Welcome

On behalf of our students, staff, and faculty, it is my great pleasure to welcome you and invite you to discover the Electrical and Computer Engineering Department at The University of Arizona. Established in 1910 as the Electrical Engineering Department, we have a long and rich history and an outstanding record of contributions to the profession and community.

This publication highlights the key areas of our activities, strengths, and accomplishments. You will learn about the signature research we pursue and our spirit of innovation and discovery. You will read about our extensive outreach that goes well beyond engineering. Our activities span a spectrum of projects from Theater Arts and Entertainment Technologies to Astronomy, Neuroscience, and Medicine, just to name a few. Electronics and computer-based technologies are the foundation of modern life. We are proud to contribute to their advancement and the society at large.

At present, we are rapidly recruiting and hiring exceptional new faculty who strengthen our teaching and research in both fundamental and signature research areas. Compelled by significant changes in the funding model of public universities, we have become increasingly self-reliant. As this has become a necessary condition to sustain a vibrant and well-functioning department, we continue to grow externally funded programs. We also benefit from the generous support of the community, private donors, and industry sponsors. Such aid is indispensable in providing need-based student assistance, which is a core tenet of our mission. For such support, we are grateful.

We are also affecting changes to the undergraduate and graduate curricula so that they reflect state-of-the-art electrical and computer engineering, and provide adequate breadth, depth, and rigor. We are deeply committed to excellence in student training at all degree levels and maintain focused efforts to attract top student talent to our programs. ECE faculty, together with outstanding administrative, student advising, and technical support staff, have created an environment that fosters collaboration, a culture of accomplishment, and strong support of ethnic, cultural, and intellectual diversity.

I invite you to read on and see for yourself.

With Warm Greetings,
Dr. Jerzy W. Rozenblit
Professor and Department Head

Our Mission

The mission of the ECE Department is to maintain programs of excellence in teaching and research that support the State of Arizona as a leading center for high-technology industry, and address national needs for the development and application of electronic and computer-based technologies. With its broad range of instructional and research activities, the ECE Department conducts a strong program of undergraduate and graduate instruction and research that has earned a distinguished national reputation.
UA's ECE Department is a national leader in teaching innovation. With ABET-accredited undergraduate programs in both Electrical Engineering and Computer Engineering, our curriculum is built around a systems approach to engineering design, emphasizing communication and teamwork as critical skills for the modern professional.

While new courses are regularly introduced into both the undergraduate and graduate curricula to keep pace with emerging technologies, our efforts to produce capable, world-class engineers go beyond technology. For example, over the past six years the Department has imbedded a formal writing assessment process into its undergraduate curriculum. Fostered by faculty attuned to encouraging writing as part of their course requirements, this effort has led to measurably enhanced writing ability for our engineering graduates.

We also possess excellent physical infrastructure, including a state-of-the-art computer classroom called the Integrated Information Technology Laboratory that allows our faculty an excellent venue for demonstrating, explaining, and teaching students how best to understand and utilize complex software tools and environments.

Undergraduate Students (Fall 2005)
- Undergraduate Enrollment: 677
  - Domestic Students: 568
  - International Students: 109
- BSEE Degrees Conferred: 81
- BSCE Degrees Conferred: 58

Graduate Students (Fall 2005)
- MS Degree Enrollment: 142
  - Domestic Students: 59
  - International Students: 194
- MS Degrees Conferred: 45
- PhD Degrees Conferred: 10

Faculty and Staff
- Tenure Track Faculty: 34
- Joint Faculty: 16
- Emeritus Professors: 13
- Professionals: 14
- Staff: 22

Professional Members
- IEEE Members: 17
- Senior Members: 14
- Fellows: 8
- OSA Members: 3
- Fellows: 3
- SPIE Members: 4
- ASEE Members: 2

“The ECE faculty helped me develop my research skills early on as an undergraduate, and after being exposed to a broad range of disciplines, I decided to stay on as a graduate student in electromagnetics.”

– Beatrice Fankem, Master’s Student
The ECE Department supports over 40 research and teaching labs, all housed in a modern building that includes more than 35,000 square feet of lab space.

**Research Labs**

- Analog Microelectronics Laboratory
- Antenna and Packaging Laboratory
- Artificial Intelligence and Simulation Laboratory
- Atmospheric Remote Sensing Laboratory
- Wireless and Advanced Networking Group
- Computer Aided Design Laboratory
- Computer Vision Laboratory
- Condensed Matter Photonics Laboratory
- Digital Image Analysis Laboratory
- Embedded Systems Design Laboratory
- Fiber and Integrated Optics Laboratory
- The Higgins Lab
- High Performance Distributed Computing Laboratory
- High Performance Embedded Computing Laboratory
- Information Processing and Decision Systems Laboratory
- Integrated System Design Laboratory
- Intelligent Systems Laboratory
- Lab for Sensor and Array Processing
- Microwave and mmW Laboratory
- Microwave Engineering Laboratory
- Model Based System Design Laboratory
- Nanostructures and Circuit Simulation Laboratory
- Numerical Computing Laboratory
- Optical Computing and Processing Laboratory
- Optical Materials Research Laboratory
- Optical Networking and Parallel Processing Laboratory
- Photonics Systems Laboratory
- Signal and Image Laboratory
- Signal Processing and Coding Laboratory
- Tissue Optics Laboratory
- VLSI Design Laboratory

**Teaching Labs**

- Biomedical Instrumentation Laboratory
- Graduate Computer Laboratory
- Integrated Information Technology Laboratory
- Microwave Engineering Laboratory
- Undergraduate Classroom Labs (6)
- Undergraduate Computer Laboratory

**ECE Seniors Win Design Award**

It’s like getting something for nothing – electricity from the vibrations that naturally occur when goods are moved by ship, plane, truck, or train.

A team of ECE seniors recently designed a device that converts these vibrations to electricity for trickle charging batteries in GPS tracking units made by local Tucson company ARGO Tracker.

"Companies can put these tracking units in their shipments and then log onto the Internet to see the progress of their shipment in real time," said EE senior David Tinnin.

"The tracking unit has a lithium-ion battery that lasts 2 to 4 weeks. After that, it has to be hooked to an external power source and recharged. We want to eliminate the external power source and make these tracking units self-sufficient, so they can be deployed indefinitely."

The ECE team included three electrical engineers (David Tinnin, Kyle Zukowski, and Asher Kells) and two computer engineers (Victor Mendez and Daniel Burillo). The electrical engineers worked on the circuitry, while the computer engineers wrote the code for the device.

After designing the device and a circuit board and then writing the software for the microcontroller, the students built a prototype system, which they displayed at UA’s Engineering Design Day. Their "Piezoelectric-Based Portable Power System" won the $500 Texas Instruments Best Electrical and Computer Engineering Design Award at the event.
Emeritus Professor and Former Department Head John Reagan, an internationally recognized authority on LIDAR (Light Detection and Ranging), won NASA’s Distinguished Public Service Medal in 2005. NASA grants the award “only to individuals whose distinguished accomplishments contributed substantially to the NASA mission. The contribution must be so extraordinary that other forms of recognition would be inadequate.” Part of his contribution continues with CALIPSO, the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite. CALIPSO combines LIDAR with infrared and visible-light imagers to examine the vertical structure and properties of thin clouds and aerosols. This mission will help scientists improve their understanding of the effect of human activity on the atmosphere.

Assistant Professor Janet Wang won a NSF CAREER Award for Variational Methods for Design Complexity in Nanometer VLSI Circuits. The 4-year project entails building electronics design automation (EDA) software tools that will automate many steps in circuit design, reducing the complexity of the process. This will help improve yields in circuit fabrication labs, translating to huge revenue savings for high-volume chip manufacturers. Professor Wang was also awarded the 2005 Presidential Early Career Award for Scientists and Engineers for her EDA work. This is the nation’s highest honor for professionals at the outset of their independent research careers.

Professor Michael Marcellin was honored with the 2006 UA Technology Innovation Award for his major contribution to the design and promulgation of JPEG2000. The Technology Innovation Awards are given annually to selected University of Arizona researchers in recognition of excellent, innovative achievements in translating original ideas from the laboratory to the marketplace. Not only did he literally help write the book on JPEG2000, Professor Marcellin became part of the ISO Standards Committee that selected his team’s algorithm design (from approximately two dozen international entries) as the second-generation standard for image compression. With countless commercialization opportunities, his efforts focus chiefly on applications of JPEG2000 in digital cinema. Indeed, in the next 3 to 5 years all major theaters will convert to digital projection technologies and will employ this premiere encoding solution for the distribution of digital movies.

Each year, the National Training and Simulation Association recognizes non-DoD individuals or teams for outstanding achievements in the development or application of models and simulations. Awards are given for outstanding achievement in the specific Modeling and Simulation (M&S) functional areas, as well as for outstanding achievement in support of the overall M&S effort. Professor Bernard Zeigler and Master’s student Eddie Mak won the overall award in 2005 for ATCGen (Automated Test Case Generator) - an M&S-based methodology and software toolset developed to modernize and automate standards conformance testing required in systems acquisition. They had previously won the Golden Eagle Award - the highest award given to civilian contractors - from Ft. Huachuca’s Joint Interoperability Test Command for the same work. Based on formal DEVS theory, ATCGen is leading an evolution to rigorous, automation-capable M&S-based acquisition-support methodology.

“UA ECE…Where Excellence is a tradition”
Microwave to Optical Metamaterials

In recent years, there has been a growing interest in advanced materials that either mimic known material responses or that possess qualitatively new physical behaviors that do not occur (or may not be readily available) in nature. These “metamaterials” are artificial materials whose electromagnetic and optical properties can be tailored to specific applications, including revolutionary concepts in electrically small radiators and sensors, resonant devices and components, miniaturization of cavities and waveguides, transparency and scattering management for high- or low-observables, imaging and nanolithography, nanoantennas and nanosensors, and nano-scale circuit elements and nanosystems.

A research group led by Professor Richard Ziolkowski is investigating the interactions of electromagnetic fields at microwave and optical wavelengths with complex materials and structures. As a major participant in a DARPA-funded effort, his team is investigating the use of metamaterials to realize efficient, electrically small antennas for commercial and military wireless communications applications.

The potential impact of metamaterials is enormous: if one can engineer and tailor the wave properties of these artificial materials for specific applications, significant decreases in the size and weight of components, devices, and systems appear to be realizable, along with attendant performance enhancements.

Other ECE faculty pursuing related research include: Nathan Goodman, Kathleen Melde, Mark Neifeld, Kelly Simmons Potter, and Hao Xin.

Mixed Signal Electronics and Packaging

As chip complexity and speed continue to increase, the performance of electrical systems will be increasingly affected and ultimately dominated by the electrical performance and characteristics of the package and interconnects. To effectively address the opposing requirements of design accuracy and CPU efficiency, system design and simulation must include the high frequency effects of such structures.

UA’s ECE Department has been involved in packaging research for over 20 years. A diverse number of novel modeling and simulation tools and techniques have been developed, principally within the Center for Electronic Packaging Research. The development of these tools has been augmented by frequency and time domain measurements. The research has provided an in-depth understanding of the electromagnetic and circuit-related behavior of high density signal interconnects and power delivery systems for high-speed digital, and mixed digital/analog/RF systems. Ongoing research in these areas is influenced by future needs as specified in the International Technology Roadmap for Semiconductors (ITRS), the Semiconductor Research Corporation (SRC), and the NSF.

ECE faculty pursuing Packaging and other Mixed Signal Electronics research include John Brews, Steven Dvorak, Charles Higgins, Kathleen Melde, Dongsheng Ma, Olgierd Palusinski, Harold Parks, and Janet Wang.
Engineering large-scale, complex, computer-based systems (e.g., computational architectures based on biological neural systems, on-chip power management for VLSI systems, and landuse effects on biodiversity) requires advanced simulation modeling. The ECE Department has established a strong program not only in the development of concepts and techniques for simulation modeling frameworks, but also in developing principles and methods for explicitly enabling, validating, and verifying these simulation models. Major projects in modeling and computer simulation, hardware/software codesign, design decision support, and visualization have been funded by the NSF, US Army Research Laboratories, NASA, and numerous industry sponsors.

The Model Based System Design Laboratory, directed by Professor Jerzy Rozenblit, has recently partnered with The Arizona Simulation Technology and Education Center (ASTEC) at UA’s College of Medicine to build virtually assisted surgical training and performance modules for laparoscopic procedures. In this type of procedure, surgeons lose many of the tactile and visual cues they rely upon in conventional surgery. The prototype developed jointly with ASTEC implements sensor-based tracking that collects and fuses data about the surgical instruments and how they are being used.

Professor Rozenblit’s lab is also developing a system that delivers multi-sided operational evolution for military operations and stability and support operations. Based on the concepts of genetic algorithms and game theory, this decision support simulation environment will consider cultural, psychological, economic, and linguistic data to develop meaningful and relevant potential courses of action for military and civilian decision-makers.

Other ECE faculty pursuing simulation modeling research include Ali Akoglu, Salim Hariri, Charles Higgins, Roman Lysecky, Dongsheng Ma, Michael Marefat, Miklos Szilagyi, Hal Tharp and Bernard Zeigler.

High Performance Computing

Over the past several years, high-throughput technologies have led to an exponential growth in the amount of data generated in the fields of geophysics, biosciences, signal processing, and image and video processing. Yet current technologies fall short of providing low cost, scalable, and flexible solutions in responding to such processing demands. These drawbacks have compelled ECE faculty to research, develop, and design novel architectures and networks for scalable high-performance computing (HPC) systems.

Assistant Professor Ali Akoglu is delving into custom configurable logic and interconnect design tailored to the computation characteristics of specific target applications. Configurable computers based on Field Programmable Gate Arrays (FPGAs) are capable of accelerating suitable applications by several orders of magnitude compared to traditional processor-based architectures, and have the great potential of delivering less expensive systems with faster number crunching capability.

Assistant Professor Roman Lysecky is designing dynamically adaptable computing systems that automatically adjust execution to increase performance or reduce energy consumption. One of his research projects involves “warp processors” that dynamically and transparently optimize an executing software binary by moving software kernels to on-chip configurable logic. Warp processors have been shown to improve performance seven-fold and more, and reduce energy consumption by an average of nearly 50%.

Professor Salim Hariri is investigating “autonomic computing” middleware that employs biologically-inspired strategies to deal with complexity, heterogeneity, and uncertainty. Autonomic computing aims to engender computing systems and applications capable of managing themselves with minimum human intervention.

Professor Ahmed Louri leads a team that is exploring scalable optical interconnects, chip multiprocessors, power-aware parallel architectures and networks, and network-on-chips. One of his chief research efforts is an optical interconnect based system architecture called RAPID (Reconfigurable, All-Photonic Interconnect for Distributed and parallel systems), which maximizes bandwidth, reduces network latency, and dynamically reconfigures the network by adapting to communication traffic – and scales to roughly 4,000 nodes!

Other ECE faculty involved in High Performance Computing research include Elmer Grubbs and Susan Lysecky.
As the demand for pervasive and increasingly sophisticated communications escalates throughout commercial, industrial, and military domains, ECE is tackling the hard questions related to both wired and wireless networking. One such question that is repeatedly highlighted in emergency situations around the globe is the issue of seamless connectivity in harsh wireless environments that are characterized by highly fluctuating bit error rates, low channel bandwidth, and user mobility. In such environments, “conventional” radios with omni-directional antennas and fixed-spectrum allocation cannot achieve high throughput and/or timely information delivery, as required by various critical applications. Accordingly, the networking group is investigating new generations of network protocols and channel-access mechanisms tailored for next-generation radios, including smart antennas with beam-forming capabilities, multi-input, multi-output (MIMO) communications, and cognitive radios (CRs).

Inspired by research on software-defined radios, CRs promise to provide programmable wireless communications whenever and wherever needed through efficient (dynamic) sharing of the radio spectrum. By exploiting underutilized portions of the frequency spectrum (a.k.a. “white spaces”), CRs can perform opportunistic communications, significantly boosting the network performance.

They can also provide interoperability between heterogeneous legacy wireless devices, thus improving network connectivity. Although the development of CRs is still at the conceptual stage, the technology has already attracted attention from government agencies and private corporations. By collaborating on both the hardware and software challenges, UA ECE is working to make good on the enormous promise of these next-generation communication devices.

Substantial research in wireless optical communications is also underway, including a medium-scale NSF ITR grant focused on Advanced Optical Networks. Led by Professor Bane Vasic, the program’s goal is to develop a framework for error control in combination with bandwidth management and routing in optical networks that is aware of optical channel characteristics and can allocate network resources to optimize system performance.

ECE faculty involved in networking-related research include Shuguang Cui, Ivan Djordjevic, Salim Hariri, Raymond Kostuk, Marwan Krunz, Michael Marcellin, Mark Neifeld, Srinivasan Ramasubramanian, William Ryan, and Bane Vasic.

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**Optical Imaging Systems and Image Processing**

The Optical Computing and Processing Laboratory (OCPL) within ECE is a prime example. Directed by Professor Mark Neifeld, OCPL has involved itself since 1991 with research projects in the general areas of optical communications, optical data storage, and non-traditional/computational optical imaging. Its current DARPA-sponsored MONTAGE (Multiple Optical Non-Redundant Aperture Generalized Sensors) program seeks to develop and demonstrate truly revolutionary imagers that balance the burden of image information more equally.
between optical and electronic sub-systems. These so-called computational imagers are enabled by recent advances in non-traditional optical components as well as the substantial processing capabilities of modern CMOS VLSI. The joint optimization of optical and post-processing degrees is just beginning to yield important results in terms of imager performance, form factor, and cost (e.g., size, weight, power, complexity).

New techniques are also being developed for use in the processing and analysis of digital signals and images for a variety of applications, particularly in the biomedical field. Our faculty are actively involved in optical coherence tomography, automated tissue classification with confocal microendoscopic images, analysis of chromosome images for cytogenetic applications, color histogram modification for image enhancement, and segmentation of cranial magnetic resonance images.

Numerous other research projects include the development of image restoration and super-resolution algorithms, digital image watermarking, watermarking of VLSI layouts, texture analysis of aeromagnetic anomaly images for geological classification, sensor fusion for target surveillance and tracking, and spectral-spatial imaging with volume holographic elements.

ECE faculty pursuing research in these domains include Jennifer Barton, Raymond Kostuk, Michael Marcellin, Mark Neifeld, Jeffrey Rodriguez, Robin Strickland, Malur Sundareshan, and Urs Utzinger.

**Coding and Compression**

Source and channel coding are imperative research domains for digital communication and data storage systems. ECE’s internationally-recognized faculty is pursuing research in a variety of related areas, including:

- Image compression of 2D, 3D, and higher-dimensional image sources
- Graph-based codes for data transmission and storage, including turbo and Low-Density Parity-Check codes
- Constrained codes for magnetic disk, optical disc, and holographic storage
- VLSI implementations of advanced coding methodologies

Source codes seek to represent source information with a minimum of symbols. ECE’s source coding research is focused on the compression of imagery and video. Professor Michael Marcellin is one of the two primary researchers responsible for the development of the recent JPEG2000 image compression standard. This standard is already having enormous impact on science, medicine, and culture – from the way scientists explore Mars to the way surgeons analyze live medical imagery to the way we enjoy movies. In the next several years, JPEG2000 will also be implemented in digital cameras, web browsers, and even in digital movie theaters.

Whereas the role of a source code is efficient representation of information, the role of a channel code is to allow reliable transmission or storage of information. The research being directed by Professors William Ryan and Bane Vasic involves the design of channel codes for transmission on wireless communication channels, satellite channels, optical fiber channels, magnetic disk or tape drives, and optical disk drives. Each of these applications involves different tradeoffs, balanced between theoretical and practical work. Prof. Vasic also directs research in the area of constrained coding that has applications in magnetic and optical recording as well as optical fiber transmission systems.

ECE faculty involved in coding and compression research include Michael Marcellin, Mark Neifeld, William Ryan, and Bane Vasic.
The Arizona Center for Integrative Modeling and Simulation (ACIMS) is devoted to research and instruction that advance the use of modeling and simulation as a means to integrate disparate partial solution elements into coherent global solutions to multidisciplinary problems. To accomplish this, the Center advances the concepts, tools, and methodology of modeling and simulation so that it can make the enormous computation power available today applicable to emerging problems requiring multidisciplinary solutions.

www.acims.arizona.edu

The Center for Microcontamination Control (CMC) Founded in 1984, the Center for Microcontamination Control is a NSF Industry/University Cooperative Research Center devoted to contamination control for the semiconductor industry. CMC projects involve faculty and students from Electrical and Computer Engineering, Chemical and Environmental Engineering, Materials Science and Engineering, Optical Sciences, Physics, and Chemistry.

www.ece.arizona.edu/-cmc

Connection One is a NSF Industry/University Cooperative Research Center working closely with private industry and the federal government on various projects in RF and wireless communication systems, networks, remote sensing, and homeland security. Connection One’s mission is to develop the technology to enable end-to-end communication systems for a variety of applications, ranging from cellular to environmental and defense applications. One aspect of the research is the development of integrated RF and wireless circuits-on-a-chip to simplify and enable a small, portable, all-in-one communication device. An additional research focus is the development of efficient architectures and routing techniques for networked applications. The industry/university partnership combines an academic environment with state-of-the-art research initiatives and real-world applications. Currently, Connection One has over 18 industry members and 4 university members: University of Arizona, Arizona State University, University of Hawaii, and Rensselaer Polytechnic Institute.

www.connectionone.org

The Center for Electronic Packaging Research (CEPR) performs funded research in the areas of electrical and thermal characteristics of electronic device packages and interconnected devices. Modeling and simulation of these characteristics as well as experimental verification of the modeling results is also being conducted. Founded by the late Dr. John L. Prince III, a member of ECE’s faculty for 22 years, the program’s support has been provided primarily by research contracts and student fellowships from the Semiconductor Research Corporation (SRC). Professor Prince was instrumental in creating SRC’s packaging program, serving as Distinguished Visiting Scientist and Director of Packaging Sciences at SRC in 1991-1992. CEPR continues his legacy of leadership and innovation in an industry dominated by the electrical performance and characteristics of electrical system packaging and interconnects.

www.ece.arizona.edu/-cepr
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