Department of Electrical & Computer Engineering

April 2006

Industrial Affiliates Newsletter

Department of Electrical and Computer Engineering: Quick Overview

The Department of Electrical and Computer Engineering at UC Davis has a long-standing tradition of continuing enhancement to undergraduate and graduate education and high quality research from its faculty. We are one of the largest departments in the College with 30+ ladder-rank faculty, 15 emeritus professors, and several adjunct and research faculty, post-docs and visiting scholars.

We serve over 700 undergraduate and 185 graduate students, meeting the needs of a diverse constituency. Our mission, research and educational objectives, and program objectives stem directly from the land grant origins of the University of California and our constituent's needs.

Our research activities are broadly divided into seven major areas of electrical and computer engineering. Specifically, our faculty actively conduct research in Communication, Signal & Image Processing; Computer Engineering; Electronic Circuits; Optoelectronics; RF, Micro- & Millimeter Waves; Solid State Electronic Devices and Systems & Control.

Our faculty's research and teaching activities receive constant recognition from professional communities and sponsoring agencies. The recent $9.5M DARPA grant for research in ultra-fast optical networking, two NSF CAREER awards to two of our assistant professors, and election of a senior faculty member as IEEE Fellow are just a few examples that happened recently. This issue covers recent news of our department in more depth.

In addition to graduate student education and research, our undergraduate programs provide a rigorous foundation, and enhance the undergraduate experience through exposure to a strong research environment.

Message from the Chairman

Professor Bahram Ravani

I would like to welcome everyone to our Industrial Affiliate Program (IAP). The department is making outstanding progress in its path to excellence.

This year our department ranking has increased to be number 33 among more than 270 Universities in "America's Best Graduate School's " ranking of US News, two of our recent faculty hires have received the prestigious NSF CAREER award, the department has established a new center on "Intelligent and Integrated Networking Systems" headed by Professor S.J. Ben Yoo with major multi-million dollar funding from DARPA, and we have also been able to receive new major funding for support of our graduate students through a GAANN award and for upgrading our computer facilities through a competitive grant from Intel corporation.

I am hoping that our Industrial Affiliates will help us add industrial relevance to our educational programs, help recruitment of our graduates, help our faculty in gaining industrial experience, and assist us in providing internships for our students.

In this issue:

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With 30+ ladder rank, 15 emeriti, and several adjunct and research faculty members, the ECE dept is home to numerous exciting research projects.

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Department research activities are broadly divided into seven major areas of electrical and computer engineering.

Communication, Signal and Image Processing

The Communication, Signal and Image Processing group focuses on research projects ranging from mathematical foundations to applications of signal processing in wireless communication, image processing, coding, storage systems, genomics, networking and several other application domains.

Present research projects focus on novel wireless digital communication system design and implementations, MIMO wireless transceiver optimization and crosslayer integration, space-time coded modulation and channel estimation, wireless LAN and WiMAX, new methods for hybrid ARQ equalization and decoding, higher order statistical signal processing, channel estimation and channel equalization, ultra-wideband (UWB) local area networks, cyclo-stationary signal processing, adaptive and array signal processing, image processing and coding based on image analysis and on properties of human perception, 3D sound perception modeling and simulation, customized 3D spatial hearing modeling and approximation for high-quality spatial sound simulation, event detection in seismic signals and target cueing in hyperspectral images.

Computer Engineering

The Computer Engineering group encompasses the research efforts of ten faculty members and their students. Research projects span over a wide range of topics ranging from high-level design specification and compilation to digital circuit design and optimization.

Currently, the following research topics are actively pursued in the computer engineering group: architecture, implementation and compilation for chip multiprocessors, embedded system for multi-media applications, distributed and collaborative embedded systems, energy-aware compilation, computer-aided design, verification and testing of digital systems, fault-tolerant computing and reliable data compression, life-time validation of digital systems, optimal instruction scheduling and register allocation in compilers, robust, stable and efficient management of network control plane, network measurement and monitoring, graphics and graphics architecture, and sensor networks.

Solid State Electronic Devices and Sensors

The Solid-State group focuses on research projects involving fabrication of electronic materials and devices as well as non-electronic micro and nanostructures.

Research projects include investigation of kinetic phenomena during epitaxial growth of Si-Ge-C films; synthesis and device integration of semiconductor nano-structures; development of novel characterization techniques for quantum structures; nano-structured sensors; semiconductor wafer bonding and low-temperature wafer bonding of silicon and compound semiconductors; etch-stop development; field-emission vacuum microelectronics for flat-panel display and microwave amplifier application; micro-sensor packaging; microjoints for 3-D assembly; high-temperature electronic materials research; semiconductor opto-electronics and optical excitation of field emitter arrays; microfabricated bio and chemical analysis instruments; Silicon-on-Insulator (SOI) device physics and processing.

Electronic Circuits

This group's interests are in analog and digital circuit design, specifically focusing on designs for integrated circuits in CMOS technologies. The goal of the research is to develop new circuit architectures and techniques that advance the state of the art in specific areas, including the following: analog or mixed analog/digital implementations of advanced signal processing algorithms for digital magnetic recording, digital communications, including adaptive equalizers, Viterbi detectors, timing recovery circuits; analog-to-digital converters and their calibration; mismatch insensitive double-sampled delta-sigma modulators; low voltage circuits for data communications and conversion; circuitry for integrated sensors; development of CAD software for IC design; and design of multi-valued logic.

RF, Micro and Millimeter Waves

The research of this group focuses on the efficient generation and transfer detection of electromagnetic energy in the frequency ranges from approximately 100 MHz to greater than 100 GHz. Primary topics of research include active devices including the development of low power consumption, compact size and low-noise Bipolar and FET amplifiers and voltage controlled oscillators, operating in the lower microwave band of 0.9 - 2 GHz. Passive devices including the design of reduced-size microstrip coupling devices, filters, T-junction power divider circuits, and broadband direction-finding antennas; nonlinear microwave device research with extensive activity being directed toward active RF/microwave multipliers (1-30 GHz range), quasi-optical grid arrays and solid state devices to serve as high power millimeter wave oscillators, amplifiers, frequency multipliers, beam controllers and mixers; generation of picosecond signals using monolithically-fabricated nonlinear transmission lines; research centering on the automatic phase noise measurement system, which permits the analysis and modeling of the phase noise characteristics of oscillators, phase-locked loops and amplifiers used in wireless communication systems; photonic control of phase array antennas; and high-frequency characterization methods for low-dielectric constant thin films and biosensors.

Optoeletronics

The optoelectronics group performs research on devices and systems for optical communication and instrumentation. The objective is to develop new materials, devices, and system-concepts that will advance optical technology.

At present, the group is involved in the following research projects: design and modeling of transparent optical networks; research on space-switching and wavelength conversion techniques for Next Generation Network applications; design and fabrication of micromachined optical systems for fiber-optic networks; development and integration of organic polymeric films with large electro-optic effects into devices used for high-bandwidth modulation, second-harmonic generation, photonic integrated circuits, and phased-array antennas; investigation of optical gating of field emission from microtip arrays for advanced microwave tube applications; and development of new concepts for femto-second characteristics and application of femto-second lasers to the study of nonlinear optical devices.

The opto-electronic research facility consists of six laboratories equipped with state-of-the-art lasers and high-speed instrumentation for optical and electronic characterization. Fabrication of photonic integrated circuits and micromachined optical systems takes place in the ECE Microfabrication Facility. The opto-electronic group collaborates with researchers at several academic and industrial institutions, including UC Berkeley, Stanford University, Lawrence Livermore Lab and IBM Almaden.

Currently, the dept serves about 700 undergraduate and 185 graduate students. About two thirds of graduate students pursue the Ph.D. degree.

Systems and Control

This group focuses its research on control of constrained linear and nonlinear systems. The major research activities include nonlinear system theory, robust and reliable systems, adaptive control, intelligent control, neural systems, optimization-based design and control and rapid thermal process control.

In the systems and control area research is performed on theoretical and/or design-oriented topics in the following areas: nonlinear systems and control theory, multi-input multi-output feedback systems, decentralized control, robust control, reliable control, adaptive control, and optimization-based design of nonlinear control systems;

Current activities in the decision and control area include decision support and scheduling for IC manufacturing, VLSI physical design automation, global and local optimization with applications, neural networks, and control system design.

Recent Accomplishments

DARPA awards $9.5M to a collaborative project that will be carried out by teams from UC-Davis, MIT and industrial partners. The project is led by UC-Davis professor S.J. Ben Yoo who directs the "Optical Switching and Communications Systems Laboratory".

Grant for Ultra-fast Optical Communications

The Defense Advanced Research Projects Agency (DARPA) has awarded $9.5 million over three and a half years to UC Davis, MIT and commercial partners to develop new high-speed devices for ultrafast optical communications, imaging and other applications.

"We will be prototyping a compact, optical arbitrary waveform generator capable of communicating at unprecedented bandwidth, potentially 10 thousand times faster than the fastest commercial communications system today," said co-principal investigator S.J. Ben Yoo, professor of electrical and computer engineering and director of the UC Davis Center for Information Technology Research in the Interests of Society.

"Optical and radio communications devices generate a carrier wave of a specific frequency. For example, the transmission frequency of a radio station. The amount of information, or bandwidth, carried by the wave can only be a fraction of that frequency. Optical communications links can carry far more information than radio because light waves have a much higher frequency than radio waves. The DARPA project aims to investigate how to use and manipulate the high carrier frequencies of mid-infrared light most effectively", Yoo said.

Yoo's research group will use technology invented at UC Davis to design, build and test thumbnail-sized chips that can potentially encode data at rates up to 100 terahertz, 10 thousand times faster than devices currently available. The MIT group, led by Professor Erich Ippen, will build devices to generate the high-frequency carrier wave.

"Apart from high-speed communications, the technology could also be applied for light-based radar devices or "ladar," capable of very high resolution scanning; medical imaging; or in devices for synthesizing very rich electronic tones", Yoo said.

The other UC Davis investigators in the project are Jonathan Heritage, Anh-Vu Pham, and Brian Kolner, all professors in the Department of Electrical and Computer Engineering. The commercial partners are Inphi Inc. of Westlake Village, Calif., and Multiplex Inc. and Inplane Photonics Inc., both of South Plainfield, N.J.

The new project, which will fund an additional 15 researchers at UC Davis and others at the industrial partners, grew out of another DARPA-funded project on optical communications technology awarded to Yoo and collaborators in 2002.

The citation recognizes Prof. Spencer "for contributions to integrated circuits for communication, and magnetic recording".

Professor Richard Spencer Is Elected a Fellow of IEEE

Professor Richard Spencer was elected a Fellow of the IEEE, effective January 1, 2006. Dr. Spencer's main area of expertise and interest is analog and mixed-signal circuit design for both RF and baseband communication and signal processing. His past work has focused mostly on circuitry for disc drive read channels and wireline interfaces (e.g., Ethernet). More recently he has initiated several projects in RF CMOS circuit design.

The citation reads "for contributions to integrated circuits for digital communication, and magnetic recording."

Professor Amirtharajah Receives NSF Early Career Award

Dr. Rajeevan Amirtharaj received the prestigious NSF Early CAREER Development award for the project titled "Energy Scalable Signal Processing for Energy Harvesting Microsystems". Dr. Amirtharajah's research focuses on powering electronic systems from environmental sources by harvesting energy from solar radiation or mechanical vibration. The goal is to reduce battery size and volume, decrease system maintenance costs, and increase operating lifetime for portable or wearable electronics or wireless sensors. Research under the new grant will include the exploration of circuit styles and signal processing architectures for energy harvesting sensors which enable a trade off between system performance and available power. This work will open new possibilities in long-lifetime sensors for monitoring critical infrastructure, health care, and security applications.

Professor M. Saif Islam Receives NSF Early Career Award

Assistant Professor M. Saif Islam was recently awarded a Faculty Early Career Development (CAREER) Award by the National Science Foundation. The Program is a Foundation-wide activity that offers the NSF's most prestigious awards in support of the early career-development activities of those teacher-scholars who most effectively integrate research and education within the context of the mission of their organization. Such activities build a firm foundation for a lifetime of integrated contributions to research and education. His work is titled "Massively Parallel and Manufacturable Self-Assembly Techniques for Interfacing and Integrating Nanowires in Devices and Circuits".

Dr. Islam, while working for Hewlett-Packard Laboratories before joining UC Davis, has developed two novel nano-device integration and mass-production techniques termed 'nano-bridges' and 'nano-colonnades' that are entirely compatible with existing microelectronics fabrication processes. His current research objectives include the development of massively parallel nano-structures synthesis and integration processes for potential applications in bio-chemical sensors and sensor networks, nanoelectronics, nanophotonics, memory and logic devices for future computing.

Research under the new grant will continue the development of new types of devices and circuits that will be formed starting with a single atom. The goal will be to minimize the device size and increase the density of devices in future electronic and photonic systems. Dr. Islam's bridging techniques will connect the devices to the rest of the world without using expensive and tedious interfacing techniques.

Prof. Islam wins the prestigious NSF Early CAREER development award for the project "Massively Parallel and Manufacturable Self-Assembly Techniques for Interfacing and Integrating Nanowires in Devices and Circuits".

Students Accomplishments:

Special Merit in Research Award for UCD Undergraduate

On February 24-26, 2006, Eighty nine CAMP (California Louis Stokes Alliance for Minority Participation in Mathematics, Science and Engineering) researchers gathered at UC Irvine to present their research in engineering, sciences and mathematics fields. The Symposium recognizes annually special merit in research, honors student research for originality, and depth of understanding and likelihood of sparking further research.

At this event, Antonio Orozco, a UC-Davis undergraduate researcher, received the "Special Merit in Research" award for his poster presentation, entitled "Dose Radiation Effects in FinFETs", in the Physical Sciences and Engineering category. Antonio is an Electrical Engineering major and will be graduating in Spring 2006. Presently, he is working as an assistant researcher in the Mentorships and Opportunities for Research in Engineering (MORE) program.

He currently conducts research under the supervision of Professor Jean-Pierre Colinge and has a position as an Engineering Intern for Caltrans. In addition, Antonio is a member of the Institute of Electrical and Electronic Engineers (IEEE) and Chicano and Latino Engineers and Science Society (CALESS).

ICASSP'06 Best Paper Award Nomination

Yunxia Chen, a second-year Ph.D. student, has recently been selected as one of the finalists for the Student Paper Contest at ICASSP 2006, the flagship conference of the IEEE Signal Processing Society.

Her paper, entitled "Transmission Scheduling for Sensor Network Lifetime Maximization: A Shortest Path Bandit Formulation," is coauthored with her adviser Qing Zhao, and Professor Krishnamurthy and Dr. Djonin at UBC.

Among the 9 finalists in the technical area of Signal Processing for Communications, her paper is the only one that received full score from all three reviewers. Six of these finalists will be awarded after their papers are presented at the conference in Toulouse, France, May 15-19.

2006 IEEE International Microwave Symposium Best Student Paper Finalist

Electrical Engineering graduate student Kunia Aihara has been selected as a finalist of the 2006 IEEE International Microwave Symposium Best Student Paper Award Competition for his paper entitled "Development of Thin-Film Liquid Crystal Polymer Surface Mount Packages for Ka-band Applications," co-authored with his Ph.D. supervisor, Professor Anh-Vu Pham. There were 169 paper submissions for the Student Best Paper Competition. Approximately 50% of these papers were accepted for presentation, and then given additional detailed scrutiny by the subcommittees of the TPC to select a group of finalists. Of these, 22 papers are considered for the award.

Selected Research Activities:

Microwave Devices and Systems Laboratory

Prof. Rick Branner

The Microwave Devices and Systems Laboratory has been under the leadership of Professor G. Rick Branner for over 25 years. The research laboratory consists of four PhD researchers with well over 80 years of combined experience in Microwave and RF engineering. The nationally renowned curriculum has produced many hundreds of RF and Microwave Engineers over the course of its existence.

Our group is conducting research in several areas. A major area is the modeling of GaAs and wide band gap semiconductors including SiC and GaN. Devices include HEMT, PHEMT and MESFETS. Ground breaking work has been done on Large Signal Nonlinear Models for these devices.

Other areas include phase noise characterization of semiconductor devices, and active and passive component development for microwave systems. Some examples of our work include active frequency multipliers, power amplifiers using SiC, diplexers, phased array and microstrip antennas.

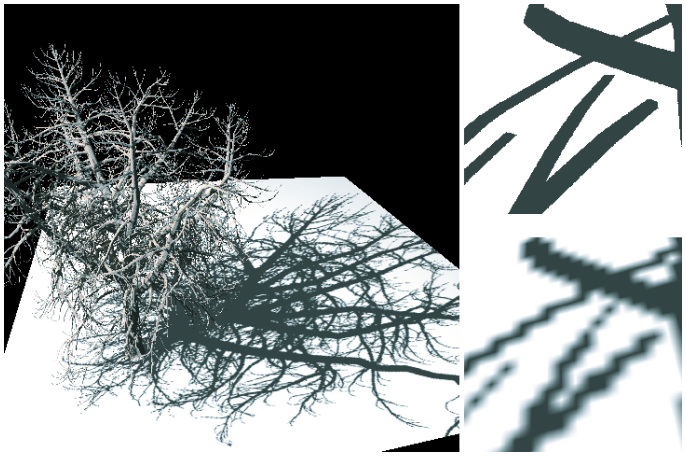
Another area of investigation is focused on Radar detection of a selected class of objects in a dense clutter environment employing FM/CW and Ultra wideband technology.

Under the leadership of Prof. G. Rick Branner, the Microwave Devices and Systems Laboratory focuses on projects in modeling of GaAs and wide band gap semiconductors including SiC and GaN.

Research in Graphics Hardware

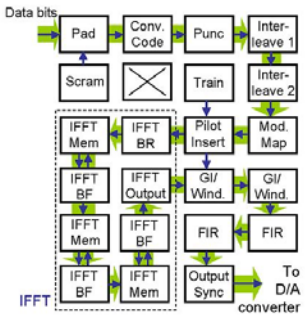
Prof. John Owens

Assistant professor John Owens and his research group are investigating the use of graphics processors (GPUs) for general-purpose computation. The recent increases in the performance and programmability of the GPU have made it an attractive platform for computationally demanding applications. John and his group are designing programming systems that can effectively harness the power of these new processors, and are applying their results to both traditional graphics problems such as shadow generation as well as to more general-purpose problems like numerical simulation.



VLSI Computation Laboratory

Prof. Bevan M. Baas (http://www.ece.ucdavis.edu/vcl/)



Members of the VLSI Computation Laboratory (VCL) are seeking to discover and develop novel contributions in high performance and energy efficient VLSI computation, with an emphasis on digital signal processing (DSP) workloads.

The group recently completed a fully-functional single-chip processing array containing 36 programmable processors. The architecture is called an Asynchronous Array of Simple Processors (AsAP) and was presented at ISSCC in February.

Although each processor has standard synchronous-style circuits, each of the 36 processors contains its own oscillator and is fully asynchronous with respect to all others (GALS). All inter-processor data synchronization is handled in hardware.

Each processor operates up to 475 MHz, which is believed to be the fastest processor designed in a university. On average, each processor dissipates 32 mW while executing applications. Applications include numerous DSP and general purpose kernels, a 9-processor JPEG encoder, and a 22-processor 802.11a/g wireless LAN transmitter that is fully compliant with the IEEE standard. The group recently completed a working C compiler for AsAP.

Each processor occupies 0.66 mm^2. If this exact design were scaled to a 90 nm 13mm x 13mm chip, it would contain over 1000 processors, operate at almost 1 GHz, have a peak throughput of 1.0 TeraOp/sec, and dissipate a total of 8 Watts plus leakage while executing applications.

The VCL group is now working on extensions to AsAP, high performance and efficient Low Density Parity Check (LDPC) decoders, and other DSP engines.

The group has 11 graduate students and a number of undergraduate researchers. Funding is provided by Intel Corporation, UC MICRO, grants from the National Science Foundation (NSF), and a UC Davis Faculty Research Grant.

Robust & Ubiquitous Networking (RUBINET) Research Group

Prof. Chen-Nee Chuah (http://www.ece.ucdavis.edu/rubinet/)

The focus of the RUBINET research group is to address a broad range of core issues in modern communication networks including distributed protocols and architecture, Internet measurements, routing and traffic engineering, performance modeling, security, and wireless/ mobile communication systems.

Led by Prof. Chen-Nee Chuah, our group strives to improve the fault-tolerance, stability, security, and performance of the most complex distributed system – the Internet. In fact, RUBINET was among the first to conduct a thorough measurement-based characterization of network failures and routing instability, and their impact on traffic forwarding.

Prof. Chuah's vision for the future is to develop a *clean-slate design* of a *Robust, Secure, and Efficient (RoSE) Internet control plane.* Our group is also exploring architecture and protocols that utilize all available communication channels through heterogeneous wireless networks, including highly mobile networks (e.g., vehicular ad hoc networks), to provide new networking and computing paradigms.

RUBINET currently consists of seven PhD students and one MS student, and the projects are funded by National Science Foundation (NSF) grants, UC Micro Programs, gifts from industrial sponsors (Cisco, Fujitsu, HP, Intel, and Sprint) and student fellowships (Accel, GAANN, CITRIS, and UC-Davis NRTF).

Recent Highlights:

- Prof. Chuah received the NSF CAREER award in 2003 and the Outstanding Junior Faculty award in 2004.
- Ram Keralapura (PhD student) is a 2005-06 Fellow of the campus-wide Professors for the Future Program.
- Prof. Chuah, with co-PIs Su and Chen (Computer Science), received a new NSF NeTS grant (2005-08) to design a unified framework for validating, optimizing, and adapting critical packet filters in the Internet (e.g. distributed firewalls).

The members of RUBINET research group strive to improve the fault-tolerance, stability, security and performance of the most complex distributed system: the internet.