrated, can significantly improve forecasting accuracy and help disaster management."

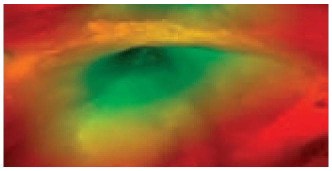
The integration effort stretches across universities and government organizations, including the National Weather Service (co-PI Thomas Adams is a Virginia Tech alumnus), George Mason University, the University of Pittsburgh, and NASA Goddard Earth Sciences Data Information and Services Center.

The team is developing a system to integrate soil moisture data from NASA satellites and NASA-NOAA land surface models, and a spatial data assimilation framework recently developed at the University of Pittsburgh into the National Weather Service River Forecast System. Surface soil moisture data from multiple satellites in conjunction with the NASA-NOAA models and the data assimilation framework will significantly improve the evapotranspiration rate calculation, which plays a critical role in the river forecast system. The integration will be achieved by extending the hydrological integrated data environment (HIDE) developed by Liang and Nimmy Ravindran.

"Our ultimate goal is to enable the National Weather Service to seamlessly avail itself of the soil moisture data, that was previously unavailable," Liang said. The project results are expected to be extendable to the national level, via the adoption of the system by river forecast centers at both national and regional levels. The $860,499 project is funded by NASA.



Computational Bioinformatics & Bioimaging Lab
Director: Yue Wang
www.cbil.ece.vt.edu



Computer Vision Laboratory
Director: Lynn Abbott
http://vision.ece.vt.edu/

BioImaging Systems Laboratory
Director: Chris Wyatt
www.bsl.ece.vt.edu

Finding Faces at Any Angle

Many applications today would benefit from an ability to pick out human faces automatically among other elements in a color image. These include systems that perform face recognition, systems that track faces for videoconferencing or human-computer interaction, and surveillance systems. Unfortunately, both face detection and face recognition are very difficult computational problems, although the human visual system makes it seem easy. The challenges include variations in illumination, size and orientation changes, occlusion, and skin color.

An ECE team has developed a new technique that detects faces based on variations of skin tone, as well as shapes of skin-colored portions of an image. The system does not explicitly attempt to locate face-related features such as noses and eyes. The system relies on an unusual combination of two techniques, known as the Discrete Cosine Transform and a type of artificial neural network known as a Self-Organizing Map.

The technique has dramatically lower computational requirements than more conventional techniques and is well suited for low-cost, real-time hardware implementation, according to Abdallah S. Abdallah, a doctoral student in the VT-MENA program. (VT-MENA is Virginia Tech's graduate program in the Middle East and North Africa.) Abdallah is working with ECE's Lynn Abbott and Mohamad Abou El-Nasr of the Arab Academy for Science and Technology in Alexandria, Egypt.

Abdallah notes that "even though different people have different skin colors, studies have demonstrated that intensity, rather than chrominance (color) is the main distinguishing characteristic." Using segmentation based on skin color eliminates the need for multiresolution image pyramids, which are used in more traditional face-detection standard methods. "Most of the computational load in previous techniques comes from the large sizes of the feature vectors being used," Abdallah says.

Given an intensity representation (a grayscale, or "black-and-white" image), the technique relies on steps of region analysis, feature extraction, and pattern recognition. If faces are present in the image, a self-organizing map (which has been trained in advance) attempts to locate each one.

For benchmarking and testing, the team compiled a new image database, named the VT-AAST image database, consisting of 286 images, containing 1027 faces. The database is currently available on-line for non-commercial use at http://filebox.vt.edu/users/yarab/VT-AAST Database.htm

"Several large image databases are widely available for human face recognition," Abdallah says, "but relatively few are available for face detection." The main difference is that most face-recognition databases contain images that closely resemble "mug-shot" photographs, with the subject facing the camera and centered in the image. More general face-detection systems must deal with individuals who do not face the camera, who may be at various distances from the camera, and may be partially occluded. Each image in the VT-AAST database is available in four formats, including the original color and images segmented by skin color.

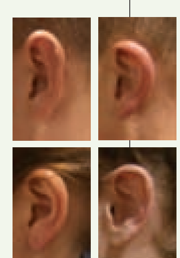
Your ears can give you away

Most people think of fingerprints, faces, and gait and iris patterns when they hear of automatic human recognition systems. ECE researchers, however, are investigating using ears for this biometric.

"Ear-based recognition is of particular interest because it is non-invasive and because it is not affected by environmental factors such as mood, health, and clothing," according to Mohamed Saleh, a student in Virginia Tech's graduate program in the Middle East and North Africa (VT-MENA).

"The appearance of the outer ear is relatively unaffected by aging, making it better suited for long-term identification when compared to other non-invasive techniques, such as face recognition," he explains.

Surprisingly, ears have a different appearance for every individual—even for "identical" twins. Ear recognition has not received much attention, he says, but other research teams had indicated that it may be at least comparable to face recognition, at about 71 percent accuracy. Saleh and his advisor, Lynn Abbott, recently applied image-based classifiers and feature-extraction methods to a small dataset of ear images with strongly positive results.



The team used six small (50x40 pixels) grayscale images for 17 individuals, each image showing different luminance and orientation. Comparing seven different image recognition techniques, they achieved accuracies ranging from 76 percent to 94 percent.

"We believe ear recognition has significant potential," Saleh says. Further research needs to be done in the area, using larger datasets, and considering problems of interfering hair, clothing, jewelry, eyeglasses and other artifacts, he says. For future research, the team is considering "multimodal" approaches for recognition that involve ears and faces simultaneously.

VLSI & DESIGN AUTOMATION

FACULTY

Peter Athanas
Dong Ha
Michael Hsiao
Chao Huang
Tom Martin
Patrick Schaumont
Sandeep Shukla
Joseph Tront

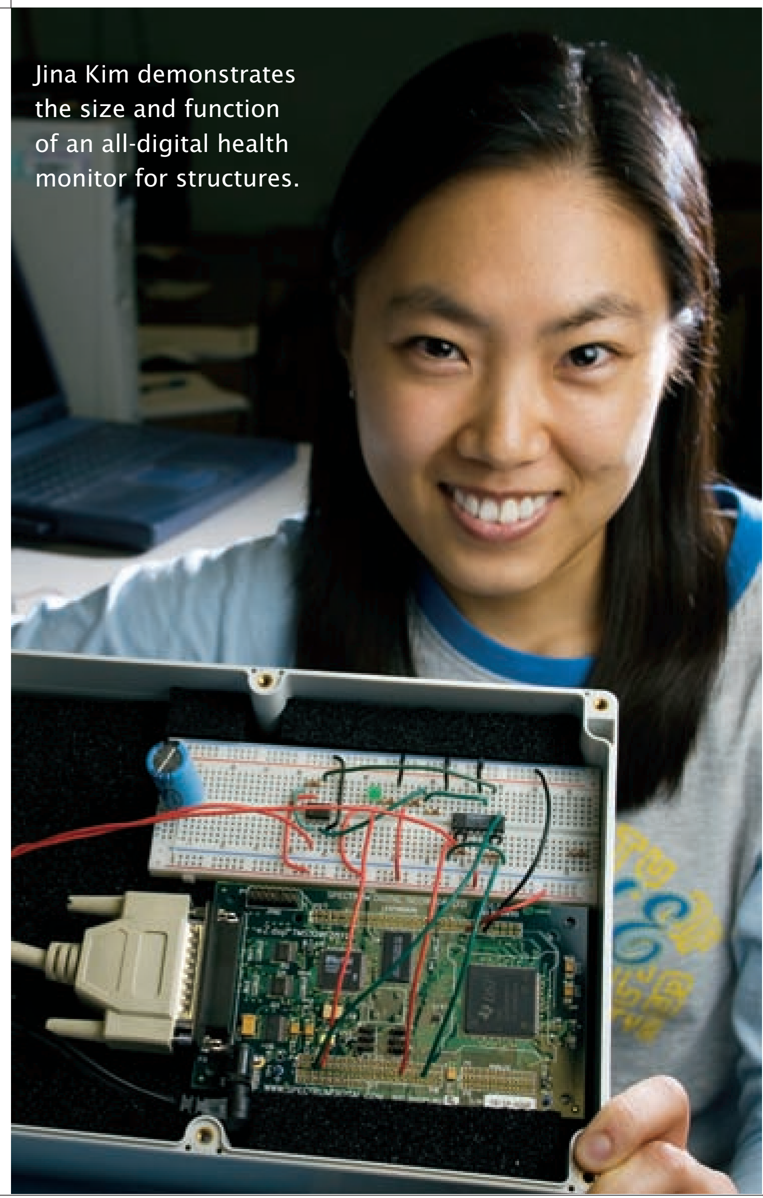
All-digital monitor for structural health

The Virginia Tech VLSI for Telecommunications (VTVT) group has developed a prototype system to monitor the health of infrastructures, from buildings and railroads to spacecraft. The prototype, which is the first all-digital signal processing system, reduces power consumption by 80 percent of that of its predecessors and paves a way for a self-contained monitoring system.

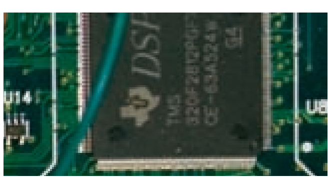
"We want to be able to diagnose damage to infrastructures and verify the repair efficacy," said ECE's Dong Ha, director of the VTVT group. "The single most important aspect of developing a self-contained monitoring system is low-power dissipation. The system should operate on energy harvested from the ambient such as solar, thermal, or vibration. We need to squeeze out every drop to reduce the overall power dissipation ranging from DSP algorithms to the interface between a sensor and a digital signal processing chip."

Ha explained that, in typical monitoring systems, sinusoidal tones are used to excite the structure, then the responses in the form of electrical impedance are measured and processed. His team, including graduate students Jina Kim (CPE) and Ben Grisso (ME), reduced power consumption by using digital pulse trains rather than sinusoidal tones and by observing only the polarity of the response signals. Using digital signals on both the structural excitation and the sensing allowed the team to eliminate both power-hungry digital-to-analog and analog-to-digital converters. It also simplified signal processing of the response signals, Ha said.

The interdisciplinary team from the VTVT lab and mechanical engineers from the Center for Intelligent Material Systems and Structures is supported by NSF on the effort. VTVT is part of the Center for Embedded Systems for Critical Applications (CESCA).



Jina Kim demonstrates the size and function of an all-digital health monitor for structures.



Center for Embedded Systems in Critical Applications (CESCA)
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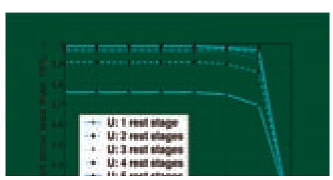
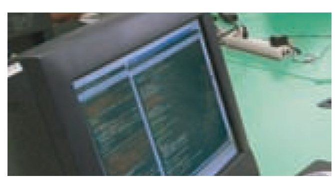


FERMAT
Director: Sandeep Shukla
http://fermat.ece.vt.edu



PROACTIVE
Director: Michael Hsiao
www.proactive.vt.edu

VT VLSI for Telecommunications (VTVT)
Director:Dong Ha
www.ee.vt.edu/~ha/research/research.html

Applying CPE skills to protect children's privacy

Computer engineering researchers, led by Michael Hsiao and Jung-Min Park are applying their verification, testing, and network security expertise to a system that can help protect the online privacy of children.

The system involves using a trusted third-party server, where parents register and allow different levels of access. The computer engineering team is developing the prototype and verifying that the overall system is secure, in order to protect children's online privacy. They are working with researchers in the business college who are providing legal and focus group input and assessing the system with users.

The verification challenges in the system spring from the very large state spaces involved, said Hsiao. "One of the key steps is representation of the system during the state space traversal to avoid state space explosion." The team is developing methods that are less vulnerable to memory explosion, such as automatic test pattern generation and satisfiability solvers.

Nano electronics bring mega design challenges

While scientists and engineers view the promise of greater performance, efficiency, and smaller size from nano-scale electronics, a group of computer engineers see the challenges of higher manufacturing defect rates, more frequent fault incidence and greater susceptibility to variational effects. They are investigating nano computing: how to build complex processors or application-specific computing architectures with nano scale components and materials that may be fault-prone or defective.

"People are building quantum dot cellular automata, molecular switches and fabrics and nano tube-based transistors/interconnects and discovering there are issues with reliability, quality, and performance," says Sandeep Shukla, an assistant professor of computer engineering. "Silicon devices reaching 45nm and beyond are experiencing variational effects, which lead to unpredictable timing, capacitance, resistance and other factors. Manufacturing techniques are imprecise at that scale and we are seeing high defect rates. Moreover, with very thin oxide layers, these devices are susceptible to atmospheric radiation," he explains.

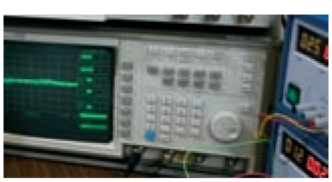
"How can we efficiently map logic onto an array of quantum dot cellular automata so the logic uses minimum resources, bypasses defective cells and works correctly in the presence of radiation that might inadvertently change the states of the quantum cells involved?" he asks.

Molecular fabrics introduce issues as well. "Many researchers believe that in the near future, hybrid structures will dominate computing. How do we interface CMOS with nanofabric; micro structures with nanostructures? There will be more nanowires in the memory than micro addressing lines and, hence, a problem with interfacing," he adds.

Nanotube-based fabrics will also affect software and may require spatial programming rather than temporal view of programming today, he says. Also probabilistic computing will possibly replace deterministic computing of today. "How do you write code that can harness the massive parallelism afforded by billions of switches?"

Some of the technologies under development are speculative and may not be feasible, but the industry must be prepared to deal with the issues involved, he says. The issue is growing in importance as evidenced by the growing number of workshops studying nano computing.

This spring, Shukla co-chaired a workshop on nano computing at Europe's biggest conference on Design Automation and Test (DATE 07). He is also organizing a workshop on nano electronics at the NSF in September to help NSF assess the importance of investing in the area. Last May, Shukla organized a workshop for researchers from Virginia sponsored by NSF, Virginia Tech, Virginia Commonwealth University, and the IEEE Joint Chapter on Computer/Industrial Electronics and Control.



Secure Embedded Systems Group
Director:Patrick Schaumont
www.ece.vt.edu/schaum/research.html

COMMUNICATIONS

FACULTY

Wireless
Charles Bostian
Michael Buehrer
Claudio da Silva
Allen MacKenzie
Tim Pratt
William Tranter
Amir Zaghloul

Fiber Comm
Ira Jacobs

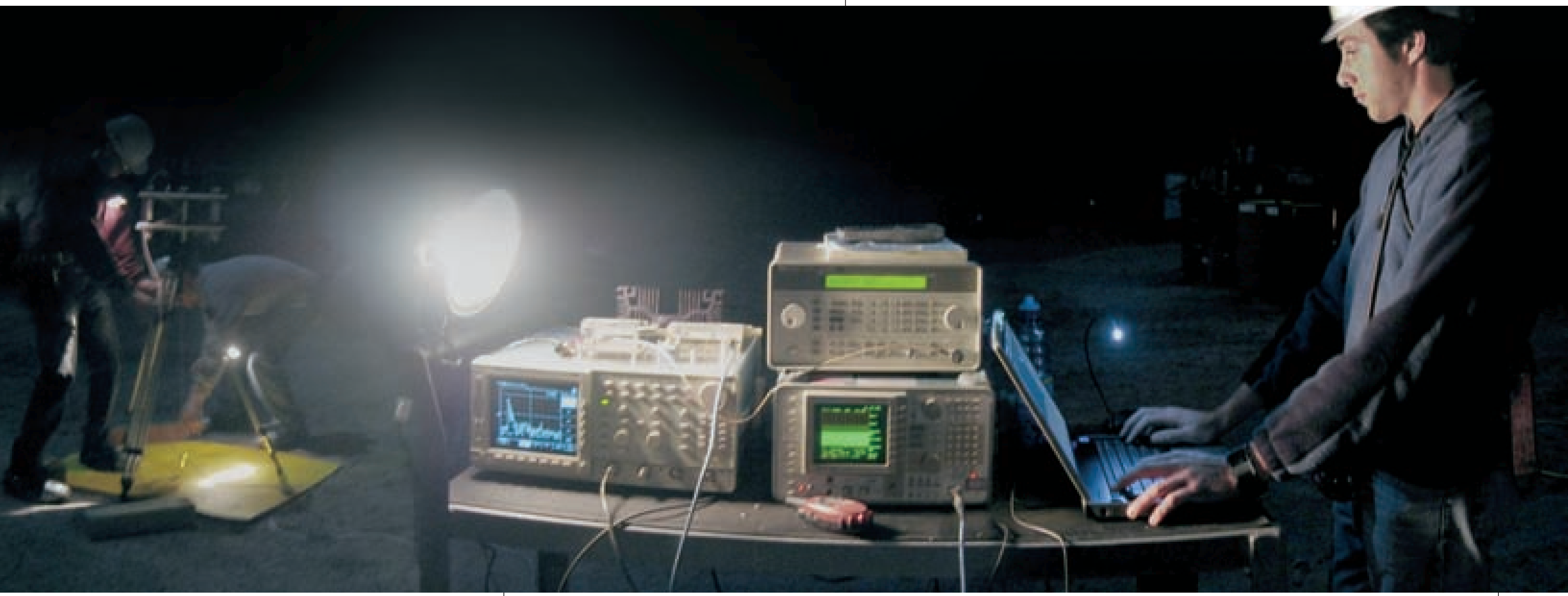
DSP
Louis Beex
Amy Bell
Lamine Mili
Jeffrey Reed

Networks
Luiz DaSilva
Thomas Hou
Yao Liang
Scott Midkiff
Amitabh Mishra
Jung-Min Park
Yaling Yang

VLSI Circuits
Peter Athanas
Dong Ha
Michael Hsiao

Optics
T.-C. Poon

Propagation
Gary Brown
William Davis
Steven Ellingson
Sanjay Raman
Sedki Riad
Ahmad
Safaai-Jazi



From left: Chris Anderson (Ph.D. '06), Chris Headley and Haris Volos prepare propagation measurements at the Kimballton limestone mine.

Adapting UWB wireless to mine safety

An ECE research team is investigating UWB-based wireless sensor network technology to boost the safety of mining and improve rescue operations during disasters. "Mining continues to be one of the most dangerous professions due to the possibility of mine accidents," said Haris Volos, a graduate student on the project.

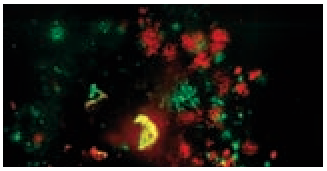
"We hope to develop the technology that would provide robust wireless notification and coordination under normal operations and during disasters, plus enable rescue teams to track the movements of miners and locate them if they are disabled and unable to communicate."The team's goal is a wireless sensor network specifically designed for a mine environment. UWB was selected as the base technology due to its ability to simultaneously provide both communications and position location data. Initial efforts involve characterizing UWB propagation in mines. "Relatively little information exists on how electromagnetic signals—particularly UWB signals—propagate in a mine environment," Volos said. Measurement work has begun at the Kimballton limestone mine in western Virginia, where the team took both UWB and narrow-band path loss measurements in tunnels in addition to grid measurements in a room-and-pillar environment.

Volos is working with fellow graduate student Chris Headley; Chris Anderson, a post-doctoral associate; ECE faculty members Michael Buehrer and Claudio da Silva; and Antonio Nieto of mining and minerals engineering.

W@VT one of largest wireless groups

Wireless@Virginia Tech is one of the largest wireless research groups in the United States. The center brings together 27 faculty members and more than 100 graduate students, in efforts ranging from circuits to networks. W@VT incorporates eight centers, groups, and laboratories, including the Center for Wireless Telecommunications, the Mobile and Portable Radio Research Group (MPRG) and the Virginia Tech Antenna Group.

Wireless@Virginia Tech
Director: Jeffrey Reed
www.wireless.vt.edu



Digital Signal Processing & Communications Lab
Director: Amy Bell
www.ece.vt.edu/fac_support/DSPCL

Low-power satellite/sensor system can operate with randomly located packages

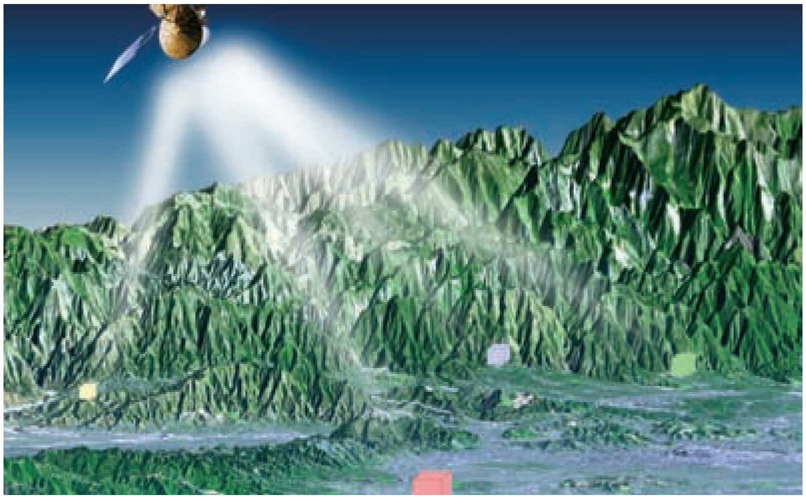
A team led by Amir Zaghloul, an ECE professor, is developing a low-power system for randomly located sensors to communicate with satellites. The sensors can be dropped—and even camouflaged—in uncontrolled or unfriendly environments, making the technique appropriate for disaster situations as well as homeland security, counter-terrorism and combat.

Each sensor in the system operates independently and may relay the same information, which creates a built-in redundancy. "Damage or discovery of the any of the sensor package nodes will not affect the transfer of the required information," he says.

The sensors use scanning antennas with hemispherical coverage and use small phased arrays with relatively high gain and narrow beam width. The array beam is continuously scanned within the expected angular range of the satellites, with a pre-set dwell time at each scanning position. The coded sensor data is transmitted in all scanning directions.

A geostationary (GEO) or a moving low-earth-orbiting (LEO) satellite then receives the data when the array beam is in the corresponding direction. "This data acquisition by the satellite is performed without the need for satellite tracking by the sensor," Zaghloul explains. Low-gain hemispherical-beam antennas can also be used for lower frequency operation.

The low-power sensor and antenna are housed in a miniature package along with a sensor processor to translate the sensor information to the RF package. "Initial calculations indicate that, at an information rate of 100 bps, a 3x3 cm phased array of the sensors can link to a LEO satellite at 1400 km altitude with 36 W of RF power at 30 GHZ, with a 9 dB link margin," he says. The low-power system is in the milliwatt range for medium data rates.



Securing SDR devices from hackers, opponents

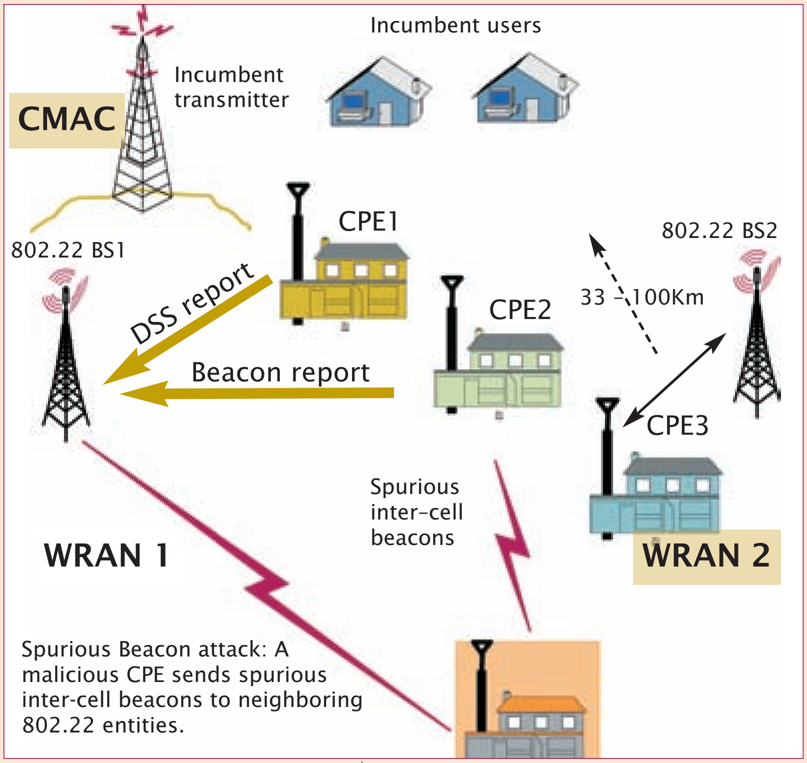
An ECE research team has been awarded a $400,000 Cyber Trust grant from the National Science Foundation (NSF) to improve the security of software-defined radio (SDR) technology.

Although software radio technology promises to alleviate the spectrum shortage problem and improve spectrum utilization, it raises new security issues, according to Jung-Min Park, principal investigator, and co-principal investigators Thomas Hou and Jeffrey Reed. "The software may be vulnerable to failure and malicious tampering," Park said.

"Changes to conventional ASIC (application specific integrated circuit) devices requires technical skills and specialized equipment, which makes unauthorized changes very difficult," he said. With SDR, user services or RF parameters can be reconfigured via the software. SDR research and standardization efforts focus on cryptosystems securing the download process and preventing tampering of downloaded software.

"That is the first line of defense," Park said. "We are exploring other measures to secure SDR devices from malicious hackers and military opponents seeking tactical advantages."

The team is investigating security vulnerabilities in the physical and MAC layers of SDR networks.

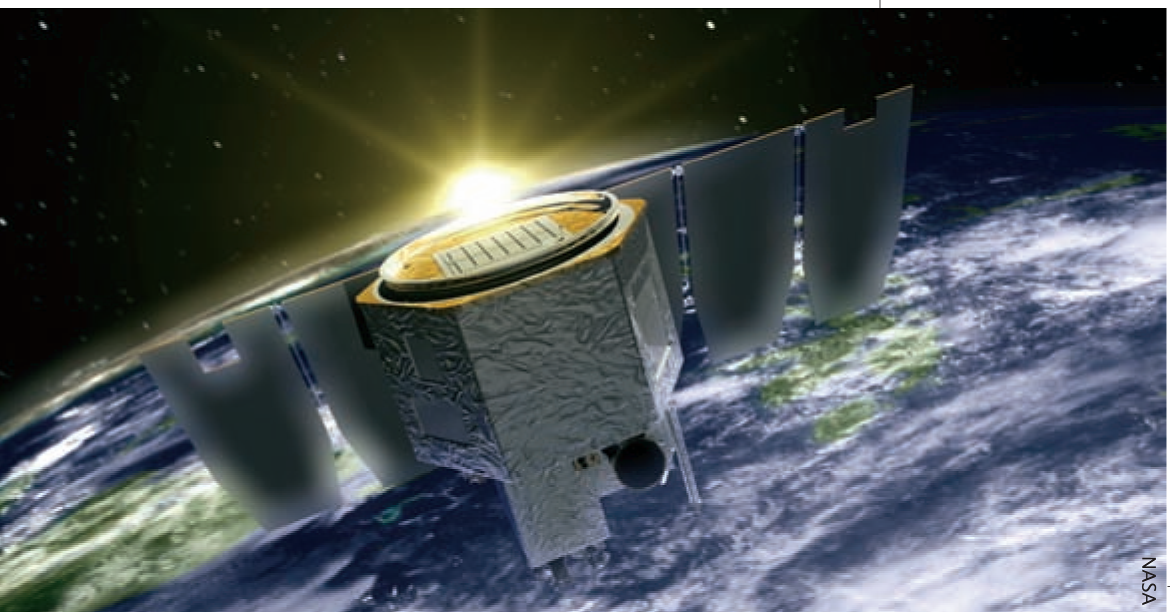


SECURITY THREATS IN COGNITIVE RADIO NETWORKS

ELECTRO-MAGNETICS

FACULTY

Scott Bailey
Charles Bostian
Gary Brown
C. Robert Clauer
Richard Claus
William Davis
Steven Ellingson
Louis Guido
Ira Jacobs
Brent Ledvina
Kathleen Meehan
Hardus Odendaal
T.-C. Poon
Ranjay Raman
Sedki Riad
Ahmad Safaai-Jazi
Wayne Scales
Anbo Wang
Yong Xu
Amir Zaghloul



Scott Bailey is deputy principal investigator of NASA's AIM mission. Right: At South Pole Station—testing a prototype of an instrument that will help map the electrical current systems that are driven by solar wind and the magnetosphere.

AIM satellite to study noctilucent clouds

ECE's Scott Bailey is serving as deputy principal investigator for NASA's AIM mission, which launches in April. AIM is a two-year mission to study polar mesospheric clouds, which form an icy membrane 50 miles above the ground at the edge of space. The clouds, when viewed from the ground, are seen as very bright clouds reflecting the sun at twilight and are called noctilucent clouds.

The clouds have been seen for more than a century in spring and summer at high latitudes. The mission's primary goal is to explain why the clouds form and discover what is causing them to appear more frequently and at lower latitudes.

The AIM satellite is 55 inches tall, 43 inches wide and weighs 430 pounds. The satellite carries three instruments: Cloud Imaging and Particle Size (CIPS); Solar Occultation For Ice Experiment (SOFIE), which measures the thermal and chemical environment inside the clouds; and the Cosmic Dust Experiment (CDE), which measures the input of cosmic dust into the atmosphere.

James M. Russell III of Hampton University serves as the project's principal investigator.

Mapping the systems driven by solar winds

Bob Clauer wants to understand the global electrical current systems that are driven by the solar wind/magnetosphere interaction. He is currently involved in establishing an ionospheric HF radar at Virginia Tech to measure ionospheric plasma convection —measurements that can be used to deduce the electric field of the ionosphere.

He is also developing an autonomous magnetic field measurement platform for use in remote regions of the Antarctic. In December (the Antarctic summer), the system will be redeployed from the South Pole where it has been tested for the past year, onto the Antarctic Plateau. The system will be the start of a magnetometer chain along the 40-degree magnetic meridian that will be magnetically conjugate (reciprocal) to the Greenland west coast chain of magnetometers. Using data from both hemispheres, it will be possible to begin to map the global electrical current systems that are driven by the interaction of solar wind with the magnetosphere.

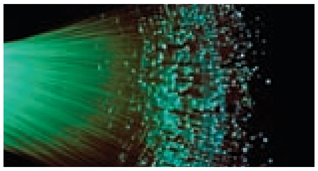
ETA telescope coming near Tech

In 2006, an ECE/physics research team, including Steven Ellingson and Cameron Patterson, began operation of a low-cost, direct-sampling radio telescope in a rural mountainous region of North Carolina. Called the ETA (Eight-meter-wavelength Transient Array), the telescope was designed for unattended operation to monitor the skies for single, dispersed radio pulses associated with prompt emission from gamma ray bursts and exploding primordial black holes. The telescope analyzes signals from 24 dipole antennas using an arrangement of 28 FPGA boards and four PCs interconnected with custom I/O adapter boards. Thanks to additional funding from the physics department, a second, portable instrument is planned near the Tech campus to improve performance using “anticoincidence”—a technique in which simultaneous detections are required at both sites as a means to rule out local radio frequency interference.

Measuring an ozone destroyer

ECE researchers are studying high altitude nitric oxide, which is a catalytic destroyer of ozone, in the first-ever effort to measure the chemical in the polar night. Scott Bailey is collaborating with Chris Hall of aerospace and ocean engineering on the $1.4-million NASA project, which will launch in 2010. The instrument will consist of a very large telescope and will view a bright UV star in occultation. Bailey and Hall are working with researchers from the University of Colorado on the project.

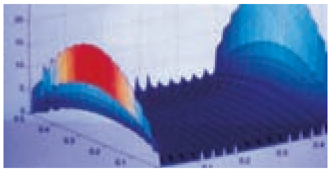
Center for Photonics Technology
Director: Anbo Wang
www.ee.vt.edu/~photonics/



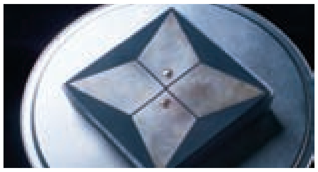
Fiber & Electro-Optics Research Center
Director: Richard Claus
www.ee.vt.edu/~feorc/

Dusty Plasma Laboratory
Director: Wayne Scales

Time Domain & RF Measurement Laboratory
Director: Ahmad Safaai-Jazi
www.ee.vt.edu/~tdl



ElectroMagnetic Interactions Laboratory
Director:Gary Brown
www.ee.vt.edu/~randem/emil/emil



Virginia Tech Antenna Group
Director: William Davis
http://antenna.ece.vt.edu

Bradley Fellow Evan Lally sets a stone on a prototype imaging system for asphalt aggregates.

High-res, 3D imaging for asphalt aggregates

Work is underway at the Center for Photonics Technology to develop a new laser imaging system for small rocks and sand particles. Sponsored by the National Cooperative Highway Research Program (NCHRP), the three-year project is geared towards improving the analytical models of rocks and small particles in asphalt aggregates.

A special mounting system holds particles ranging from 50mm to 75μm in diameter, allowing the user to position them for viewing at any angle. The object is illuminated by a series of interference fringes, generated by a red visible laser and an end-polished fiber optic coupler. These fringes, when reflected off the face of the object, contain quantitative information about the surface height profile. The image itself is collected with a high-resolution digital camera. The camera uses a thermoelectric cooling device to cool the CCD pixel array for extremely low noise operation. This low noise results in increased measurement resolution. The system is projected to achieve better than 5μm resolution in all three imaging directions.

Sapphire temperature sensor stands up to harsh environment

A miniature fiber optic sensing probe has proven its mettle in the harsh industrial environment of a coal gasifier at Tampa Electric’s Polk Power Station. The sapphire-wafer-based fiber optic temperature sensor was installed in late May 2006 and continued operation for seven months—far exceeding the project objective of 45 days. During that time, all thermocouples installed in the gasifier were replaced.

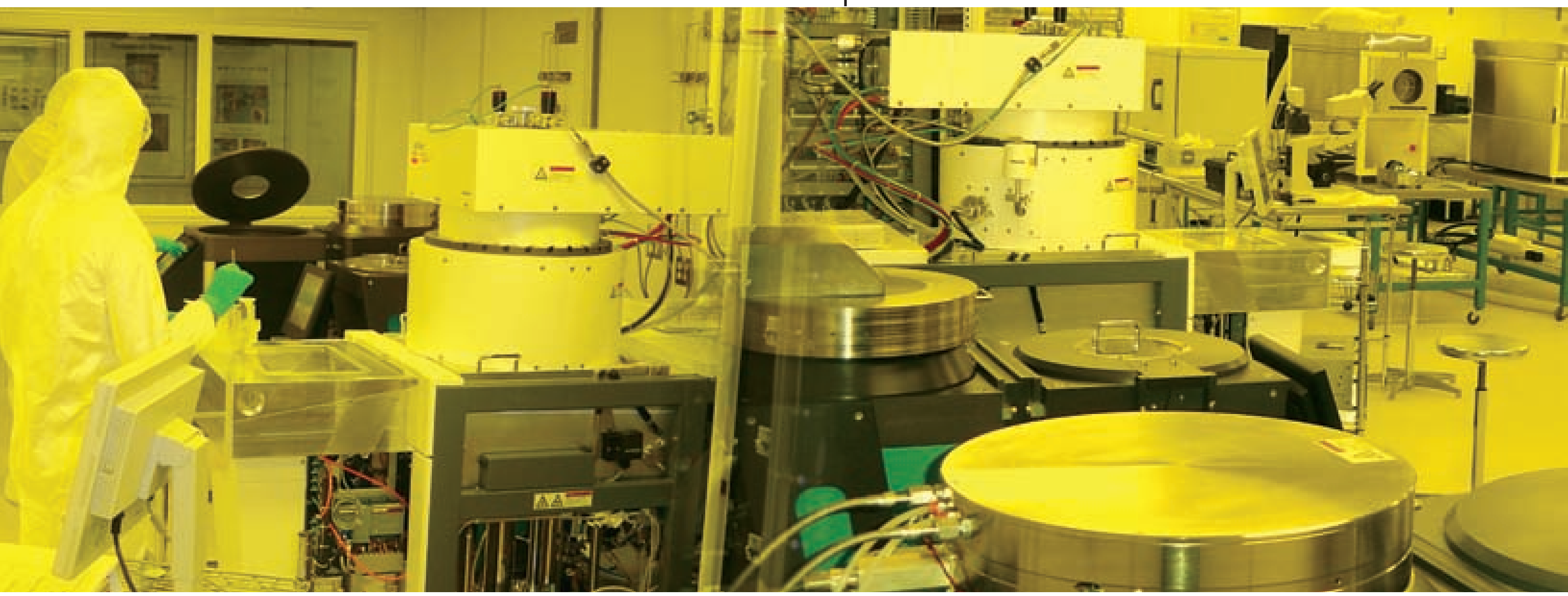
In a coal gasifier, most of the fuel is not burned, but chemically broken down by temperature and pressure in a limited oxygen environment, producing syngas. The syngas is cleaned and used as fuel in a combustion turbine. Accurate, reliable temperature measurements are critical: operating too high will reduce conversion efficiency and shorten the refractory life, while operating too low will cause the molten slag to become viscous, plugging the tap-hole.

The sapphire temperature sensor, developed by the Center for Photonics Technology, provided continuous, real-time temperature data as high as 1392°C. The research program is funded by the National Energy Technology Laboratory of the U.S. Department of Energy. A second field test is underway in 2007.

ELECTRONICS

FACULTY

Masoud Agah
Dushan Boroyevich
Rick Claus
William Davis
Louis Guido
Robert Hendricks
Chao Huang
Jason Lai
Fred C. Lee
G.Q. Lu
Kathleen Meehan
Khai Ngo
Hardus Odendaal
Ranjay Raman
Anbo Wang
Fred Wang
Ming Xu
Sedki Riad
Amir Zaghloul
Kwa-Sur Tam
Krishnan Ramu
Douglas Lindner
Joseph Tront
Yong Xu

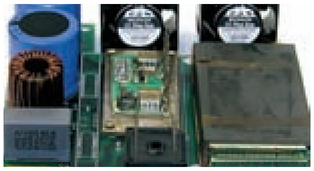


Semiconductor Processing Lab Dedicated

ECE opened its new Micron Technology Semiconductor Processing Laboratory this fall. The Class 1,000/10,000 clean-room laboratory is the latest of the new facilities operated by Virginia Tech's multidisciplinary Microelectronics, Optoelectronics and Nanotechnology (MicrON) Group.

The laboratory occupies 1800 square feet in Whittemore Hall and builds on a teaching laboratory that opened in 2001. New or improved capabilities include state-of-the-art photolithography, wet processing, dry etching (RIE/DRIE), chemical vapor deposition, and metallization. This gives Virginia Tech researchers on-site capabilities to produce cutting-edge prototypes for nano-structured biological and chemical sensors, organic and molecular nanoelectronics, solid-state lighting devices, microelectromechanical systems (MEMS) for sensing and communications, microfluidics for on-chip biological assays and cooling of high-power electronic circuits, and advanced chip-level packaging strategies.

The research and teaching laboratory is named for Micron Technology, in recognition of the firm's $750,000 gift that provided the final funds that allowed the laboratory's completion. The clean-room joins several other of Tech's MicrON Group facilities: a metal-organic chemical vapor depositions (MOCVD) laboratory, an electronic/optoelectronic materials laboratory, and a device characterization laboratory. An electronic packaging laboratory is also available.



Center for Power Electronics Systems
Director: Fred C. Lee
www.cpes.vt.edu

Future Energy Electronics Center
Director: Jason Lai
www.feec.ece.vt.edu

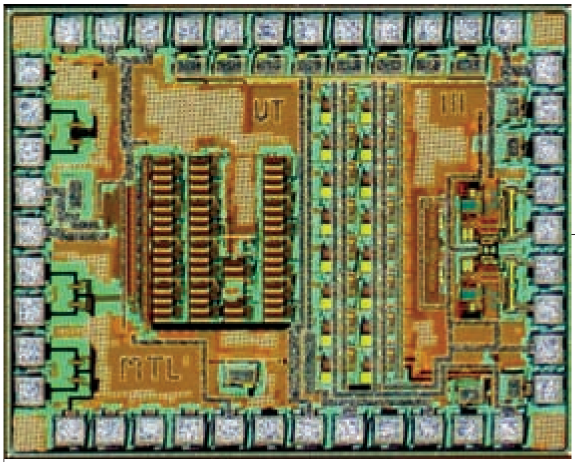
Microelectronics, Optoelectronics and Nanotechnology Group (MicrON)
Director: Louis Guido
www.micron.ece.vt.edu

Motion Control Systems Research Group
Director: Krishnan Ramu

A “black box” system of modeling

Researchers in the Center for Power Electronics (CPES) have developed a “black-box” modeling approach for designing new power electronics-based electric energy distribution systems. The new method diverges from the conventional “white-box” approach, which requires detailed knowledge of the converter structure and parameters. However, the growing use of power electronics in distribution systems has complicated design: the size and complexity of future systems alone make white-box modeling difficult. Another complication is that converters are commercially available from numerous different vendors, who provide little or no information about the internal structure of their products.

The CPES approach is based entirely on the terminal characteristics of power converters, using a simple set of small-signal measurements to construct the low-frequency model without requiring any knowledge of the converter structure or any of its internal parameters. Called the black-box modular-terminal-behavioral modeling methodology, the model captures the information without neglecting parasitics or simplifying the converter internal operation, as is common with conventional reduced-order models. The CPES approach is modular, enabling computations efficient analysis of all electrical phenomena in the system.



High-speed analog-to-digital converters

Bradley Fellow Mark Lehne is investigating new analog-to-digital conversion-circuit architectures that improve a broadband wireless transceiver’s ability to efficiently detect information in the presence of strong interference. The goal is better overall performance while allowing for higher data rates and more intelligent transceivers. In order to coexist with legacy narrow-band transceivers, high-speed analog-to-digital converters must allow the receiver to operate with sufficient fidelity to detect target signals while identifying and rejecting narrow-band interference.

Testbed developed for self-sustained, zero-emissions power system

To facilitate communications in remote locations, CPES researchers have developed a self-contained, 3 kW, autonomous hybrid power system for data communications in remote locations. The testbed system serves as a demonstration of an electric power system for future self-sustained, zero-emission applications. The scaled-down generic electronic power distribution system is representative of systems that could be used for future homes, data centers, hybrid electric cars, aircraft, and ships.

The testbed incorporates representative renewable sources, power converter-based loads, and a grid-interfaced controllable distribution network, in order to evaluate system-level impacts of CPES technologies.

As implemented in the CPES laboratory, the testbed includes a solar photovoltaic source simulator and AC grid connection as energy sources, lead-acid batteries, a battery charger, an AC transfer switch, and DC-AC inverter, and mixed AC-DC power distribution with computer-controlled measurement and supervision as the energy management system.

The system is designed to provide uninterrupted energy supply to the data servers and air-conditioning electrical loads.

Mapping power electronics development

Power electronics researchers from around the world are collaborating on how to focus efforts to ensure that power electronics helps industries and countries globally to reduce energy consumption and environmental impact.

Power electronics has emerged as an enabling technology in this global effort.

As one of the largest power electronics research groups in the world, CPES has taken the lead on gathering academic and industrial researchers to develop a roadmap for development. CPES has organized two annual roadmap workshops, the most recent during October 2006. The roadmap effort is funded by an NSF supplemental grant.

POWER

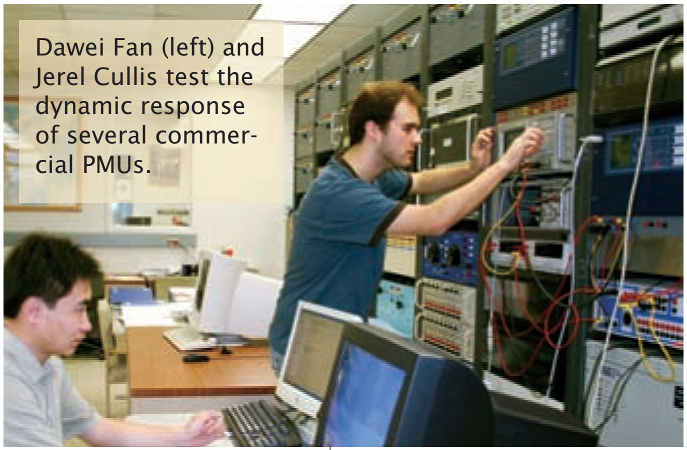
FACULTY

Robert Broadwater
Virgilio Centeno
Jaime de la Ree
Yilu Liu
Lamine Mili
Saifur Rahman
Kwa-Sur Tam
James Thorp

Improving California's power system

Higher energy costs and recent blackouts in North America and other systems around the world have spawned an increased emphasis on protection systems. Wide area measurement concepts and devices developed at Virginia Tech are being applied worldwide to reduce catastrophic failures of the power grids, limit the regions affected by such events, and to increase the speed of restoration after such an event.

In one project, researchers are using real-time wide area measurements of the California power system to determine optimum protection policies and settings for critically located relaying systems. The goal of the three-year development and demonstration project is to improve protection system supervision by making it adaptive to the prevailing state of the system.



Dawei Fan (left) and Jerel Cullis test the dynamic response of several commercial PMUs.

Towards this goal, the team is developing techniques for adaptive adjustment of dependability and security, potential load encroachment alarm systems, and more-intelligent out-of-step relaying functions.

The team will determine key locations on the California grid where an insecure relaying operation during stressed system conditions would be detrimental to the viability of the power system. The team will also develop a method for using real-time wide area measurement data and the existing protection system data to determine which of the relay characteristics are in danger of being encroached upon during a catastrophic event. Appropriate countermeasures will be developed for those vulnerabilities.

Finally, the team will develop a technique to use wide-area measurements to improve out-of-step decision-making at key locations where out-of-step blocking and tripping functions are used. Out-of-step relays are traditionally set based on transient stability studies performed for assumed base case and contingency conditions. However, in practice, the power system and the actual complex sequence of events differ from the study cases, and the protection settings in use are not appropriate to the changed system conditions.

DEVICE CHARACTERIZATION

The increased demand, availability, and applications of wide area measurement devices have created the need for proper testing and standardization. Virginia Tech power engineering researchers are collaborating with the National Institute of Standards and Testing (NIST) to develop procedures and testing devices that will allow researchers, users, and manufacturers to document, evaluate and compare the dynamic response of the different wide area measurement devices on the market. In addition to the NIST work, graduate students from Virginia Tech and Otto-Von-Guericke University in Germany have collaborated on efforts to test industrial prototypes of wide area measurement devices.

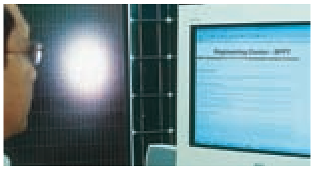
Designing the distribution system of the future

Virginia Tech, Southern California Edison and KEMA, Inc. are working to extend the use of synchronized measurements beyond conventional transmission system applications to enhance distribution system reliability in a project sponsored by the U.S. Department of Energy. The team seeks to improve fault localization, prediction, isolation, and service restoration capabilities. Moreover, system security will be enhanced through the use of distributed intelligence to execute system islanding and service restoration. The team is also investigating the use of synchronized measurement of single phase and harmonic components for the detection of incipient faults in distribution protection.

PMUs go global

Virginia Tech's wide area measurement technologies are gaining popularity worldwide, with researchers making presentations last year in Taiwan, China, India, Sweden and France. ECE teams are working with the Power Grid in India and the National System Operation Center in Brazil to aid in developing optimal wide area measurement systems based on the phasor measurement technology (PMU) developed at Virginia Tech. The Indian PMU system is being designed to improve power system monitoring and to control their rapidly growing system. The Brazilian system seeks to monitor and control their system to take full advantage of hydro generation and reduce the effect of regional weather on energy generation. ECE researchers are working to determine the optimal placement and deployment schedule to obtain the greatest benefit from the measurement system at every stage of implementation.

Center for Power Engineering
Director: Yilu Liu



Center for Energy & the Global Environment
Director: Saifur Rahman

SYSTEMS & CONTROLS

FACULTY

William Baumann
A.A. (Louis) Beex
Pushkin Kachroo
Douglas Lindner
Krishnan Ramu
Daniel Stilwell
Chris Wyatt

No-cable elevator uses VT switched reluctance motor drive technology

ECE researchers have built a 1:10 scale prototype of a cable-less elevator that would cost less than one-fifth the price of conventional elevator technology. The energy-efficient elevator technology has the potential to make home elevators more affordable, improve ship-board transportation, and even allow more than one cage in a shaft.

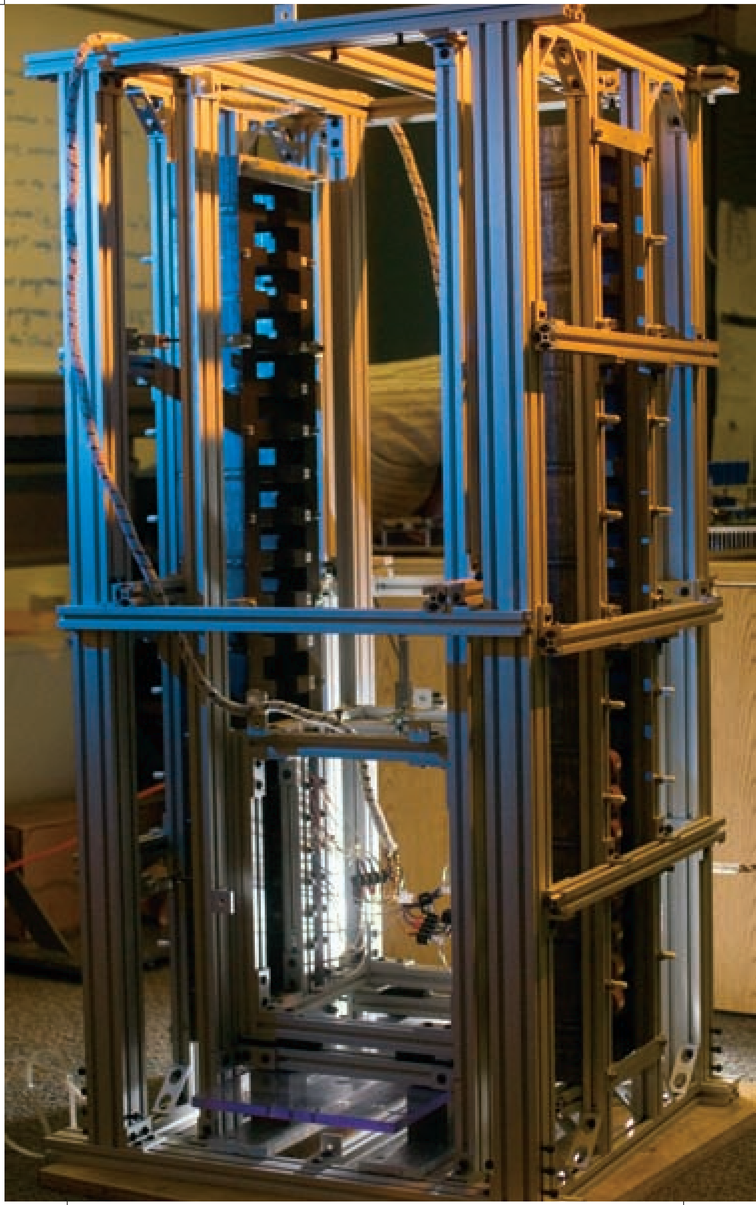
The elevator prototype was designed for weapons elevators in battleships and was funded primarily by the Naval Postgraduate School. The elevator uses an electric propulsion system based on the switched-reluctance linear actuator first developed in ECE laboratories for maglev transportation.

The elevator uses no cables and is propelled by a system comprising of stators along the shaft and translators on the elevator cage. It was designed so that increasing the lift force does not require more stators, just translators.

The control equipment is carried at the sides of the cage, instead of at the top, which is in the plenum space between floors in conventional elevator technology. "Carrying the control equipment on the sides of cage means the elevator does not need as much head room as traditional elevators," said Krishnan Ramu, director of the Motion Control Systems Research Group that developed the system. "This means that tall buildings can fit more usable floor space. It also means that in home elevator systems, even a short, 7-feet tall basement can accommodate an elevator."

Putting the control equipment on the cage also enables multiple cages in one shaft, according to Ramu. The shaft could be a circular system in a large building or ship, where the unoccupied cages travel horizontally above the top floor and beneath the bottom floor.

The project has taken more than four years from concept to prototype. "The control system was the most excruciating," Ramu said. "We had to make sure we could accelerate and decelerate smoothly in all circumstances and that, in case of power interruption, the elevator would glide smoothly without harm to occupants."



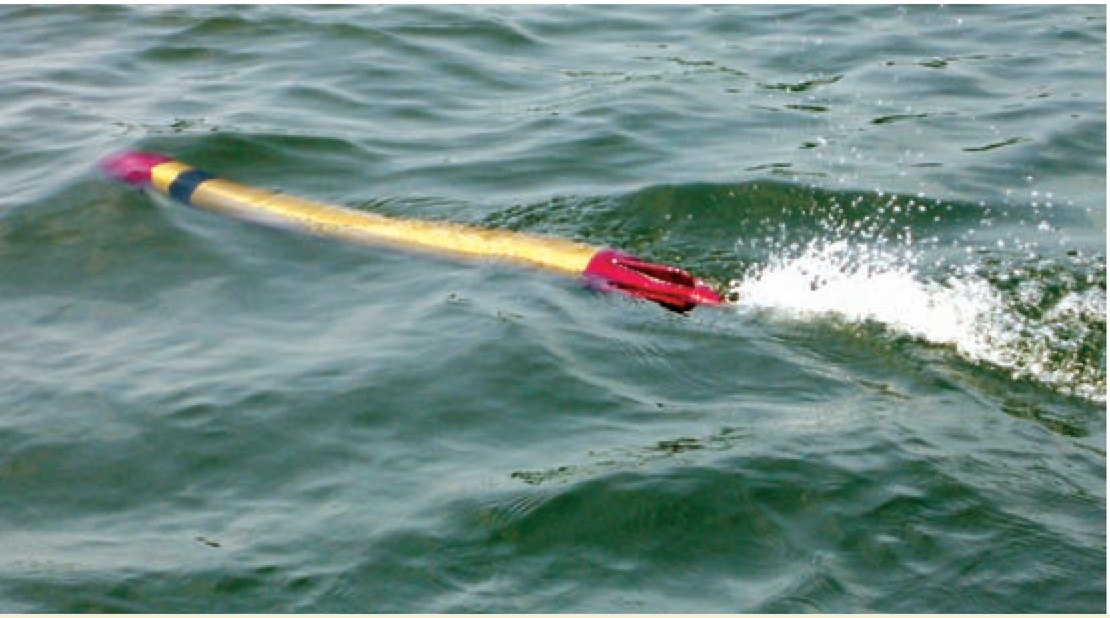
A 1:10 scale prototype of an elevator that can operate inexpensively in smaller spaces uses Virginia Tech's switched reluctance motor drive technology.

Mini, high-speed AUV exceeds 15 knots

A very small, high-speed autonomous underwater vehicle (AUV) has been developed by ECE's Dan Stilwell and Wayne Neu of aerospace and ocean engineering. The high-speed AUV is approximately 39 inches long and 3 inches in diameter. It is capable of speeds greater than 15 knots; most AUVs operate at between 2-3 knots. The AUV was developed as a "crash project" directed by the Naval Underwater Warfare Center in Newport, RI. The team went from concept to first successful demonstration in just 10 months.

The high-speed AUV presented a number of unusual design challenges. It is 50 percent heavier than the water it displaces. If it is not being actively controlled, the AUV sinks quickly to the bottom.

The most unusual feature of the high-speed AUV is that it does not possess a vertical separation between its center of mass and its center of buoyancy. Almost all submersibles are designed so that the heavy parts are near the bottom and the lighter parts are near the top. This means it naturally tends to stay upright. The high-speed AUV, however, has no passive stability. The team developed and is patenting a method of actively stabilizing the roll motion.



When the high-speed AUV is not in high-speed flight, it transitions into nose down hover. It can then transition back into high-speed flight.

Anti-jitter technology for better rifle aim

Controls researchers are developing a new rifle system technology to enable the shooter to maintain better aim control under ergonomic disturbances.

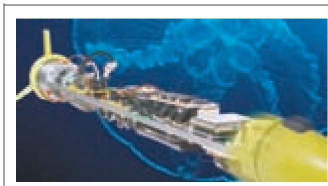
The technology is expected to improve shot accuracy and dispersion under combat stress and to extend the effective range of small arms rifles, according to Douglas Lindner, the Virginia Tech lead on the project.

Called the INertially STAbilized Rifle (INSTAR), the system's goal is to compensate for these physiological effects and improve the overall accuracy of the soldier by stabilizing the gun barrel relative to the stock taking out the human induced disturbances.

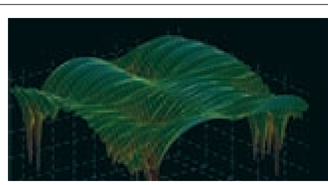
INSTAR operates similar to a video camera with a simple feedback control system that rejects any tracking commands at lower frequencies and compensates for the jitter disturbances due to breathing, heart rate, and muscle movement, etc., at higher frequencies.

INSTAR features a specially designed gun barrel suspension, compact high energy density piezoceramic actuators to effect gun barrel motion, inertial sensors to measure gun barrel motion and power, control, and signal conditioning electronics integrated into the multifunctional gun stock.

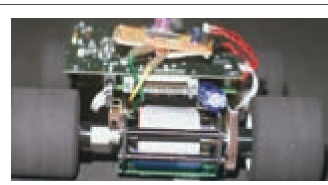
Lindner is collaborating with Chris LaWigna of Techno-Sciences, Inc. and Diann Brei of the University of Michigan.



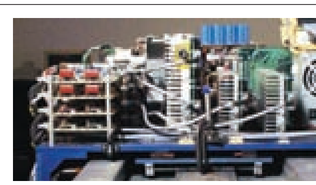
Autonomous Systems & Controls Laboratory
Director: Dan Stilwell
www.ascl.ece.vt.edu



Digital Dignal Processing Research Laboratory
Director: A.A. (Louis) Beex
www.ee.vt.edu/~dsprl/



Intelligent Control Group
Director: Pushkin Kachroo



Motion Control Systems Research Group
Director: Krishnan Ramu

PH.D. DEGREES AWARDED

Adams, William Joseph
Decentralized Trust-Based Access Control for Dynamic Collaborative Environments
Committee Chairs: Davis, N.J. Midkiff, S.F.

Al-Bandakji, Mohammad Rachad
Modeling and Analysis of Photonic Crystal Waveguides
Committee Chair: Safaai-Jazi, A.

Al-Ghadhban, Samir Naser
Multi-Layered Space Frequency Time Codes
Committee Chairs: Buehrer R.M.; Woerner, B.D.

August, Nathaniel J.
Medium Access Control in Impulse-Based Ultra Wideband Ad Hoc and Sensor Networks
Committee Chair: Ha, D.S.

Bae, Kyung Kyoon
Analytical Framework for the Performance Analysis of Multiple Antenna Systems
Committee Chair: Annamalai, A.; Tranter, W.H.

Brownfield, Michael Ignatius
Energy-Efficient Wireless Sensor Network MAC Protocol
Committee Chair: Davis, N.J.; Midkiff, S.F.

Chandrasekar, Kameshwar
Search-Space Aware Learning Techniques for Unbounded Model Checking and Path Delay Testing
Committee Chair: Hsiao, M.S.

Chung, Woo Cheol
The Dual Use of Power Distribution Networks for Data Communications in High Speed Integrated Circuits
Committee Chair: Ha, D.S.

Dietze, Kai P.
Blind Identification of MIMO Systems: Signal Modulation and Channel Estimation
Committee Chair: Stutzman, W.L.

Goel, Nitin Kumar
Development of "Core-Suction" Technique for Fabrication of Highly Doped Fibers for Optical Amplification and Characterization of Optical Fibers for Raman Amplification
Committee Chairs: Pickrell, G.R.; Stolen, R.H.

Gong, Michelle Xiaohong
Improving the Capacity of Wireless Ad Hoc Networks through Multiple Channel Operation: Design Principles and Protocols
Committee Chair: Midkiff, S. F.

Hadjichristofi, George Costa
A Framework for Providing Redundancy and Robustness in Key Management for IPsec Security Associations in a Mobile-Ad Hoc Environment
Committee Chair: Davis, N.J.

Hall, Kristopher Joseph
Thwarting Network Stealth Worms in Computer Networks through Biological Epidemiology
Committee Chairs: Davis, N.J.; Abbott, A.L.

Han, Ming
Theoretical and Experimental Study of Low-Finesse Extrinsic Fabry-Perot Interferometric Fiber Optic Sensors
Committee Chair: Wang, A.

Huang, Zhengyu
Quasi-Distributed Intrinsic Fabry-Perot Interferometric Fiber Sensor for Temperature and Strain Sensing
Committee Chair: Wang, A.

Joshi, Gaurav Gaurang
Ultra-Wideband Channel Modeling using Singularity Expansion Method
Committee Chair: Stutzman, W.L.

Kim, Jong-Kook
Investigation of High-Nonlinearity Glass Fibers for Potential Applications in Ultrafast Nonlinear Fiber Devices
Committee Chairs: Safaai-Jazi, A.; Stolen R.H.

Lee, Hyung-Jin
Digital CMOS Design for Ultra Wideband Communication Systems: from Circuit-Level Low Noise Amplifier Implementation to a System-Level Architecture
Committee Chair: Ha, D.S.

Leu, Ching-Shan
Improved Forward Topologies for DC-DC Applications with Built-In Input Filter
Committee Chair: Lee, F.C.

Liu, Qian
Modular Approach for Characterizing and Modeling Conducted EMI Emissions in Power Converters
Committee Chairs: Boroyevich, D.; Wang, F.

Liu, Wenduo
Alternative Strutures for Integrated Electromagnetic Passives
Committee Chair: Van Wyk, J.D.

Nguyen, Anh Minh Ngoc
High-Quality Detection in Heavy-Traffic Avionic Communication System Using Interference Cancellation Techniques
Committee Chair: Zaghloul, A.I.

Papenfuss, Cory M.
Wideband Active Vibration Control Synthesis and Implementation on Uncertain Resonant Structures
Committee Chair: Baumann, W.T.

Qiu, Yang
High-Frequency Modeling and Analyses for Buck and Multiphase Buck Converters
Committee Chair: Lee, F.C.

Subramanian, Anbumani
Layer Extraction and Image Compositing Using a Moving-Aperture Lens
Committee Chair: Abbott, A. L.

Sulistyo, Jos B.
High Speed Circuit Design Based on a Hybrid of Conventional and Wave Pipelining
Committee Chair: Ha, D. S.

Syal, Manan Rohini
Static Learning for Problems in VLSI Test and Verification
Committee Chair: Hsiao, M. S.

Tcheslavski, Gleb V.
Coherence and Phase Synchrony Analysis of Electroencephalogram
Committee Chair: Beex, A. A.

Tebben, Daniel James
Limitations and Improvement of Subcarrier Multiplexed Systems over Optical Fiber
Committee Chair: Jacobs, I.

Teotia, Seemant
Influence of the Number of Degrees of Freedom on the Capacity of Incoherent Optical Fiber Communication Systems
Committee Chair: Jacobs, I.

Tsai, Shu-Jen Steven
Study of Global Power System Frequency Behavior Based on Simulations and FNET Measurements
Committee Chair: Liu, Y.

Varma, Krishnaraj M.
Fast Split Arithmetic Encoder Architectures and Perceptual Coding Methods for Enhanced JPEG2000 Performance
Committee Chair: Bell, A. E.

Wang, Shuo
Characterization and Cancellation of High-Frequency Parasitics for EMI Filters and Noise Separators in Power Electronics Applications
Committee Chair: Lee, F. C.

Wang, Zhiyong
Ionic Self-Assembled Multilayers Adsorbed on Long Period Fiber Gratings for Use as Biosensors
Committee Chair: Stolen, R.H.

Wu, Haisang
Energy-Efficient, Utility Accrual Real-Time Scheduling
Committee Chair: Ravindran, B.

Xu, Chunchun
High Accuracy Real-Time GPS Synchronized Frequency Measurement Device for Wide-Area Power Grid Monitoring
Committee Chair: Liu, Y.

Xu, Juncheng
High Temperature High Bandwidth Fiber Optic Pressure Sensors
Committee Chair: Wang, A.

Xu, Yang
Synthesis and Characterization of Silica Coated CdSe/CdS Core/Shell Quantum Dots
Committee Chair: Meehan, K.

Yin, Jian
High Temperature SiC Embedded Chip Module (ECM) with Double-sided Metallization Structure
Committee Chair: Van Wyk, J.D.

Zeng, Dongsong
Pulse Shaping Filter Design and Interference Analysis in UWB Communication Systems
Committee Chairs: Zaghloul, A.I.; Annamalai, A.

Zhang, Xin
Fully Distributed Control and Its Analog IC Design for Scalable Multiphase Voltage Regulators
Committee Chairs: Huang, A.Q.; Thorp, J.S.

Zhang, Yan
Miniature Fiber-Optic Multicavity Fabry-Perot Interferometric Biosensor
Committee Chair: Wang, A.

Zhang, Zhiye
Sintering Micro-Scale and Nanoscale Silver Paste for Power Semiconductor Device Attachment
Committee Chair: Lu, G.Q.

Zhong, Zhian
Power Systems Frequency Dynamic Monitoring System Design and Applications
Committee Chairs: Liu, Y.; Centeno, V.

Zhou, Xigen
Electrical, Magnetic, Thermal Modeling and Analysis of a 5000A Solid-State Switch Module and Its Application as a DC Circuit Breaker
Committee Chairs: Huang, A.Q.; Wang, F.

Zhu, Huiyu
New Multi-Phase Diode Rectifier Average Models for AC and DC Power System Studies
Committee Chair: Linder, D.K.

Zhu, Ning
Planar Metallization Failure Modes in Integrated Power Electronics Modules
Committee Chair: Van Wyk, J.D.

PATENTS AWARDED

"Planar Wideband Antennas," S-Y Suh and W. L. Stutzman

"Topologies for Multiple Energy Sources," J.S. Lai

"Apparatus and Method that Prevent Flux Reversal in the Stator Back Material of a Two-Phase SRM (TPSRM)," K. Ramu

"Radial-Axial Electromagnetic Flux Electric Motor, Coaxial Electromagnetic Flux Electric Motor, and Rotor for Same," K. Ramu

"System to Generate and Control Levitation, Propulsion and Guidance of Linear Switched Reluctance Machines (LSRMs)," K. Ramu

"Quasi-Resonant DC-DC Converters with Reduced Body Diode Loss," M. Xu, F.C. Lee, Y. Qiu

"Self-Driven Circuit for Synchronous Rectifier DC/DC Converter," M. Xy, F.C. Lee, Y. Ren, D. Sterk

"Two-Stage Voltage Regulators With Adjustable Intermediate Bus Voltage, Adjustable Switching Frequency, and Adjustable Number of Active Phases," J. Wei, M. Xu, F.C. Lee

"Adaptive Bus Voltage Positioning for Two-Stage Voltage Regulators," J. Wei, M. Xu, F.C. Lee

"EMI Filter and Frequency Filters Having Capacitor with Inductance Cancellation Loop," S. Wang, F.C. Lee, W. Odendaal

"Buck Converter with High Efficiency Gate Driver Providing Extremely Short Dead Time," Y. Ren, F.C. Lee

"Optical Fiber Pressure and Acceleration Sensor Fabricated on a Fiber Endface," Y. Zhu, X. Wang, J. Xu, A. Wang

"Optical Fiber Sensors for Harsh Environments," J. Xu, A. Wang

"Optical Fiber Sensors Based on Pressure Induced Temporal Periodic Variations in Refractive Index," A. Wang

"Self-Compensating Fiber Optic Flow Sensor Having an End of Fiber Optic Element and Reflective Surface Within a Tube," W. Peng, B. Qi, A. Wang

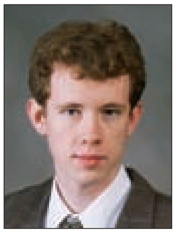
"Method and Apparatus for Accessing Memory Using Ethernet Packets," P. Athanas, H. Green, T. Brooks, K. Paar, P. McFall

"Smaller Aperture Antenna for Multiple Spot Beam Satellites," A. Zaghloul, O. Kilic, A. Williams.

BRADLEY SCHOLARS 2006-2007

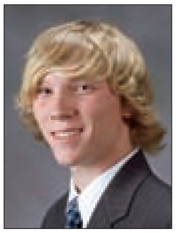
The Bradley Scholarships were founded by Marion Bradley Via in honor of her father, Harry Lynde Bradley

Benjamin A. Beasley
EE/Music '09
Kernersville, NC
J.B. West Scholarship; National Merit Scholarship; Robert C. Byrd Scholarship; Sam Walton Community Scholarship; University Symphonic Wind Ensemble; Chamber Winds; Horn Ensemble;
Co-op: Analog Devices
Why ECE: It's the ideal combination of math, science, and tinkering. It manages to be both abstract and practical in a very appealing way.

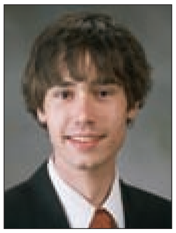


Ross Benjamin Clay
CPE '09
Raleigh, NC
Minor: Economics; Dean's Scholarship; Aikido; Work experience: IT consultant, WebSphere Application Server System tester for IBM
Summer plans: A Department of Energy SULI internship at Los Alamos National Laboratory working with researchers on projects related to wireless communications, streaming media optimization and virtual networks.

Brittany Clore
GE/CPE '10
Fairfax, VA
Society of Women Engineers; Hypatia engineering community; intramural volleyball
Career aspirations: Find ways to make computers available to everyone
Most memorable experience: Being part of the Hypatia program....We do everything... from homework to laser tag.



Thomas Alan Cooper
EE '10
Oak Ridge, TN
Galileo engineering community; Student Engineers' Council Publicity Committee; intramural soccer; Projects: Sustainable Energy Design Project, Contemporary Issue Research Project
Why ECE: I have always liked working with computers,electrical systems, and radios.



David C. Craven
CPE '08
Winston-Salem, NC
Pratt Engineering Scholarship; Academic officer for HKN honor society
Most memorable experience: Being part of the honors community in Hillcrest has been a tremendous experience, I've had the opportunity to be more exposed to fields outside my own.

Courtesy of Joe Gibbs Racing

Matt Carson '98:

It takes more than an expert driver like Tony Stewart and a fast Chevrolet Monte Carlo to win a NASCAR race. Another type of race is run in the shop, where designers, machinists, and —yes, engineers—work against the clock and competitors to design, build, test, and install new parts.

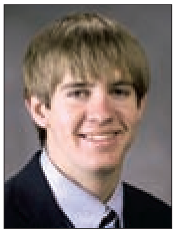
Matthew Carson (EE '98, ME '01), engineer on the Joe Gibbs Racing team, often has only a few days to figure out what went wrong in last weekend's race and redesign it or fix it for a race the upcoming weekend.

"Luckily, I don't need to go to the tracks to test a part," says Carson. "We can test it on our equipment. Ideally, we won't have to build it to test it—that's the project I'm working on when I'm not putting out fires."

The role of the data provided by an engineer is crucial to the success of Joe Gibbs Racing. Since Carson began there five years ago, he's partied at NYC's Waldorf Astoria, celebrating the team's 2002 and 2005 Nextel NASCAR championships of driver Tony Stewart. Many think the team's advanced standing has everything to do with its advanced technology. Joe Gibbs Racing has ramped up its digital environment, especially its use of digital product development and testing.

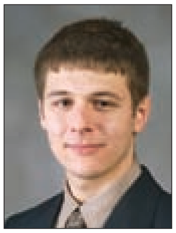
Working virtually first and then later in the shop, engineers stripped excess metal from upper components and applied it below the centerline of axles to improve handling. Now Carson is working on evaluating new engine configurations virtually. "I'm always trying to make components lighter and stiffer," he says.

Carson has written an analysis tool for valve train testing; he's created programs in Visual Basic to keep track of overall testing.

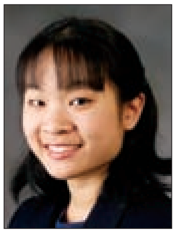


Daniel Michael Hager
CPE '08
High Point, NC
National Merit Finalist; Robert Byrd Scholar; Society of Automotive Engineers Scholar; Work experience: Worked for Lockheed Martin on the Information Technology Agency contract
Career aspirations: NASA Mission Specialist Astronaut
Why ECE: My Digital Design and Microprocessor Design courses have confirmed that I made the right choice.

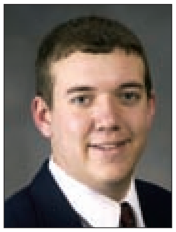
Edward Jones
EE '07
Richmond, VA
President and co-founder of Tech's Engineers Without Borders; Tau Beta Pi
Research: Honors thesis on power electronics with the Future Energy Electronics Center
Work experience: Department of Energy: I traveled around the country to meet with power and power electronics experts and discuss the DOE's fuel cell program



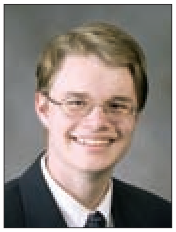
Zachary La Celle
CPE '09
Lansing, NY
University Honors Program; NSCS; soccer
Career aspirations: Research AI and robotics
My most memorable aspect of Tech experience has been both the digital logic and analog circuits classes.
Why ECE: electronics have always fascinated me and I want to learn exactly how they work and how to engineer them



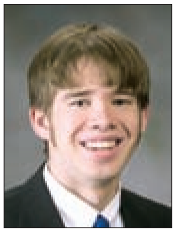
My Linh Pham
CPE/Physics '07
Annandale, VA
Minors: Microelectronics, Mathematics
Micron Scholar; Tau Beta Pi; Phi Beta Kappa; Sigma Pi Sigma; choir; swing dancing
Research: Spin Hall effect in semiconductors (physics) and half-metallic behavior of ferromagnetic CrSe nanocrystals
Why Virginia Tech: Virginia Tech told me that if I provided the desire and motivation, they would provide the means.



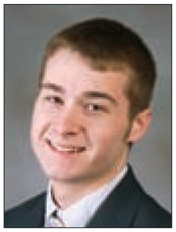
Adam Shank
CPE '07
Stuarts Draft, VA
University Honors Program; fencing
Co-op: Software engineer/ IBM
Most memorable experience: Current independent study: we are using Lego Mindstorms robots linked to PDAs and writing a group communications library for use with swarm technology.



Jacob Simmons
CPE '08
Smithfield, VA
Hillcrest Honors Community; intramural softball; intramural soccer
Why ECE: ECE is always a challenge to create and innovate, rather than simply relying on the research and methods of others. It is a field that changes people's lives with every new project.



Jerry Towler
EE '08
Greer, SC
Student Technology Council evaluating hardware and software for use in the engineering curricula
Career aspirations: Considering patent law—its application, interpretation, and abuse.
Summer plans: Working at DRT, Inc. to design automated testing software for industrial and military signal processing hardware.



Matthew W. Welch
EE '09
Richmond, KY
National Society of Collegiate Scholars; Student Engineers Council; Tao Beta Pi; WUVT Assistant Engineer; University Honors Program; IEEE; learning Chinese and Spanish
Why ECE: I have always been interested in how electricity works and how it can be applied to almost everything.

LIFE IN THE NASCAR FAST LANE

Carson routinely evaluates engine parts from Gibbs' vendors. In some cases, he can test the parts to higher tolerances than the suppliers can.

"Sometimes I find a substandard part or design," he says. "I might want to redesign and have our shop make the part. Some of our vendors sell to all the teams and, unless it's a safety issue, we'll just fix the problem ourselves and keep it a secret. Competitive advantage is important."

Cost is not an issue in the racing world, Carson says. "A fuel pump cable failed on Tony Stewart's car at Bristol. Tony could have won the race, so that cable breaking cost us about $100,000."

Each car has a 780-hp motor that costs more than $50,000 to make—and it is designed to last one race. The team goes through at least 280 engines, each designed for 500 miles, in one season, and it makes many parts for the engines in its modern machine shop. Carson, who worked for General Motors, loves the excitement and fast pace of the racing industry. "It's fun. It's something different every day, not like the corporate world where you work on one part for one car and it may not come out for four years. Here we see performance on the weekend."

Desha Carson

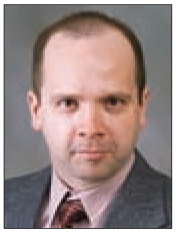
Matt Carson '98, as pilot

Carson enjoys tearing the engine apart and doing analyses after a race. The thrill of the race is not just vicarious with him; Carson has been racing in Sports Car Club of America autocross events since his college days, most recently in a Camaro. He also holds a commercial pilot's license and is working toward his flight instructor's rating this year.

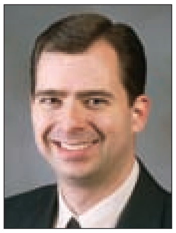
But Carson is spending more time at home these days. He and his wife, Desha, have a year-old son, Micah Matthew, who likes to spend time with his dad.

—By Su Clauson-Wicker

BRADLEY FELLOWS 2006-2007



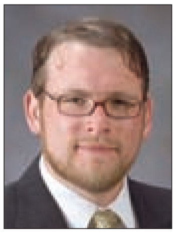
Mark W. Baldwin
BSEE '93, MSEE '05, Virginia Tech
Advisor: Yilu Liu
Research: Power system dynamic response to line and generator outages. Primary focus is the use of bulk power system eigenproperties to determine event type; location and assess overall power system condition. Also investigating generator rotor train torsional response to pulsating loads, transformer condition assessment, FACTS/ESSS applications in power system oscillation damping.



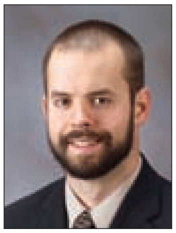
Aric D. Blumer
B.S. Engineering Science / Physics, '92, Bob Jones; MSCPE, '94, Clemson
Advisor: Cameron Patterson
Research: The acceleration of digital circuit simulation using process migration between hardware and software—moving busy processes into the hardware to be run in parallel and moving idle processes out of the hardware. Results show that for an example circuit description with 35 processes, the simulation can run 25 times faster.

More than 75 graduate students have been supported by the Bradley Fellowship program since it was instituted in 1988

Daniel Friend
BSEE, MSEE '98, Brigham Young University
Advisor: Allen MacKenzie
Research: Distributed cognitive networks, which can sense their environment, reason using observations and experiences, enact changes, and learn from prior actions. Developing architectures and analyzing distributed optimization and the trade-off between partial information and optimality.



Robert M. Gardner
BSEE '03, MSEE '05, Virginia Tech
Advisor: Yilu Liu
Research: Wide area monitoring and control of large-scale, complex networks, such as power systems. He is working on frequency data analysis and conditioning, power system event detection, and power system event location, using the FNET wide area frequency monitoring network developed at Tech.



Evan Lally
BSEE '03, MSEE '06, Virginia Tech
Advisor: Anbo Wang
Research: High-resolution particle imaging system for asphalt aggregates, plus preliminary investigation into the production of single-crystal sapphire structures for pressure sensing. Studying the adaptation of the LHPG method of growing single crystal sapphire fibers to product more advanced structures (see p. 31).

ALUMNI

JoAnn M. Adams (BSEE '94)
Co-owner, Big Fish Design
Centerville, Va.

Robert J. Adams (Ph.D. '98)
Assistant Professor, ECE
University of Kentucky

J. Shawn Addington (Ph.D. '96)
Department Head, ECE
Virginia Military Institute

Sarah S. Airey (BSCPE '01)

Christopher R. Anderson (BSEE '99) Post-Doctoral Associate; Virginia Tech

Matthew Anderson (BSCPE '04)

Nathaniel August (Ph.D. '06)

Carrie Ellen Aust (BSCPE '98)

William Barnhart (BSEE '00, MSEE '02)

Brian L. Berg (Ph.D. '01)

Ray A. Bittner, Jr (Ph.D. '97)

Kirsten Brown (BSEE '94)
Special Assistant to the CEO
MicroStrategy Inc.,
Alexandria, Va.

Steve Bucca (BSEE '87, MSEE '90)

Mark Bucciero (BSCPE '01, MSCPE '04) Argon ST, Inc.; Fairfax, Va.

R. Michael Buehrer (Ph.D. '96)
Assistant Professor
Virginia Tech

Charles F. Bunting (Ph.D. '94)
Associate Professor
Oklahoma State University

Carey Buxton (Ph.D. '02)

Scott C. Cappiello (BSCPE '94)
Senior Director of Program Management; MicroStrategy, Inc.,
Carlsbad, Calif.

J. Matthew Carson (BSEE '98)
Joe Gibbs Racing
Huntersville, N.C.

Ricky T. Castles (BSCPE '03)
Ph.D. Student; Virginia Tech

Eric Caswell (Ph.D. '02)

Kevin Cooley (BSEE '02)
IAS Corporation

Cas Dalton (BSCPE '03)

Phillip Danner (BSCPE '91)

Bradley A. Davis (Ph.D. '01)

Daniel Davis (BSEE '03)

Scott Davis (BSCPE '00)

Brian M. Donlan (MSEE '05)

Joel A. Donohue (MSEE '94)

Thomas Drayer (Ph.D. '97)

Bradley D. Duncan (Ph.D. '91)
Professor, ECE
University of Dayton

Gregory D. Durgin (Ph.D. '00)
Assistant Professor
Georgia Tech; won 2006 NSF CAREER award

W. Ashley Eanes (BSEE '95)
Duke Energy, Burlington, N.C.

Richard B. Ertel (Ph.D. '00)

Brian F. Flanagan (BSEE '97, MSEE '98)

Kevin P. Flanagan (BSCPE '00, MSCPE '01)

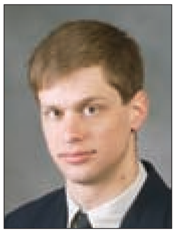
Todd Fleming (BSEE '94, MSEE '96)

Ryan J. Fong (BSCPE '01, MSCPE '04)

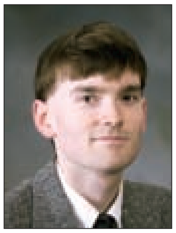
Jayda B. Freibert (BSEE '98)

Bradley H. Gale (BSEE '97)

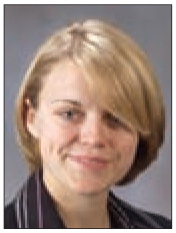
Mark Lehne
BSEE ’94, Seattle Pacific University; MSME ’98, MSEE ’00, Oregon State University
Advisor: Sanjay Raman
Research: Investigating new analog-to-digital conversion circuit architectures that improve a broadband wireless transceiver’s ability to efficiently detect information in the presence of strong interference. The goal is better overall performance while allowing for higher data rates and more intelligent transceivers (see p. 33).



Andrew Love
BSCPE ’05, University of Virginia
Advisor: Thomas Martin
e-Textiles research involving garment tracking and shape sensing. A user’s garments incorporate microprocessors and sensors, which allow the garments to monitor their acceleration and orientation. Additional technologies are currently being looked at that will allow for the clothing to detect their shape and position.



Keith McKenzie
BSEE ’01, MSEE ’04, University of Tennessee
Advisor: Yilu Liu
The utilization of wind energy with the power grid, including developing a model for wind turbine and associated power electronics interface. Issues being studied include the impacts of utilizing different configurations of energy storage, issues involved in connecting wind turbines to the grid, and low voltage ride-through capability of a wind turbine.



Parrish E. Ralston
BSEE ’06, Virginia Tech
Advisor: Kathleen Meehan
Research: Synthesis and characterization of II-VI nanoparticles. Room temperature and pressure techniques have been developed to produce CrSe and CoSe nanoparticles. Such nanoparticles have potential in the biomedical field, where they can be used as tags and as a contrasting agent in imaging.

David C. Reusch
BSEE ’04, MSEE ’06, Virginia Tech
Advisor: Fred C. Lee
Research: Developing improved voltage regulators for future computer microprocessors that will achieve higher efficiency and higher power density than current industry designs. He is currently studying high frequency DC/DC conversion at the 5-20 MHz switching frequency.

Justin Rice
BSEE/BSCPE ’02, MSEE ’04, University of Florida
Advisor: Cameron Patterson
Research: Develop tools to allow dynamic run-time reconfiguration of FPGA devices. He seeks to create a design environment that enables engineers to take advantage of the benefits offered by run-time reconfiguration while hiding the complexities involved (see p. 21).

“The Bradley Fellowship has given me the opportunity to work on leading edge stuff that doesn’t yet have commercial value, and thus few other sources of funding...”
—Neil Steiner

Daniel J. Gillespie (BSCPE ’95)

Brian Gold (BSEE ’01)
Ph.D. Student; Carnegie Mellon

Jonathan Graf (BSCPE ’02, MSCPE ’04) Luna Innovations, Blacksburg, Va.

Timothy Gredler (BSCPE ’03)

Christopher Robert Griger (BSCPE ’02)

Alex Hanisch (BSCPE/Math ’03)
Joint Warfare Analysis Ctr., DoD

Abigail Harrison (BSCPE ’04)

Jennifer J. Hastings (BSEE ’96)

Dwayne A. Hawbaker (MSEE ’91)
Senior Staff Engineer; Johns Hopkins Applied Physics Lab

Matt C. Helton (BSEE ’01)
Resident EE; Coal Gasification Plant; Eastman Chemical Co.; Kingsport, Tenn.

Benjamin E. Henty (MSEE ’01)

Jason Hess (MSEE ’99)

H. Erik Hia (MSCPE ’01)
Software Engineer
Hatteras Networks, N.C.

James Hicks (Ph.D. ’03)

Hugh E. Hockett (BSCPE ’03)

Janie Hodges (BSCPE ’01)

Spencer Hoke (BSCPE ’03)

Russell T. Holbrook (BSCPE ’03)

Andrew Hollingsworth
BSCPE ’02

Ryan Hurrell (BSEE ’03)

John Todd Hutson (BSEE ’93)

Madiha Jafri (BSCPE ’03)

Daniel A. Johnson (MSEE ’01)

Adam Kania (BSEE ’01)

David A. Kapp (Ph.D. ’96)

Dimosthenis C. Katsis (Ph.D.’03)

David Kleppinger (BSCPE ’04)

Paul A. Kline (Ph.D. ’97)

Gregory Kozick (BSCPE ’03)

William B. Kuhn (Ph.D. ’95)
Professor, EECE
Kansas State University,

Jeffery D. Laster (Ph.D. ’97)
Product Specialist, Analog, Mixed Signal, and RF IC; MentorGraphics

Charles Lepple (BSEE ’99, MSEE ’04)

Jason Lewis (BSEE ’99)

Joseph C. Liberti (Ph.D. ’95)

Zion Lo (BSEE ’94)
Sr. Software Engineer/Architect
IQNavigator, Colorado

Daniel L. Lough (Ph.D. ’01)

Cheryl Duty Martin (BSEE ’95)

Stephanie Martin (BSEE ’04)

Michael Mattern (BSEE ’02)

Christopher Allen Maxey (BSCPE ’02)

Eric J. Mayfield (BSEE ’97)

Patrick McDougle (BSEE ’03)

Brian J. McGiverin (BSCPE ’96)

John T. McHenry (Ph.D. ’93)
Senior Electrical Engineer,
U.S. Department of Defense

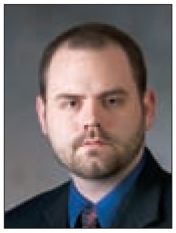
David McKinstry (MSEE ’03)

Garrett Mears (BSCPE ’00)
Head of Development
Open Vantage Ltd.,London

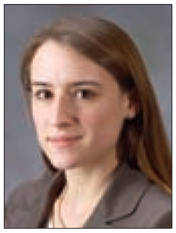
Vinodh Menon (BSCPE ’02)

Michael Mera (BSEE ’03)

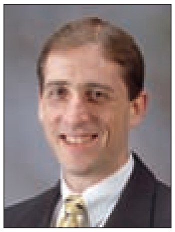
BRADLEY FELLOWS CONTINUED



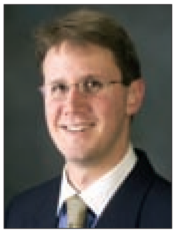
Thomas Rondeau
BSEE '03, MSEE '06, Virginia Tech
Advisor: Charles Bostian
Research: Developing cognitive radio systems that intelligently optimize wireless communications devices by appropriately tuning software "knobs" to improve performance and service. He is specifically working on the AI algorithms used to create the intelligent optimization processes.



Rebecca Shelton
BSE EE, BA English Writing '06, University of Tennessee at Chattanooga
Advisor: William Baumann
Research: Mathematical modeling and parameter estimation of small gene networks, especially man-made networks created by synthetic biology. She is currently modeling the activation switch of the HIV virus. Such models will aid in designing synthetic gene networks and understanding natural gene networks.



Neil J. Steiner
B.A. '98 Wheaton; BSEE '98 Illinois Institute of Technology; MSEE '02 Virginia Tech
Advisor: Peter Athanas
Research: Developing infrastructure and proof-of-concept for autonomous computing systems that take increased ownership for their resources and operation. Developed the first known occurrence of a system changing its own hardware in a non-trivial fashion while in operation (see p. 20).



Douglas R. Sterk
BSEE '00, MSEE '03, Virginia Tech
Advisor: Fred. C. Lee
Research: Voltage regulator modules for advanced microprocessors targeting Intel Corp.'s 2010 specifications. He and David Reusch are improving the packaging and thermal design to make use of advanced circuit design techniques and magnetic layout techniques, and selecting an optimal silicon design for server applications.

Juan E. Suris
BSEE '96, Puerto Rico; MCSPE, '98 Northwestern; MS Statistics, '99, Chicago
Advisor: Luiz DaSilva
Research: Game theoretic approach to opportunistic spectrum sharing. Researchers are seeking to improve efficient use of the limited spectrum. Also exploring cooperation among users to achieve fair and efficient spectrum access.

Ethan Swint
MSECE '02, Baylor; MSME '05, University of Texas, Austin
Advisor: Krishnan Ramu
Research: Power electronics and switched reluctance drives, with an emphasis on reducing drive complexity and cost, including the development of new control algorithms. SR drives are expected be more efficient and reliable than traditional motors and generators, with lower cost.

ALUMNI

Carl Minton (MSCPE '99)

John Morton (MSEE '98)

Stephen Nash (BSCPE '03)

Troy Nergaard (MSEE '00)
Tesla Motors; San Carlos, Calif.

Michael H. Newkirk (Ph.D. '94)
Applied Physics Laboratory
Johns Hopkins University

Paul Erik Nguyen (BSCPE '98, MSCPE '99)

J. Eric Nuckols (BSEE '97, MSEE '99); Associate Principle Embedded Software Engineer; ITT Advanced Engineering & Sciences

Neal Patwari (BSEE '97, MSEE '99)

Joseph Allen Payne (BSEE '00)

W. Bruce Puckett (MSEE '00)

Yaron Rachlin (BSEE '00)

Christian J. Reiser (Ph.D. '05)

Steve Richmond (MSEE '01)

Jamie Riggins (BSEE/BSCPE '04)
Graduate Student, Virginia Tech

Pablo Max Robert (Ph.D. '03)

Thomas W. Rondeau (BSEE '03)
Ph.D. Student; Virginia Tech

Thomas M. Rose (MSEE '96)
Engineer/Scientist IV
Boeing, University City, Mo.

Jon Scalera (MSCPE '01)

Amy Schneider (BSCPE '03)

Steven Schulz (MSEE '91)

David C. Schroder (BSEE '05)

Jeff Scruggs (MSEE '99)

Kashan Shaikh (BSCPE '02)
Ph.D. Student
University of Illinois

Raymond A. Sharp (BSEE '02)

Roger Skidmore (Ph.D. '03)

Jeff Smidler (BSEE '98)

Amanda (Martin) Staley (BSEE '99, MSEE '01)

Graham Stead (BSCPE '93)

Douglas R. Sterk (MSEE '03)
Ph.D. Student, Virginia Tech

Scott Stern (BSEE '93)

Samuel S. Stone (BSCPE '03)

Anne (Palmore) Stublen (BSEE '91) Newark, Del.

Seema Sud (Ph.D. '02)

David Tarnoff (MSEE '91)
Assistant Professor
East Tennessee State University

Daniel Tebben (Ph.D. '06)

Rose Trepkowski (MSEE '04)

Christian Twaddle (BSCPE '01)

Matthew C. Valenti (Ph.D. '99)
Associate Professor
West Virginia University

Wesley Wade (BSEE '93)

Kristin Weary (BSEE '03)

Michael L. Webber (MSEE '03)

Jason Wienke (BSEE '02)

Thomas Williams (BSEE '00)

William J. Worek (BSCPE '99)

Kai Xu (BSEE '95)

Jason Jon Yoho (Ph.D. '01)

Gregory A. Zvonar (MSEE '91)

HONORS & ACHIEVEMENTS

Honors & Awards

Arun Phadke was one of four professors honored with the "Docteur Honoris Causa di l'INP Grenoble."

Tom Martin was honored as a recipient of the Presidential Early Career Award for Scientists and Engineers (PECASE).

Patrick Schaumont received an NSF CAREER award for "Hardware/Software Codesign for Secure Embedded Systems: Methods and Education."

Yong Xu received an NSF CAREER award for "Single Carbon Nanotube Based Nano-Optical Imaging."

Jason Lai was named an IEEE Fellow.

Amy Bell was awarded the IEEE Outstanding Student Branch Counselor award.

Daan Van Wyk received the IEEE Power Electronics Society 2006 Distinguished Service Award.

Fred Lee was the keynote speaker at the 10th International Conference on Optimization of Electrical and Electronic Equipment (OPTIM '06), May 2006.

Dushan Boroyevich was named the American Electric Power Professor of ECE.

Anbo Wang was named the Clayton Ayre Professor of ECE.

Jim Thorp was named Power Engineering Educator of the Year and also was recognized by the U.S. National Committee of CIGRE as an Attwood Associate.

Krishnan Ramu was an invited keynote speaker at the International Conference on Industrial Technology, December 2006.

National & International Service

Amy Bell is serving as chair of the Public Awareness Committee of the IEEE Educational Activities Board.

Ira Jacobs serves on the Federal Communications Technological Advisory Council as a special government employee.

Scott Midkiff is serving as program director for the National Science Foundation, Division of Electrical, Communications and Cyber Systems.

Krishnan Ramu served as a distinguished lecturer for the IEEE Industrial Electronics Society.

Saifur Rahman is serving as an IEEE Distinguished Lecturer.

Conference Chairs

Peter Athanas served as co-chair of Dynamically Reconfigurable Architectures, April 2006.

Thomas Hou chaired the First IEEE Workshop on Networking Technologies for Software Defined Radio Networks, September 2006.

Michael Hsiao served as general chair of the IEEE International High Level Design Validation and Test.

Fred Lee was general chair of the International Power Electronics and Motion Control Conference, August 2006.

Allen MacKenzie and **Luiz DaSilva** co-chaired the 1st Workshop of Game Theory for Networks (GameNets), which will expand into a full-sized conference in 2008.

Tom Martin was program co-chair of the 2006 International Symposium on Wearable Computers, sponsored by the IEEE Computer Society.

Krishnan Ramu served as General Co-Chair of IEEE Industrial Electronics Society's International Conference on Industrial Technology, December 2006.

Editorships

Amy Bell is serving as associate editor of *IEEE Signal Processing Letters* and *IEEE Signal Processing Magazine*.

Michael Buehrer is associate editor of *IEEE Transactions on Wireless Communications*, *IEEE Transactions on Vehicular Technologies*, and *IEEE Transactions on Signal Processing*.

Luiz DaSilva is associate editor of the *IEEE Communications Letters*.

Thomas Hou is editor of the *IEEE Transactions of Wireless Communications*, associate editor for *IEEE Transactions of Vehicular Technology*, editor of *ACM/Springer Wireless Networks*, and editor of *Elsevier Ad Hoc Networks*.

Michael Hsiao served as guest editor of *ACM Transactions on Design Automation of Electronic Systems*.

Lamine Mili is co-editor of the *International Journal of Critical Infrastructures*.

T.-C. Poon is associate editor of the *International Journal of Optomechatronics* and topical editor of *Applied Optics*.

Sanjay Raman is serving as associate editor of *IEEE Transactions on Microwave Theory and Techniques*.

Saifur Rahman served as guest editor of the *Proceedings of IEEE*.

Sandeep Shukla is associate editor for *IEEE Design & Test*, *IEEE Transactions of Industrial Informatics*, and co-guest editor of a special issue on "Electronic System Level Design" of *IEEE Design and Test magazine*.

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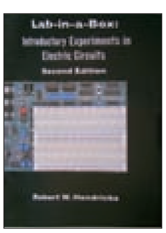

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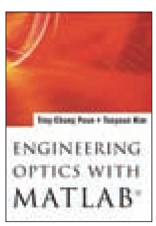

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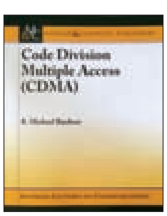

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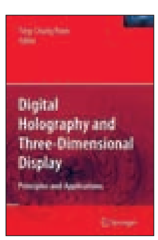

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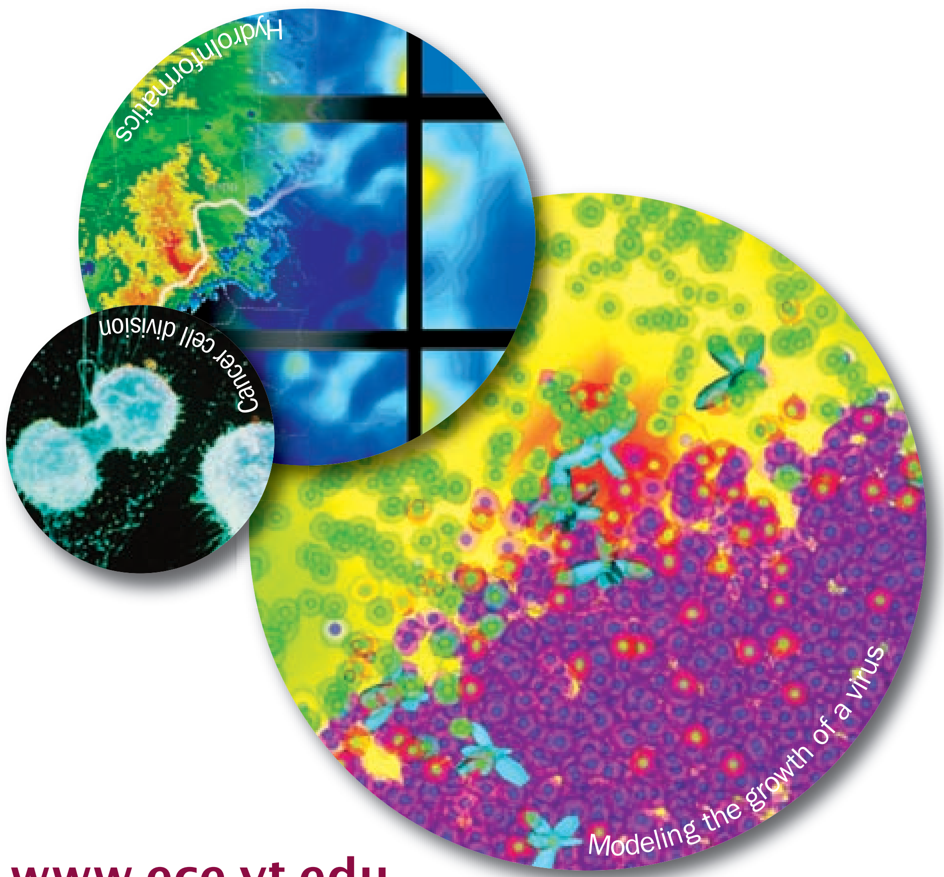

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