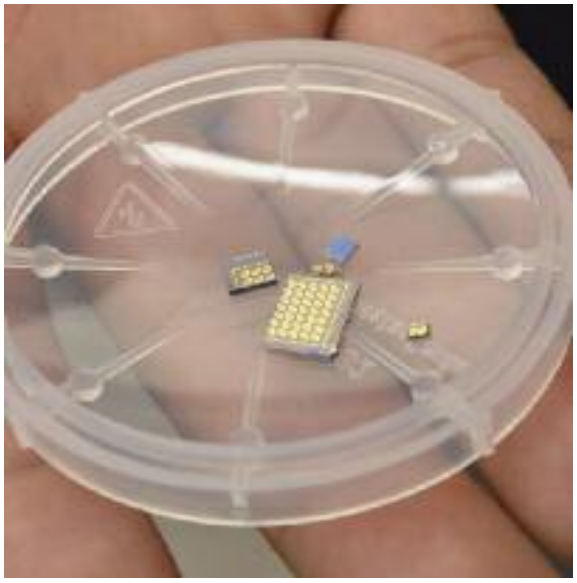
Annual Report
2014-2015



UCLA

Henry Samueli School of Engineering and Applied Science

Electrical Engineering

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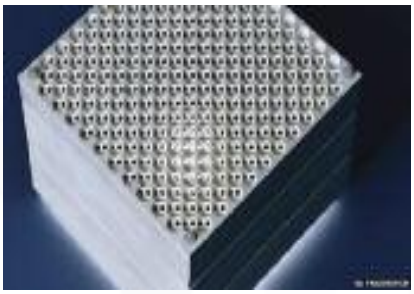


UCLA Electrical Engineering:

Transforming Lives, Transforming the World

The UCLA Electrical Engineering Department serves the State and the Nation by advancing the state of the art through its research programs and by teaching the next generation of electrical engineers the fundamentals and practical skills required for success. We are part of a proud tradition in which electrical engineers have devised inventions that have transformed our civilization through near-instantaneous electronic communication, ubiquitous availability of power through the electrical grid, electronic computers, digital cameras and displays, and advanced signal processing that enables machines to respond to speech, images, and sensor data at massive scales.

Among many other accomplishments, researchers in the UCLA EE Department have enabled radios to be fabricated on a single integrated circuit, laying the foundations of the explosive applications of wireless technology and devised the basic wireless sensor network technology that underlies the coming Internet of Things revolution. Other research accomplishments for which our faculty have been recognized include development of space-based antennas, advances in microwave circuits, development of sensors for the transportation and aerospace industries, advances in control systems for aerospace, and development of fundamental advances in digital signal processing. Our faculty is dedicated to teaching, research and service, constantly seeking to improve how we serve our students and alums and reaching out to the broader community. Our alumni are pillars of the aerospace, semiconductor, and telecommunication industries, and beyond this have pursued a broad range of pursuits including entrepreneurship, law, engineering consulting, and academia. Our students are highly qualified and bring many gifts of scholarship, service, and inventiveness. Our student chapters of HKN and IEEE are outstanding, consistently winning national awards as they pursue service roles and design competitions. In the best tradition of the profession, the UCLA EE Department welcomes change and new challenges and looks forward to continuing to provide the high quality research and educational experiences our stakeholders expect and deserve. Whether you want to learn more about electrical engineering, to become a student, to plan your studies, to explore how you can become involved in our research mission, or to understand how continued involvement with the Department can advance your career or company, on behalf of the Department, I welcome you and encourage you in your explorations.

— Gregory J. Pottie

Gregory J. Pottie
Chairman

Jayathi Y. Murthy Appointed as Dean of the HSSEAS

I am pleased to announce the appointment of Jayathi Y. Murthy as Dean of the **Henry Samueli School of Engineering and Applied Science (HSSEAS)**, effective January 1, 2016.

Professor Murthy is the Ernest Cockrell Jr. Department Chair and Professor of Mechanical Engineering at The University of Texas at Austin (January 2012-present). She served as director of PRISM: NNSA Center for Prediction of Reliability, Integrity and Survivability of Microsystems (2008-2014). A member of the faculty at Purdue University from 2001 to 2011, Professor Murthy served as the Robert V. Adams Professor in the School of Mechanical Engineering. At Carnegie Mellon University, she served as associate professor of mechanical engineering (1998-2001) and director of the Thermal Management, Electronics Cooling, and Packaging Laboratory Institute for Complex Engineered Systems (1999-2001). During her 1988-1998 employment at Fluent Inc., a leading vendor of CFD software, she developed the unstructured solution-adaptive finite volume methods underlying their flagship software Fluent, and the electronics cooling software package ICEPAK. More recently, her research has addressed submicron thermal transport, multiscale multiphysics simulations of MEMS and NEMS, and uncertainty quantification in these systems.

Jayathi Y. Murthy

Professor Murthy received a Ph.D. in mechanical engineering from the University of Minnesota, an M.S. from Washington State University and a B. Tech from the Indian Institute of Technology. She is the recipient of many honors including the IBM Faculty Partnership Award 2003-2005, the 2009 ASME EPPD Woman Engineer of the Year Award, the 2012 ASME EPPD Clock Award and numerous best paper awards. In 2012, she was named a distinguished alumna of the Indian Institute of Technology. Professor Murthy serves on the editorial boards of *Numerical Heat Transfer and International Journal of Thermal Sciences* and is an editor of the 2nd edition of the *Handbook of Numerical Heat Transfer*. She is a member of the American Society of Mechanical Engineers and the author of more than 280 technical publications. In addition, she has served on numerous national committees and panels on electronics thermal management and CFD.

I want to thank the search/advisory committee for assembling an outstanding pool of candidates and for its role in recruiting Jayathi. The committee was chaired by Joseph Rudnick, Dean of the Division of Physical Sciences. Other members were: Asad Abidi, Jane Chang, Linda Demer, Bruce Dunn, Carlos Grijalva, Chih-Ming Ho, Eric Hoek, Diana Huffaker, Richard Kaner and Richard Korf. I also want to recognize and thank Dean Vijay Dhir for his distinguished leadership of the school since February 2002.

Chancellor Block and I are confident that HSSEAS will reach new heights under Jayathi's leadership. Please join me in congratulating her and welcoming her to UCLA.

Scott L. Waugh
Executive Vice Chancellor and Provost

Control of Networked Systems and Applications to Transportation

Professor Sam Coogan's research focuses on correct-by-design control of networked systems to ensure these systems behave as expected and required. Engineered systems are increasingly composed of interconnected components, often designed in isolation, resulting in complex networked systems. At the same time, our increased dependence on these systems implies that we must be able to guarantee their correct behavior. His research draws from domains including control and dynamical systems theory, formal methods in computer science, and optimization. The work emphasizes applications to transportation systems where connected vehicles and connected infrastructure provide new opportunities for safety and efficiency.


Sam Coogan

Control and Verification of Networked Cyber-Physical Systems

Networked systems often consist of physical components coupled through the tight integration of digital computation and communication. These networked cyber-physical systems pose unique challenges for control and verification. For example, such systems include physical components that are often controlled over communication channels with finite capacity that imply a finite range of inputs, or are operated with software that, at any point in time, is executing one of a finite number of routines. The physical components require a continuous model to capture physically relevant states such as position and velocity, while other components, such as software and communication, often rely on discrete models of operation. Analyzing the networked systems requires a hybrid approach that combines these continuous and discrete elements.

The key to obtaining tractable algorithms for control and verification of networked cyber-physical systems is to exploit structure inherent in the physical components and their interconnection. Professor Coogan's research has shown that models for the controlled flow of physical material among a network of interconnected components possess mixed monotonicity structure that generalizes the well-known notion of monotone dynamical systems.

Formal Methods in Control

Control theory has traditionally explored relatively simple objectives of system behavior such as stabilizing a system around an equilibrium point or ensuring that the system does not enter an unsafe operating condition. In contrast, algorithmic tools in computer science have been developed to provide formal guarantees for the correct behavior of complex software and hardware systems. These *formal methods* ensure bank transactions are secure, communication and computation are reliable, and autopilots operate safely. Existing techniques apply to software, but don't accommodate the rich variability of the physical world.

Professor Coogan's research brings the tools of formal methods to control theory so that a control system's closed-loop behavior is guaranteed to satisfy similarly diverse objectives, for instance to guarantee your morning commute is short and your carshare fare is cheap. Developing formal methods for control systems requires new techniques for abstracting dynamical, continuous-state systems to finite models amenable to formal verification and synthesis algorithms. A primary focus of Professor Coogan's research is to develop the necessary theory and practical algorithms to ensure that these techniques scale well with system size.

Efficient and Intelligent Transportation Systems

Much of Professor Coogan's research is motivated by the practical problems found in next generation transportation systems, which are particularly rich examples of networked, cyber-physical systems. These next generation transportation systems will need to operate efficiently in densely populated environments, accommodate new technologies among legacy systems, and intelligently incorporate new data and communication for improved safety and mobility. His research has shown that modeling traffic flow as a compartmental dynamical system provides a theoretical foundation for optimal traffic flow control and congestion analysis. Professor Coogan seeks to develop the mathematical theory and algorithms to solve these and other application-driven problems in complex, networked systems.

Pervasive Personal Robots

On-demand design and fabrication of custom programmable machines — *By Professor Ankur Mehta*

Professor Ankur Mehta envisions a future with widespread integration of robots into everyone's everyday life. From home and office automation to education to healthcare, ubiquitious robotics promises to greatly improve overall quality of life. Such pervasive cyber-physical systems must often deliver uniquely specified functionality, requiring the on-demand creation of custom robots. Functional specifications must be interpreted then resolved into integrated electromechanical mechanisms. Designs must be efficiently verified, validated, and optimized. The generated systems must be manufactured and then programmed to execute the required tasks.

Professor Mehta's work takes an interdisciplinary approach to addressing theory and systems issues both individually and in networked swarms. Just as we can address any computational problem by saying "there's an app for that," his research aims to bring that paradigm into the real world — for any physical task: "there's a robot for that."

Ankur Mehta

On-Demand Design

Producing a new robotic system today typically requires domain-specific expertise across a range of disciplines. To democratize access to robotics and put the creation of custom devices into the hands of the end users, Professor Mehta uses computational tools to generate integrated robot designs from high-level descriptions. His recent work towards such a hardware compiler was awarded the 2014 IROS best paper award: a system that encapsulates mechanical, electrical, and software design elements into a common software-defined-hardware infrastructure, allowing custom programmed electromechanical devices by hierarchically connecting existing library components to define their robot design. The compiler outputs everything necessary to manufacture, program, and control the specified design in its entirety.

Current work on the hardware compiler focuses on adding further automation to the design system. Professor Mehta is investigating the use of structured or natural language inputs to generate designs from high-level functional or task-based specifications. These designs can be simulated and analyzed, and the results can be fed back to refine an auto-generated design.

Rapid fabrication

The goal also is to enable the fabrication of integrated robotic systems using a personal scale robot printer. Employing 2D and 3D printing techniques to manufacture mechanical robot bodies from common compiled design, coupled with a method of incorporating off-the-shelf sensing, actuation, communication, and control devices using plug-and-play electronics modules, his system enables personal manufacture of functional printable robots from already compiled designs.

In addition, Professor Mehta is researching the integrated manufacture of the electronics subsystem itself, with a goal of creating a "robot on a chip" — a solution comprising all of the components necessary for a complete robot controller onto a single silicon die. His past work has paved the way for a single chip radio, and his current work will extend that.

Autonomous control

To enable mobility for ubiquitous personal robots, the localization and guidance subsystem must be lightweight, inexpensive, and trivially deployable if not self-contained. Professor Mehta's earlier work achieved rudimentary localization along with flight stability for individual robots using a small inertial controller of less than 10g. Those results can be improved within multi-robot networks, and his upcoming research will investigate controllers for autonomous mobile robots that efficiently employ collective behaviors to achieve accurate network-wide localization within unstructured indoor environments using low-overhead sensors.

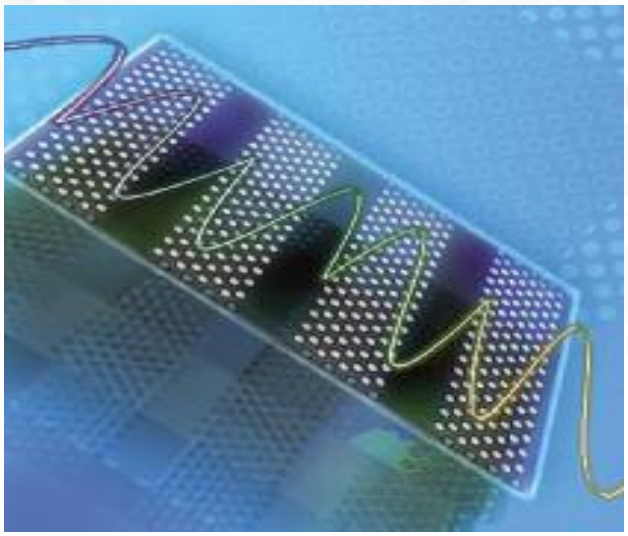
Professor Chee Wei Wong Explores Zero Phase Refraction Photonic Crystal

In his research, Professor Chee Wei Wong has demonstrated that light can travel on an artificial material without leaving a trace under certain conditions. This technology can have many applications, from the military to telecommunications. In a study published at Nature Photonics's website, Professor Wong and research partner Serdar Kocaman demonstrated how an optical nanostructure can be built to control the way light bounces off of it.

Chee Wei Wong

When light travels, it bends — in technical terms, it disperses and incurs "phase" — an oscillating curve that leaves a trail of information behind. Those oscillations show an object's properties, such as shape and size, which makes it possible to identify it. However, when light hits Professor Wong's specially engineered material, it leaves no trace.

Every natural known material has a positive refractive index: when light hits an object, it bends or refracts. Professor Wong's research etched tiny holes into a structure, creating a material known as a "photonic crystal" which behaves as if it has zero refractive index, allowing light to travel with an ultrafast velocity in this environment. The material, a coating no thicker than one-hundredth of a strand of hair, has properties that don't occur in nature.



Light waves hit specially engineered material without leaving a trace. The actual material is no thicker than one-hundredth of the diameter of a strand of hair.

"We're very excited about this. We've engineered and observed a metamaterial with zero refractive index," said Kocaman. "Even in a vacuum, light propagates with phase advancement. With the zero phase advancement, what we've seen is that the light travels through the material as if the entire space is missing."

"We can now control the flow of light, the fastest thing known to us," Professor Wong said. "This can enable self-focusing light beams, highly directive antennas, and even potentially an approach to hide objects, at least in the small scale or in a narrow band of frequencies."

The zero-index material was based on a negative refractive index material and a superlattice material demonstrated consecutively in 2008 and 2009 by the researchers. Professor Wong demonstrated that the optical phase advancement can be controlled and even eliminated under certain conditions.

The study, supported by grants from the National Science Foundation, was led by Professor Wong and Kocaman, in collaboration with researchers at Columbia University, University College of London, Brookhaven National Laboratory, and the Institute of Microelectronics of Singapore. It was the first time phase and zero-index observations have been made on both a photonic chip scale and at infrared wavelengths. These photonic chip circuits can be useful in fiberoptic networks.

Professor Wong is a recipient of the DARPA Young Faculty Award, the NSF CAREER Award, the 3M Faculty Award, and elected a Fellow of the Optical Society of America, and Fellow of the American Society of Mechanical Engineers. He has published five book chapters, 90+ journal papers and 130+ conference articles, and delivered 70+ invited talks at universities and industry. He has been awarded 18 patents and has five provisional patents currently. His work has appeared in *Nature, Nature Physics, Nature Photonics, Nature Communications, Physical Review Letters, Nano Letters, Nature Scientific Reports,* amongst others.

UCLA Receives $2.5 Million Donation from Alumnus Mukund Padmanabhan for Semiconductor Lab

Gift to UCLA Engineering will further cement UCLA as a premiere research institution

UCLA alumnus **Mukund Padmanabhan** has made a gift of $2.5 million in support of Engineering VI, the new building under construction for the **UCLA Henry Samueli School of Engineering and Applied Science**. The donation is the fourth Padmanabhan has made to his alma mater, and the largest. His three previous donations, of $500,000 each, support the Guru Krupa Foundation Fellowships in Electrical Engineering. The new $2.5 million contribution will create the Mukund Padmanabhan Systems Scaling Technology Laboratory in Engineering VI.

Mukund Padmanabhan

The lab will be dedicated to making advances in the performance, cost-effectiveness and energy efficiency of heterogeneously integrated microsystems, including 3-D integrated circuits and assemblies. Such systems have extensive commercial and industrial applications, ranging from cellphones and computers to equipment used in sophisticated health care, military and space applications.

Padmanabhan, whose research at UCLA focused on integrated circuits and signal processing, said he was inspired by the school's continuing commitment to cutting-edge research and engineering education.

"I see the quality of the work being done by the students who benefit from the Guru Krupa Foundation Fellowships, and I feel very satisfied that research is progressing full speed ahead at UCLA," said Padmanabhan, who studied electrical engineering, earning his master's degree in 1989 and Ph.D. in 1992. "When I learned that UCLA wanted to advance the frontiers of 3-D integrated circuit design, I felt that this was the right project to further extend my commitment to the school. I look forward to the lab making great advances and cementing UCLA's role as a premier research institution."

After graduating from UCLA, Padmanabhan joined the IBM Thomas J. Watson Research Center in Yorktown Heights, New York. Today, he does research in statistical financial modeling for Renaissance Technologies, a New York-based hedge fund management firm.

Padmanabhan is the founder of the Guru Krupa Foundation, a nonprofit organization that provides educational opportunities to those who could not otherwise afford it, assistance to impoverished families and support for cultural and religious organizations in the United States and India.

Engineering VI

Engineering VI is a 150,000-square-foot anchor for innovation built in the heart of the UCLA campus. The first phase of the building was completed in early 2015. The Mukund Padmanabhan Systems Scaling Technology Lab and other research and teaching centers now occupy a part of the building. Construction on the second and final phase of Engineering VI started in March 2015 and is scheduled to be completed in 2017. The state-of-the-art $130 million structure was financed entirely by donations from UCLA Engineering alumni, supporters and research partners. ***— Bill Kisliuk***

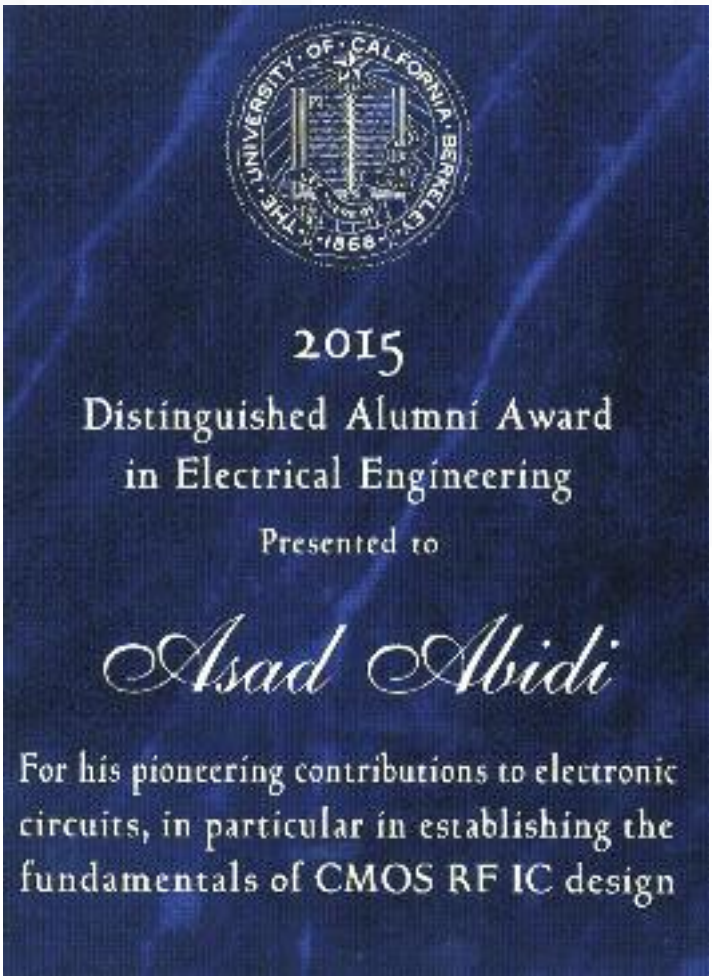
Professor Asad Abidi Selected by UC Berkeley to Receive its 2015 EE Distinguished Alumni Award

Distinguished Chancellor's Professor Asad Abidi has been chosen as a recipient of the Distinguished Alumni Award for 2015 by the Department of Electrical Engineering and Computer Sciences at the University of California, Berkeley, where he received both his master and doctorate degrees in electrical engineering.

The award is in recognition of the valuable contributions of the most distinguished alumni. Selection is based on a record of outstanding performance, as evidenced by sustained excellence in one or more of the following areas: research and engineering achievements, leadership in the profession and in public affairs, service and/or support to UC Berkeley.

Professor Abidi is widely recognized for his seminal contributions in the area of integrated circuits and was responsible for the development of the RF CMOS technology which revolutionized wireless communications. As an educator, he has the dedication and passion to bring out the best in his students to make their mark in the field. His former students are now technology leaders at leading communication IC companies in the world.

The award presentation took place in conjunction with the Berkeley EECS Annual Research Symposium (BEARS) on Thursday, February 12, 2015.



Aydogan Ozcan Named 2014 Howard Hughes Medical Institute Professor

Aydogan Ozcan, Chancellor's Professor of electrical engineering and bioengineering at the UCLA Henry Samueli School of Engineering and Applied Science, has been named a **2014 Howard Hughes Medical Institute Professor**, recognized for his breakthrough research and innovative approach to undergraduate education.

Ozcan is one of 15 researchers from around the country named a 2014 HHMI Professor. Awardees receive a $1 million grant to be used over five years to pursue high-impact, interdisciplinary research and effectively integrate their work with creative approaches to undergraduate education.

Ozcan, who is also the Associate Director of the California NanoSystems Institute, develops cost-effective and field-portable photonics tools for microscopy, sensing and diagnosis. Devices invented in his lab — including lightweight smartphone attachments to detect the presence of mercury in water, malaria in blood cells and allergens in food — are designed for point-of-care use and are adaptable to rural and resource-poor areas.

Some of his previous honors include winning the National Science Foundation CAREER Award in 2010 and the Presidential Early Career Award for Scientists and Engineers (PECASE) in 2011.

Using the HHMI grant, Ozcan has launched a program in which undergraduate researchers form interdisciplinary teams annually to design, build and test novel technologies for telemedicine and global health applications.

In addition to Ozcan, Tracy L. Johnson, Maria Rowena Ross Chair in Cell Biology and Biochemistry and associate professor in the Department of Molecular, Cell and Developmental Biology, was named a 2014 Howard Hughes Medical Institute Professor.

Johnson and Ozcan bring to five the number of UCLA professors who have been named HHMI professors since the program started in 2002.

"Exceptional teachers have a lasting impact on students," said HHMI President Robert Tjian. "These scientists are at the top of their respective fields and they bring the same creativity and rigor to science education that they bring to their research."

Headquartered in Chevy Chase, MD, **Howard Hughes Medical Institute** seeks to transform science education in the United States by encouraging hands-on, research-oriented and interdisciplinary instruction. Over the years, the organization has awarded more than $935 million to 274 colleges and universities in the United States.

– By Bill Kisliuk

Aydogan Ozcan with his portable microscopy device

Distinguished Professor Asad Madni Elected Fellow of The National Academy of Inventors and Eminent Member of IEEE-HKN

The Board of Governors of **IEEE — Eta Kappa Nu** (IEEE-HKN) have elected Distinguished Adjunct Professor Asad M. Madni to be inducted as an **Eminent Member** — the organization's highest membership category conferred upon those select few whose outstanding technical attainments and contributions through leadership in the fields of electrical and computer engineering have resulted in significant benefits to humankind. His award citation reads "for technical attainments and contributions to society through outstanding leadership in the profession of Electrical and Computer Engineering." Since 1950, only 136 individuals have been selected to receive this prestigious honor (Professor Madni will be the 137th recipient) including, Frederick E. Terman, Harry Nyquist, John Bardeen, Simon Ramo, John R. Pierce, Jack Kilby, Gordon E. Moore, Leonard Kleinrock, Vinton Cerf, four Nobel Laureates; and honorary members Thomas Alva Edison, Alexander Graham Bell, Walter House Brattain, Robert Noyce and David Packard.

In recognition of his 69 issued or pending patents, Professor Madni has also been elected as a **Fellow** of the **National Academy of Inventors (NAI)** for "demonstrating a highly prolific spirit of innovation in creating or facilitating outstanding inventions that have made a tangible impact on quality of life, economic development, and the welfare of society." The National Academy of Inventors was established in year 2010 to honor academic invention; recognize and encourage inventors; enhance the visibility of university and non-profit research institute technology and innovation; encourage the disclosure of intellectual property; educate and mentor innovative students; and translate the inventions of its members to benefit society and mankind.

During his extraordinary career, Professor Madni led the development and commercialization of numerous intelligent sensors, systems and instrumentation including:

- Extremely Slow Motion Servo Control System for Hubble Space Telescope's Star Selector System which provided it with unprecedented accuracy & stability, resulting in truly remarkable images that have enhanced our understanding of the universe
- Revolutionary Quartz MEMS GyroChip technology which is used worldwide for Electronic Stability Control and Rollover Protection in passenger vehicles and for inertial navigation in major aerospace and commercial aviation platforms
- Intelligent actuation system for Huygens Probe, an atmospheric entry probe carried to Saturn's moon Titan as part of the Cassini-Huygens mission. The system was instrumental in the precise landing of the probe on Titan's Xanadu region after it separated from the Cassini orbiter
- First broadband, miniaturized, solid-state, Microwave Noise & Deception Jamming System used for ECM in unmanned aerial targets, manned aircrafts, and ECM pods. The system is used by all three US services and a number of allies to provide a realistic ECM threat environment, and has significantly enhanced US EW capability

- Transmission Line/ Antenna System Analyzer (AN/PSM-40) which replaced an entire rack of equipment and was the first system capable of detecting the locations and magnitude of multiple faults in coaxial and waveguide transmission lines/antenna systems within minutes and with unprecedented accuracy. This breakthrough established the basis for future communication systems & network analysis and significantly enhanced the combat readiness of the US Navy.

Professor Madni is currently collaborating with Professor Bahram Jalali in guiding doctoral research in the area of high speed instrumentation utilizing time-stretch and novel digital signal processing techniques, including a single-shot ultra-fast analyzer for network analysis of optical and electronic devices.

Professor Itoh Received Honorary Degree from Universitat Autònoma de Barcelona

On May 5, 2015, Rector of Universitat Autònoma de Barcelona (UAB) announced that its Governing Council resolved to award an Honorary Doctorate (Doctora Honoris Causa) to Distinguished Professor Tatsuo Itoh. He is the first Honorary Doctor proposed by the School of Engineering of UAB. "Professor Itoh is possibly without a doubt the most influential researcher today in the field of radio frequency and microwave engineering, as demonstrated by his 48 books and chapters, over 440 articles published, 80 theses directed, 10 patents and more than 32,000 citations," UAB website describes.

Among many technical contributions, Professor Itoh's work on transmission line metamaterial known as CRLH (Composite Right/Left Handed) structures is highly appreciated as it has introduced a new paradigm in antennas and microwave circuits that offers features and functionalities which were unimaginable only a few years previously.

Professor Itoh has been at UCLA since 1991 and holds the Northrop Grumman Chair in Microwave Electronics. He received a number of awards and recognitions including membership in National Academy of Engineering and National Academy of Inventors, IEEE Microwave Educator Award, IEEE Microwave Career Award and European Microwave Association Outstanding Career Award.


Tatsuo Itoh

Professor Jalali Received IET Achievement Medal

In making the award, **The Institution of Engineering and Technology** cited Professor Bahram Jalali's "pioneering contributions to silicon photonics and real-time instrumentation and their application in cancer detection."

Professor Jalali, who also has joint appointments with the Bioengineering Department, the California NanoSystems Institute and the UCLA School of Medicine Department of Surgery, has been a member of the Electrical Engineering faculty since 1992. In 2003, Jalali's lab demonstrated the first silicon optical amplifier, and in 2004 reported the first silicon laser. In 2007, his lab developed a new type of camera that can record 100 million frames per second, and this new technology is in the clinical testing stage for detection of rare cancer cells in blood samples.


Bahram Jalali

Among other honors, Professor Jalali is also a fellow of the American Physical Society, the Optical Society of America and IEEE. He is the recipient of the Wood Prize from the Optical Society of America for the invention of the first silicon laser.

The IET mission is to inspire, inform and influence the global engineering community, supporting technology innovation to meet the needs of society by providing expert advice, publishing journals, and offering scholarships and medals. The organization has 160,000 members worldwide. ***— by Bill Kisliuk***

Mona Jarrahi Named Kavli Fellow and Lot Shafai Mid-Career Distinguished Achievement Awardee

Associate Professor Mona Jarrahi has been named a 2014 **Kavli Fellow** by the **National Academy of Sciences**. The Kavli fellow program honors young scientists who are considered leaders in their fields and have made significant contributions to science. Kavli fellows are selected by the advisory board of the Kavli Foundation and members of the National Academy of Sciences from young researchers who have already made recognized contributions to science, including recipients of major national fellowships and awards and who have been identified as future leaders in science.

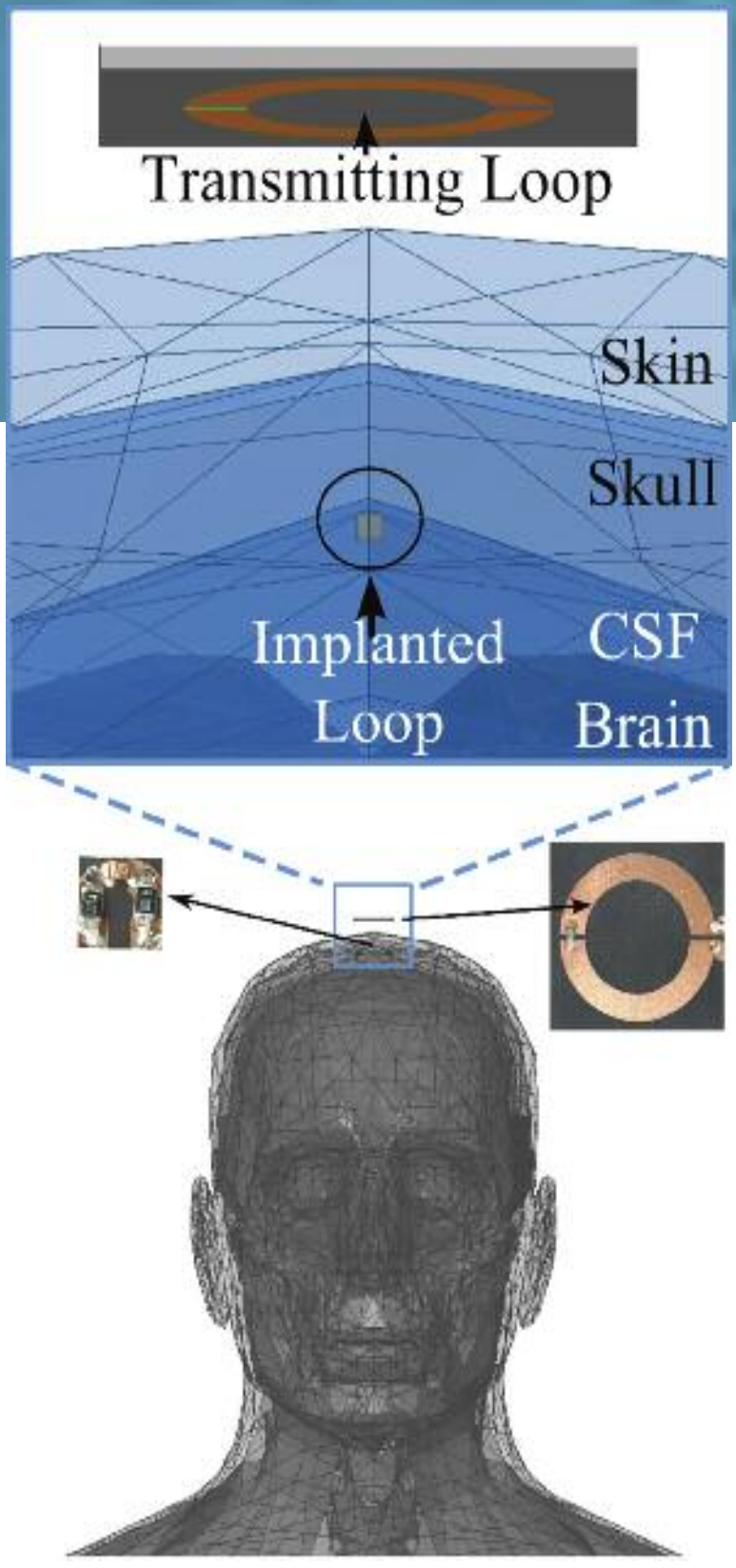
Professor Jarrahi has also received the **Lot Shafai Mid-Career Distinguished Achievement Award** from the **IEEE Antennas and Propagation Society** for her pioneering contributions to plasmonic antennas and optical phased arrays for terahertz and microwave systems. This award recognizes the technical accomplishments and future potential of an outstanding woman of mid-career status in the field of antennas and propagation, whose prior technical accomplishments and future potential earmark them as current and future leaders in the field of antennas and propagation, as well as role models for future generations of women in the field.

Professor Jarrahi's research focuses on ultrafast electronic and optoelectronic devices and integrated systems for tera-hertz/millimeter-wave sensing, imaging, computing, and communication systems by utilizing novel materials, nano-structures, quantum well structures, electromechanical structures, as well as innovative nano-plasmonic concepts. The pioneering research conducted by Professor Jarrahi and her outstanding achievements have received significant attention from scientific and industrial communities and have been recognized by numerous prestigious awards including the Presidential Early Career Award for Scientists and Engineers; Early Career Award in Nanotechnology from the IEEE Nanotechnology Council; Outstanding Young Engineer Award from the IEEE Microwave Theory and Techniques Society; Booker Fellowship from the United States National Committee of the International Union of Radio Science; Grainger Foundation Frontiers of Engineering Award from National Academy of Engineering; Young Investigator Awards from the Army Research Office, the Office of Naval Research, and the Defense Advanced Research Projects Agency; Early Career Award from the National Science Foundation; the Elizabeth C. Crosby Research Award from the University of Michigan; and best-paper awards at the International Microwave Symposium and International Symposium on Antennas and Propagation. She is also a Distinguished Lecturer of IEEE Microwave Theory and Techniques Society, a Traveling Lecturer of OSA, a Visiting Lecturer of SPIE, and a senior member of IEEE, OSA, and SPIE societies.

Mona Jarrahi

Novel Antenna

Yahya Rahmat-Samii



Wireless brain machine interface system

Wireless brain-machine interface (BMI) is a young multidisciplinary field that holds enormous potential as a therapeutic technology to help large numbers of people suffering from a wide variety of severe neurological disorders, such as paralysis, stroke, and spinal cord injury. BMI systems record neural data and transform thought into action, which can fulfill the dream of many patients — living independently, using prosthetic limbs in the same way as biological ones. To achieve that, such systems require sensors for neural recording, programs for brain simulation, and finally, a wireless link to communicate with an external unit that decodes neural data and controls prosthetic limbs. Development of wireless, ultra low power, bi-directional and fully implantable neural interfaces plays a key role in this endeavor. Additionally, patient's comfort should also be addressed in the design.

Collaborating with a research group at Tampare University, Finland, the UCLA Antenna Research, Analysis, and Measurement Laboratory (ARAM) demonstrated miniature implantable antennas that are capable of powering up the implanted neural recording microsystem and communicating with a transmitting antenna outside human body. Operating at the medical implant communications service (MICS) frequency band (402–405 MHz), such novel antennas provide low cost and low power solutions for wireless neural interfaces. They can potentially enable the widespread application of BMI technology.

Power is transferred from outside to the implants by short-range RFID inspired backscattering technology using near-field inductive links with loop antennas, which is a desirable method to transfer power efficiently through short distances and highly dissipative media, such as the human body. In an RFID backscattering system, an external reader antenna transmits an

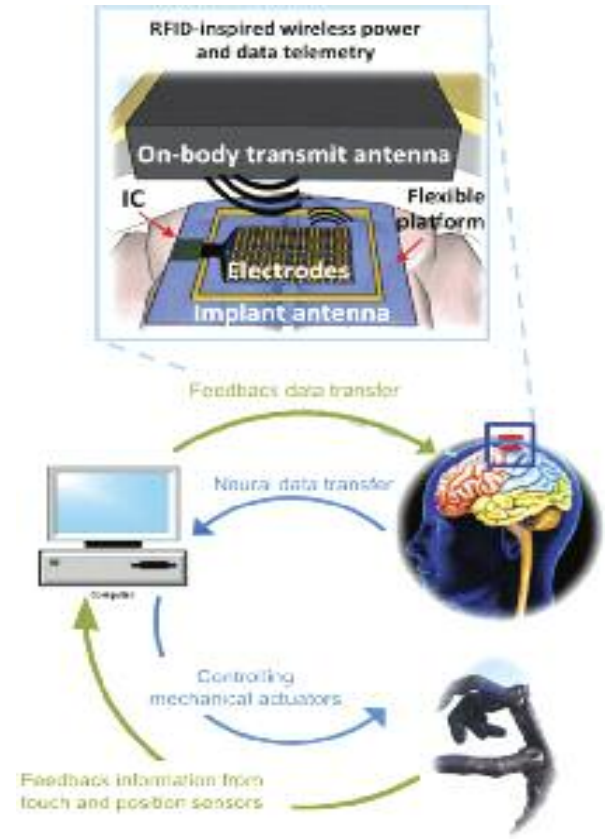
Concepts for Brain-Machine Interface Systems

unmodulated carrier signal from which the implant antenna captures energy to power the implanted microelectronic system, while the data is transferred by modulating the complex impedance at the implant antenna terminal according to the captured neural signal.

To characterize the wireless channel, UCLA ARAM numerically simulated the link between a neural sensing antenna and an external transmitting antenna in the presence of the full human head model as shown in the figure. The implanted antenna was placed in CSF fluid, a layer surrounding the brain. The primary motor cortex area of the brain was chosen as the implant site, since the primary motor cortex elicits movements of individual body parts, making a suitable target of BMI for thought-control prosthetics.

From the clinical point of view, the implantable antenna should be biocompatible and miniaturized without increasing the size of the implant significantly. Thus, millimeter-size ultra-compact antennas are required for localized neural recording systems. To enhance link power efficiency, UCLA ARAM following the lead from Tampare University evaluated 1 mm 3-D cubic loop antennas, which provide a wider current path and a larger coupling area compared to their planar counterparts with the same cross-section area. Moreover, such ultra compact loops are capable of powering up the neural recording IC, making them strong candidates for the realization of future BMI technology.

On the transmitting antenna side, the challenge is to design a transmitting loop that provides high inductive coupling with the implanted loop as well as low near electric field, which means low specific absorption rate (SAR) compliant to FCC regulation. Using an optimized planar loop antenna with segmenting structure, UCLA ARAM was able to meet both the ends. Moreover, to achieve the ultimate goal of clothing-integrated and



wearable BMI systems, different types of conductive textiles are characterized and considered to realize wearable on-body BMI reader antennas, which fulfill the requirements of wearable antennas being compact, lightweight, surface conformal and even washable.

Significant progress has occurred in the field of BMI technology during the last decade. Such novel designs of BMI antennas constitute an important milestone in the development of wireless BMI systems, and a new era of wireless body-centric systems.

Professor Eli Yablonovitch Wins Isaac Newton Medal

Photonic crystals can manipulate light in the same way that a semiconductor like silicon can steer electrical current. Professor Eli Yablonovitch, a pioneer in "photonic crystals," which can repel, trap and steer light, received the Isaac Newton Medal, the highest honor given by the Institute of Physics in London. Professor Yablonovitch proposed and created the crystals in the 1980s, while working at Bell Communications Research. His description of photonic crystals was published in 1987 when these materials had never been manufactured. It is the second most-cited paper ever published in the prestigious journal *Physical Review Letters*.

Eli Yablonovitch

Professor Yablonovitch research was built on an idea formulated 100 years earlier in 1887, by British physicist Lord Raleigh, who suggested that a material with a repeating, regular structure — such as a crystal — could block light of particular wavelengths. "Raleigh developed the idea of the one-dimensional photonic crystal," Professor Yablonovitch explained. "That's something that we've lived with for over 100 years. But no one really thought of extending Raleigh's idea into two and three dimensions."

A one-dimensional photonic crystal is a simple stack of layers, but nobody knew what shape a 2D or 3D example would take. It took Yablonovitch's team four years, and a lot of failed experiments, to produce "Yablonovite" — the first 3D photonic crystal. It consisted of a ceramic material, drilled with three intersecting series of cylindrical holes, 6mm across.

"Its power was obvious," Professor Yablonovitch said. "The multiple scatterings work out such that no matter which way the light tries to go, it's blocked — in every imaginable direction. And even in directions that we cannot imagine, it's still blocked."

Today, 2D photonic crystals are used in "silicon photonics" — integrated circuits that use both light and current to transfer information, widely used in large data centers. Other researchers have adapted the discovery to guide light in devices used in precise appliactions such as laser surgery. ***— By Jonathan Webb, adapted from BBC News***

A Fast Track to Success

Under the leadership of Prof. Chan Joshi, a new enrichment program within the EE undergraduate program has been initiated for the 2015/16 academic year. Students with high scholastic achievement are selected to be members of the Fast Track program. This features regular advising meetings, encouragement to attend special honors sections of courses, and enhanced opportunities for early participation in the research programs of the Department. The program has multiple goals. The first is to encourage more highly capable students to study EE at UCLA. The second is to make a dent in the serious shortage of US students pursuing graduate degrees by showing more students the exciting career opportunities that it opens up. In the inaugural year, 20 students are in the Fast Track program, with many enrolled in a new physics honors sequence. In subsequent years, the Department will roll out additional enrichment programs in its own courses.

Chan Joshi

New Community College Partnerships

Each year the UCLA EE Department accepts qualified community college students as transfers. Traditionally there has been relatively little interaction between the Department and these colleges at the level of cooperation on curriculum, forcing many transfer students to take additional courses. This delays their time to graduation. With the leadership of Professor Oscar Stafsudd, himself an alumnus of the community college system, we are moving towards a smoother transition. A partnership with the Santa Monica College will enable their new engineering program to offer all the lower division courses required of UCLA students. This takes advantage of new low-cost kits which enable circuits laboratories to be offered without the traditional expensive bench-top equipment. We have recently introduced these kits into our own lab sequence. We will adapt the sequence to make it even less resource intensive. From this experience, we hope to expand our interactions, making the course materials available to other community colleges that traditionally provide many applicants. This new approach adds to our existing relationships in providing summer research oppportunities to community college students via federally funded programs.

Oscar Stafsudd

UCLA HKN

The UCLA Iota Gamma Chapter of Eta Kappa Nu (HKN) is a unique organization dedicated to encouraging and recognizing excellence through a balance of scholarship, service, leadership, and character in the electrical and computer engineering fields.

In 2015, the club has provided valuable service by conducting training sessions in MATLAB and Lab View. HKN members also provide tutoring services. The club also hosts lunches with professors, technical talks, and visiting companies. With the IEEE, it co-hosts the annual EE Department Town Hall where concerns of students are discussed with the faculty.

The Iota Gamma Chapter of HKN continues to see impressive student involvement under the guidance of its advisor Professor Benjamin Williams. A total of 58 undergraduates were inducted, bringing its current active membership to over 200 members. The Iota Gamma Chapter was awarded the 2013-2014 Outstanding Chapter Award – the tenth consecutive win for the chapter.

UCLA IEEE Student Chapter

UCLA IEEE (Institute of Electrical and Electronics Engineers) is one of the largest engineering-focused clubs at UCLA. In addition to our corporate infosessions, workshops, and events aimed to help students in career building and professionalism, UCLA IEEE is known for the challenging, educational, but still fun projects that allow students to get a true hands-on experience in electrical engineering that classroom lectures do not offer.

The OPS (Open Project Space) program is geared toward first and second-year students, aimed at teaching the fundamentals of hands-on electrical engineering. Our computer science-focused analogy, C3 (Code, Create, Compete), allows computer science majors to join in on the fun with their own customized projects. For more advanced students who want a challenging robotics experience, the Micromouse and Natcar projects are perfect choices to build something crazy. Outside of these structured programs, students are also free to innovate and imagine up independent projects, which IEEE sponsors and helps to create.

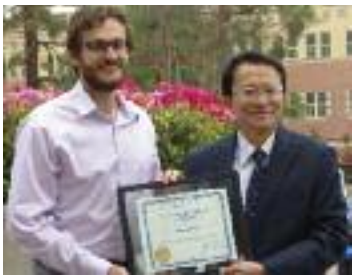
IEEE hosts several large events each year that are open to the wider engineering community. Often working with other groups on campus, UCLA IEEE hosts an annual fair showcasing local startups, as well as an all-day professional development workshop. 2015 also debuted the first annual (IDE)A Hacks Hardware Hackathon — a 36-hour design-and-build event where students work to create a product from their imagination and are judged accordingly.

The UCLA IEEE club is located on the second floor of Boelter Hall with its own lab space in the Student Creativity Center. The lab currently has a 3D printer and a mini-CNC mill that students can use for a small fee. Our lab is stocked with parts for anybody to use, whether they are part of the electrical engineering, computer science, or any other major.

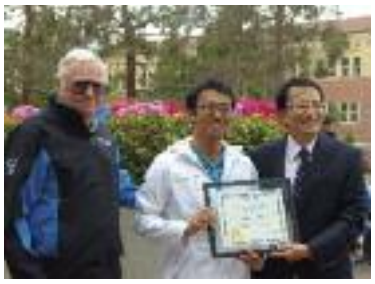
Awards:

- IEEE Region 6 Exemplary Student Branch Award
- IEEE Region 6 Outstanding Large Student Branch
- UC Davis Natcar Competition – 1st, 5th, 6th
- UCSD Grand PrIEEE Natcar – 3rd, 4th, 5th
- Region 6 Micromouse Competition (UCI) – 2nd
- All-America Micromouse Competition (UCLA) – 2nd
- UCSD California Micromouse Competition – 2nd
- IEEE Student Professional Awareness Venture (S-PAVe)

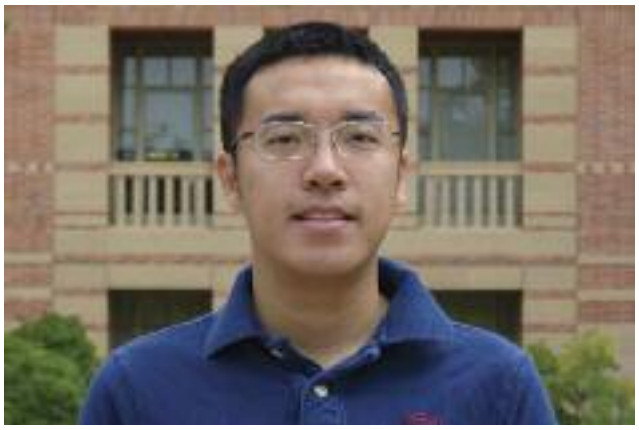
Outstanding Student and Teaching Awards



Clayton Schoeny received the Henry Samueli Excellence in Teaching Award (lecture course) with Chairman **M.-C. Frank Chang**.



Brad Liu, recipient of the Henry Samueli Excellence in Teaching Award (lab course) with Chairman **M.-C. Frank Chang**, and Vice Chair for Undergraduate Affairs and his advisor **Oscar Stafsudd**.



Xufeng Kou, Outstanding Ph.D. Dissertation in Physical & Wave Electronics: *Magnetic Topological Insulator and Quantum Anomalous Hall Effect.* Advisor: **Kang L. Wang**.

Onur Atan, Outstanding Master's Thesis Award in Signals & Systems: *Bandit Framework for Systematic Learning in Wireless Video-based Face Recognition* pictured next to Chairman **M.-C. Frank Chang**, and advisor **Mihaela van der Schaar**.

Jean Paul Santos, Outstanding Master's Thesis in Physical & Wave Electronics: *Multiband Circularly Polarized Patch Antenna Array for the Development of Direct-to-Earth Communications in Mars Rovers,* beside Chairman **M.-C. Frank Chang**, and advisor **Yahya Rahmat-Samii**.

Abde Ali Kagalwalla, Outstanding Ph.D. Dissertation in Circuits & Embedded Systems: *Computational Methods for Design-Assisted Mask Flows*. Advisor: **Puneet Gupta**.

Gary Yeung, The Outstanding Bachelor of Science Degree Recipient, pictured with Chairman **M.-C. Frank Chang**.

Hannah Chou, The Christina Huang Memorial Prize recipient and Chairman **M.-C. Frank Chang**.

Jie Xu, Outstanding Ph.D. Dissertation in Signals & Systems: *Networks of Strategic Agents: Social Norms, Incentives and Learning*. Advisor: **Mihaela van der Schaar**.

In Honor of Distinguished Professor A.V. Balakrishnan, 1922–2015

A.V. Balakrishnan, Distinguished Professor Emeritus and Research Professor of Electrical Engineering, passed away on Monday, March 16, 2015. He was 92.

Bal, as he was widely known, was a member of the UCLA Henry Samueli School of Engineering and Applied Science faculty for more than 50 years. Over his long and distinguished career, he supervised 54 master's students, 18 Engineer degree recipients and 54 Ph.D. graduates, many of whom went on to careers in academia and industry.

He greatly valued his role as advisor and friend, and often spoke of how proud he was of his students.

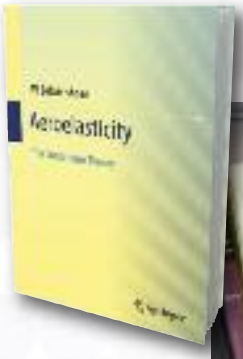
Bal grew up in Chennai, India. He earned his B.Sc. and an M.A. from the University of Madras. After moving to the U.S., he earned an M.S. in electrical engineering (1950) and his Ph.D. in mathematics (1954), both from USC.

Following his Ph.D., Bal was a project engineer at the Radio Corporation of America (RCA), taught at USC and UCLA, and was a researcher at Space Technology Laboratories in Redondo Beach. He joined UCLA Engineering at the associate professor level in 1961.

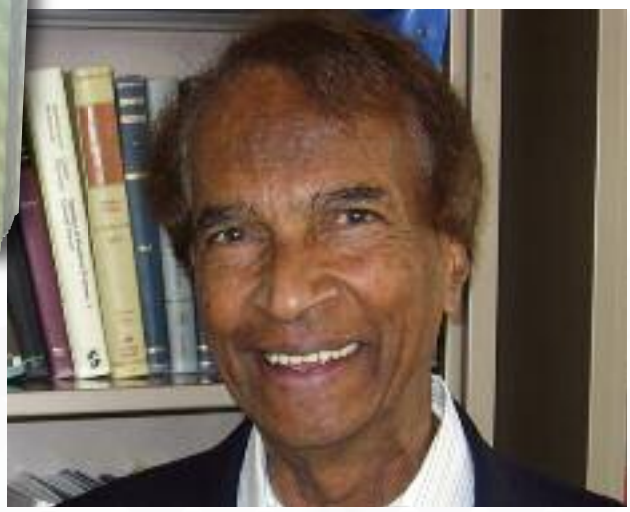
Bal was a teacher and scholar of the highest order. He published single-authored papers, while encouraging his students to publish their work under their own names. Twice, he served as chair of the Department of Systems Science. He also held an appointment in Mathematics. For several years, he was the director of the Flight Systems Laboratory at UCLA, which was supported by NASA.

Bal was named a Fellow of IEEE in 1966 and a Life Fellow in 1996. He received the NASA Public Service Medal in 1996; the Richard E. Bellman Award in 2001 from the American Automatic Control Council for distinguished achievements in control theory; and the Distinguished Alumni Award in Academia from USC Viterbi in 2004.

— By Matthew Chin



Aeroelasticity



Kalman Filtering Theory

Introduction to Random Processes in Engineering

Applied Functional Analysis

Semigroup of Operators: Theory and Applications

Communication Theory

Stochastic Diferential Systems

Members of National Academies







In 2007, ***Professor Asad A. Abidi*** was inducted into the National Academy of Engineering for his contributions to the development of MOS integrated circuits for RF Communications. Prior to joining UCLA in 1985, Professor Abidi worked at Bell Laboratories, as a member of the technical staff in the Advanced LSI Development Laboratory. He received a number of awards and honors throughout his career, including the 1988 TRW Award for Innovative Teaching, the 1997 IEEE Donald G. Fink Award, presented for the most outstanding survey, review, or tutorial paper published by the IEEE, and the 2008 IEEE Donald O. Pederson Award in solid state circuits.

Professor Mau-Chung Frank Chang was elected to the National Academy of Engineering in 2008 for his contributions in development and commercialization of III-V-based heterojunction bipolar transistors (HBTs) and field-effective transistors (FETs) for RF wireless communications. Prior to joining UCLA, Professor Chang was the Assistant Director at Rockwell Science Center where he successfully developed and transferred AlGaAs/GaAs Heterojunction Bipolar Transistor (HBT) and BiFET (Planar HBT/MESFET) integrated circuits technologies from the research laboratory to the production line. His research focuses on the development of high-speed semiconductor devices, integrated circuits for RF and mixed-signal communication, and interconnect system applications. Professor Chang received the IEEE David Sarnoff Award (IEEE-wide Technical Field Award) and the Pan Wen-Yuan Foundation Award.

Professor Tatsuo Itoh pioneered the interdisciplinary electromagnetics research beyond traditional electromagnetic engineering. He was elected to the National Academy of Engineering in 2003, "for seminal contributions in advancing electromagnetic engineering for microwave and wireless components, circuits, and systems." He developed several numerical methods to understand microwave problems, and developed the first CAD program for designing E-plane filters for millimeter wave systems. His research focuses on combining solid state devices and electromagnetic circuits for cost-effectiveness and system performance, developing the first global simulator for the RF front end. He also created the Active Integrated Antenna, which is not only a radiating element, but also a circuit element for the RF front end.

Professor Chandrashekhar Joshi was recognized by the National Academy of Engineering as the founder of the experimental field of plasma accelerators. He established the first group that proposed to significantly shrink the size and cost of particle accelerators by using charged density waves in plasmas (or ionized gas) using powerful laser pulses or particle beams. Joshi has advanced the understanding of nonlinear optics of plasmas, laser fusion and basic plasma physics. He has received numerous awards for his work, including the American Physical Society's James Clerk Maxwell Prize and Excellence in Plasma Physics Award, the IEEE's Particle Accelerator Science and Technology Award, the USPAS Prize for Accelerator Physics and Technology, and the AAC Prize for Advanced Accelerator Concepts. He is a fellow of the American Physical Society, IEEE and the Institute of Physics.

Professor Kuo-Nan Liou is Director of the Joint Institute for Regional Earth System Science and Engineering. He pioneered the use of combinations of remote sensors to obtain important cloud ice and aerosol parameters and climate radiative forcing. He derived the analytic four-stream solution for radiative transfer and discovered the depolarization principle to differentiate ice crystals and water droplets. Professor Liou was elected a Member of the National Academy of Engineering in 1999 and was the Chair of Special Fields and Interdisciplinary Engineering Section. Elected a Member of the Academia Sinica in 2004, he is also a Fellow of the American Association of the Advancement of Science, AGU, AMS and OSA. He shared the Nobel Peace Prize bestowed on the Intergovernmental Panel on Climate Change in 2007.

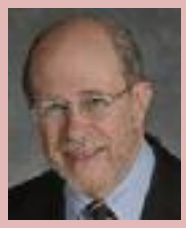
Professor Asad M. Madni was elected to the National Academy of Engineering in 2011. Prior to joining UCLA, he was President, COO and CTO of BEI Technologies Inc., where he led the development and commercialization of intelligent micro-sensors and systems for aerospace, defense, industrial and transportation industries. Prior to joining BEI he was Chairman, President & CEO of Systron Donner Corp. His honors include the IEEE Millenium Medal, IET J. J. Thompson Achievement Medal, TCI Marconi Medal and UCLA Professional Achievement Medal. In 2004, he received the UCLA Engineering Alumnus of the Year Award and in 2010 was awarded the UCLA Engineering Lifetime Contribution Award. He is a Fellow of the NAI, IEEE, IEE, IET, AAAS, NYAS, SAE, IAE and AIAA.

Professor Stanley Osher was elected to the National Academy of Sciences for "major contributions to algorithm development and applications in level set methods, high-resolution shock capturing methods, and PDE-based methods in imaging science." He has been at









UCLA since 1976 and is Director of Special Projects at the Institute for Pure and Applied Mathematics. Dr. Osher was a Fulbright and Alfred P. Sloan Fellow, and received the NASA Public Service Group Achievement Award, the Japan Society of Mechanical Engineers Computational Mechanics Award, the SIAM Pioneer Prize, and the SIAM Kleinman Prize.

Professor C. Kumar Patel, National Academy of Sciences, made numerous seminal contributions in gas lasers, nonlinear optics, molecular spectroscopy, pollution detection and laser surgery. He received numerous honors, including the National Medal of Science for his invention of the carbon dioxide laser. He also received the Lomb Medal of the Optical Society of America, the Franklin Institute's Ballantine Medal, the Pake Prize of the American Physical Society, and the Coblentz Society's Coblentz Prize.

Distinguished Professor Yahya Rahmat-Samii was elected to the National Academy of Engineering in 2008 for his contributions to the design and measurement of reflector and hand-held device antennas. Many of his design concepts are currently used in cell phones, aerospace, earth-observation satellites, and satellite dishes. Prior to joining UCLA, he was a Senior Research Scientist at Jet Propulsion Laboratory. His honors include the 2007 Chen-To Tai Distinguished Educator Award from the IEEE Antennas and Propagation Society; the 2005 International Union of Radio Science's Booker Gold Medal; the 2000 Antenna Measurement Techniques Association's Distinguished Achievement Award; the IEEE's Third Millennium Medal; and a Distinguished Alumni Award from the University of Illinois, Urbana-Champaign.

Dr. Henry Samueli was elected to the National Academy of Engineering in recognition of his "pioneering contributions to academic research and technology entrepreneurship in the broadband communications system-on-a-chip industry." Dr. Samueli has over 25 years of experience in the fields of digital signal processing and communications systems engineering and is widely recognized as one of the world's leading experts in the field. He received his B.S., M.S. and Ph.D. degrees in electrical engineering from UCLA. Since 1985, Dr. Samueli is a professor in the Electrical Engineering Department. He is the co-founder of Broadcom Corporation. In 2010, Professor Samueli received the UCLA Medal.

Professor Jason Speyer was elected to the National Academy of Engineering for "the development and application of advanced techniques for optimal navigation and control of a wide range of aerospace vehicles." He pioneered new deterministic and stochastic control, team and differential game strategies, estimation, and model-based fault detection, identification, and reconstruction theories and algorithms, as well as matrix calculus of variations for the Apollo autonomous navigation system. He pioneered the development and mechanization of periodic optimal control for aircraft fuel-optimal cruise and endurance, as well as differential carrier phase GPS blended with an inertial navigation system. He is a fellow of AIAA and IEEE (Life Fellow) and received the IEEE Third Millennium Medal as well as several AIAA Awards.

Professor Dwight Streit became a member of the National Academy of Engineering in 2001 for contributions to the development and production of heterojunction transistors and circuits. Prior to joining UCLA, he was vice president, director, technical fellow and contributing engineer for advanced technologies at Northrop Grumman and TRW Space & Electronics. He is also a Fellow of the Institute of Electrical and Electronic Engineers and the American Association for the Advancement of Science, and a member of the NASA Space Foundation Technology Hall of Fame.

Professor Eli Yablonovitch, National Academy of Engineering, National Academy of Sciences, is a Fellow of the Institute of Electrical and Electronic Engineers, the Optical Society of America, and the American Physical Society. He has been awarded the Adolf Lomb Medal, the W. Streifer Scientific Achievement Award, the R.W. Wood Prize, and the Julius Springer Prize. He is an Adjuct Professor of Electrical Engineering at UCLA, and also a Professor of Electrical and Computer Engineering at UC Berkeley.

Professor Alan N. Willson, Jr. was recognized by the National Academy of Engineering in 2014 for "contributions to the theory and applications of digital signal processing." He has played an important role in the field of circuits and systems, been responsible for cutting-edge research in theory and application of digital signal processing (including VLSI implementations), digital filter design and nonlinear circuit theory. Among the many notable honors, he has received the Vitold Belevitch Award from the IEEE Circuits and Systems Society, the IEEE Leon K. Kirchmayer Graduate Teaching Award, and the George Westinghouse Award from the American Society for Engineering Education. He is the only person to have twice received the W.R.G. Baker Prize Paper Award for best paper published in all IEEE journals, transactions and magazines.

Circuits & Embedded Systems

Design Automation for Computer Systems

We investigate methodologies and algorithms for design of digital, mixed-signal as well as FPGA-based reconfigurable integrated circuits in the context of emerging challenges of energy efficiency, security, reliability, variability and manufacturability. We look at how technology changes in devices as well as how semiconductor fabrication influence design (especially layout). On the other hand, our research seeks to dramatically reduce cost of technology by utilizing design intent in technology development and process control. The effects of nanoscale semiconductor technologies span the entire hardware-software stack and as such we have been looking into architecture and system software techniques to mitigate variability and reliability challenges of increasingly unpredictable circuit fabric. Our efforts also target modeling and design of Internet of Things and energy systems in addition to electronic systems.

Puneet Gupta

Jason Cong

Ankur Mehta

Also: Lei He

Energy-Efficient Digital Architectures and Circuits

We are focusing on digital integrated circuit optimization in the power-area-performance space, its application to emerging health care and communication algorithms, and the investigation of design principles with post-CMOS devices. This includes advanced communication algorithms such as those found in future cognitive radios and new advances in biomedical applications.

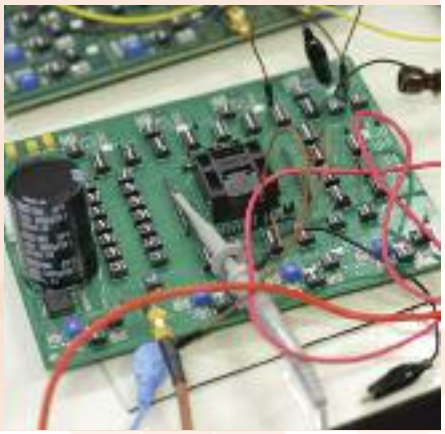

Danijela Cabric


Babak Daneshrad


Dejan Markovic


C.-K. Ken Yang

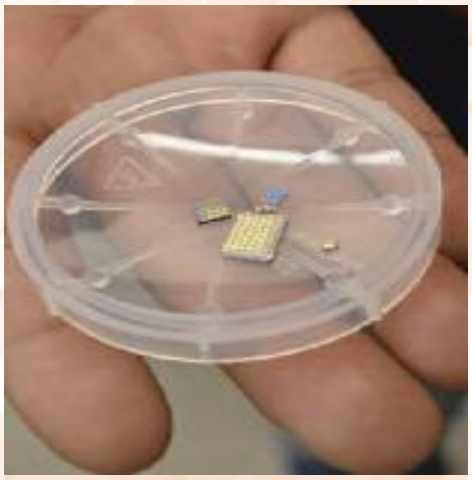
Also: Jason Cong



Neuroengineering

We address challenges that limit our ability to obtain information as well as our ability to process it in incredibly small and low-power form factors, to advance technology for science, therapy and global health. Our work brings together low-power data processing, biosignal interfaces, communication, and energy aspects to push the limits of biosignal transducer systems, where the energy, size and processing requirements are often orders of magnitude more challenging than in conventional applications. The cross-disciplinary nature of our work naturally stimulates collaboration across the areas of signal processing, circuits and systems, and devices, as well as interactions at the biological and engineering levels.

Jason Cong
Dejan Markovic



Emeriti Faculty

Rajeev Jain
Gabor Temes
Jack Willis
Alan Willson

Communication Circuits

We develop integrated circuits for data communications spanning the entire gamut of data rates, ranges, and communication media: from wireless to wired, from PCB traces to plastic waveguides, from intra-chip to long haul links, from cellular to space communications, from VHF to terahertz frequencies, and from low power links to multi-Gb/s links. Our focus is on CMOS electronics and our faculty members are pioneers in this field. We address the fundamental challenges posed by noise, device nonlinearity, and variability in effecting communications in harsh environments, employing theoretical analysis, creative circuit design, and algorithmic digital correction techniques. The recent focus has been on enabling true software defined radios, mm-wave and terahertz applications.

Also:
M.-C. Frank Chang
Y. Ethan Wang

Asad Abidi

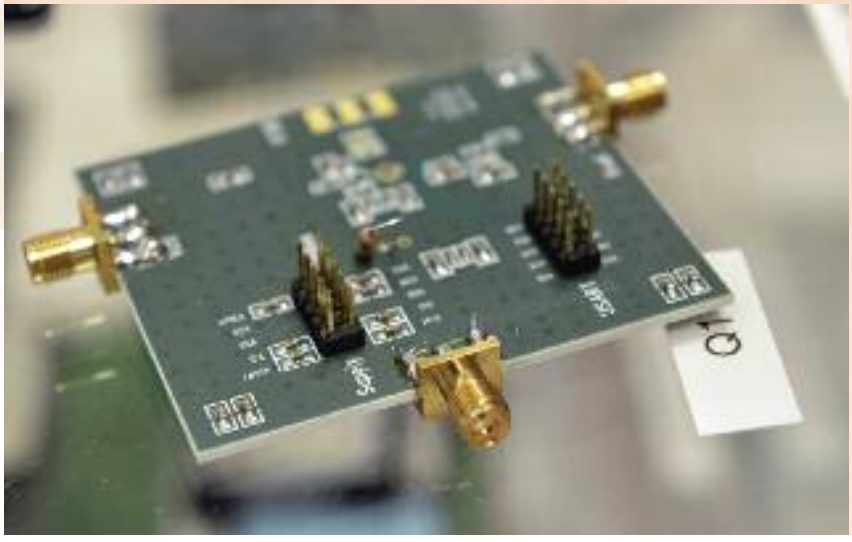
Wentai Liu

Sudhakar Pamarti

Behzad Razavi

Henry Samueli

C.-K. Ken Yang



Adjunct Faculty

Hooman Darabi

Shervin Moloudi

Embedded and Mobile Computing, and Cyber-Physical Systems

We focus on foundational hardware and software technologies and architectures for computing and communication capabilities necessary for emerging embedded, mobile, and cyber-physical systems. Such systems are found in emerging application domains of critical socio-economic importance, such as robotics, mobile health, sustainable built environments, smart electrical grids, smart water networks, and transportation systems. Our research addresses the fundamental capabilities needed by these systems such as energy efficiency, real-time performance, location awareness, precise time synchronization, adaptation to variations, secure operation, etc., and also develops novel implementation methods spanning the entire system stack from application and operating system software down to the processor, datapath, memory, and I/O hardware.

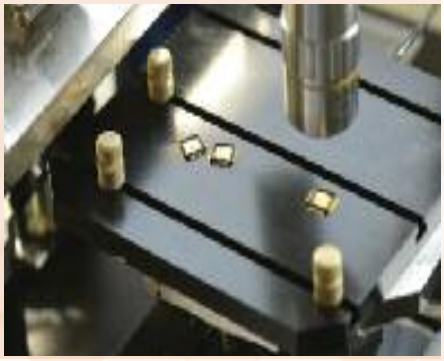
Also: Puneet Gupta, Ankur Mehta, Paulo Tabuada

Lei He

William Kaiser

Majid Sarrafzadeh

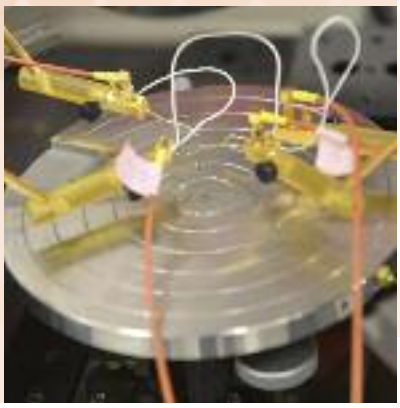
Mani Srivastava



Sensor Information Acquisition, Processing, and Applications

Sensory information is foundational to modern electronic computing systems across myriad application domains such as health, energy, environment, and communications. Our research is developing innovative technologies for the entire waveform-to-decision pathway through which sensor information flows, often in real-time, distributed and resource-constrained settings. In work, we are developing (i) high-sensitivity and low-power transducers and A/D converters for capturing and digitizing sensor signals, (ii) high-performance hardware-software platforms for processing sensor data; and (iii) efficient algorithms and protocols for processing sensor data to derive rich inferences under power, processing, and security constraints in networked settings. Moreover, the results of our research are being applied to real systems in various applications.

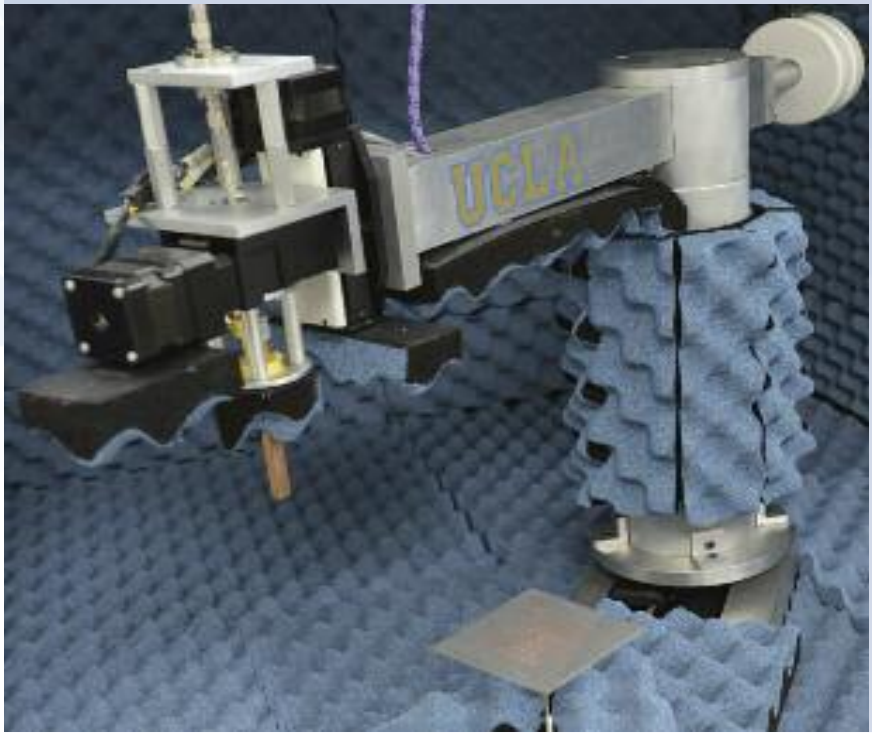
Faculty:
Chi On Chui
William Kaiser
Aydogan Ozcan
Gregory J. Pottie
Mani Srivastava



Physical & Wave Electronics

Electromagnetics

Electromagnetics embodies all aspects of science and engineering topics stemming from Maxwell's equations, describing the behavior of electric and magnetic fields and their interactions with electric charges and currents. The science of electromagnetics underlies nearly all modern electric, computation, and communications technology. Both our coursework and research address theoretical, computational, optimization, design and measurement aspects of electromagnetic devices for a variety of applications, including wireless communications, satellite, space and ground systems, medical and sensor applications, multi-function antennas and metamaterials in frequencies ranging from microwaves and millimeter waves to terahertz.

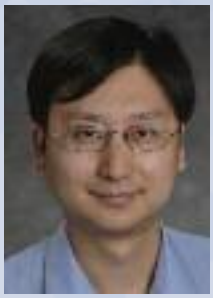


M.-C. Frank Chang

Tatsuo Itoh

Kuo-Nan Liou

Yahya Rahmat-Samii



Y. Ethan Wang

Also:
Robert Candler
Mona Jarrahi
Warren Mori
Aydogan Ozcan
Benjamin Williams

Emeritus Faculty

Frederick Schott

Nanoelectronics, Devices and Heterogeneous Integration

In the area of nanoelectronics and solid-state devices, UCLA is at the forefront of research. Major research efforts are ongoing for the synthesis and design of advanced materials, such as two-dimensional semiconductors, topological insulators, and magnetic oxides — both their fundamental properties and their applications to ultra-scaled logic and memory devices. We also have extensive activities in the design and fabrication of ultra-scaled devices on both silicon and compound semiconductors, such as power and RF transistors, spin-based switches and memory elements, tunnel FETs, and other novel devices that are suitable for applications that go beyond conventional scaling. Another major thrust is the development of neuromorphic (i.e. brain-inspired) devices and nanosystems for computation and information processing. Nanoelectronic devices are under investigation for use as sensors for compact biomedical sensing tools. This area also includes the development of Micro- and Nano-Electromechanical Systems (MEMS and NEMS.) In addition, we investigate new methods of interconnecting heterogeneous devices for a more holistic interpretation of Moore's law. Many of these research activities take place in collaboration with other research groups, both within and outside EE, on circuit/system/device co-design and co-optimization. The nanoelectronics research in the department is supported by advanced commercial simulation tools for device analysis, a state-of-the-art nanofabrication facility, and device characterization equipment with capability from DC to over 100GHz.

Robert Candler

Chi On Chui

Diana Huffaker

Subramanian S. Iyer

Mona Jarrahi

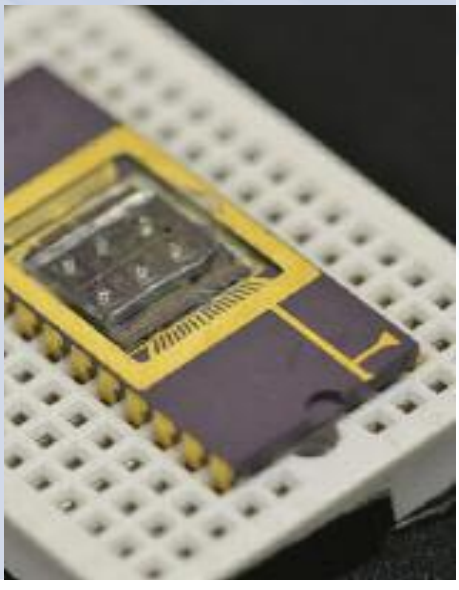
Dwight Streit

King-Ning Tu

Kang Wang

Chee Wei Wong

Jason C. S. Woo

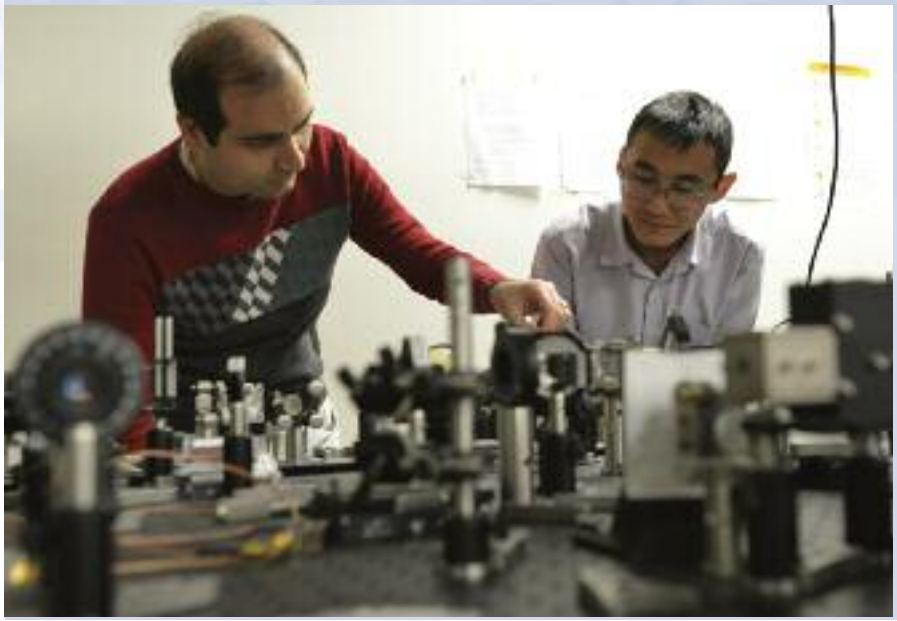


Emeriti Faculty

Fred G. Allen
Harold Fetterman
Dee Son Pan
Chand Viswanathan

Photonics

Photonics deals with the generation, detection, and manipulation of light — specifically how it can be harnessed to provide useful functions. For example, nearly all of the information on the internet is transported by encoding it onto signals of infrared light carried on optical fibers. Many unknown materials can be identified by studying how light interacts with them (i.e. by scattering, absorbing, phase shifting, or polarizing some incident photons). The name "photonics" emphasizes the importance of quantum mechanical properties of light and its interaction with matter. Many topics in photonics research involve development and/or use of lasers. Our research program encompasses topics such as how light interacts both with matter on the nanoscale and in plasmas, as well as new ways to generate, detect, and control light in underdeveloped spectral regions. Applications under investigation include the diverse topics of solar energy generation, lensless microscopy for cell-phone based telemedicine, high energy laser wakefield particle accelerators, ultra-high frame rate imaging, silicon photonics, biomedical imaging, and use of stabilized lasers for ultra-high precision measurements — just to name a few.



Katsushi Arisaka

Warren Grundfest

Bahram Jalali

Jia-Ming Liu

Aydogan Ozcan

Oscar Stafsudd

Benjamin Williams

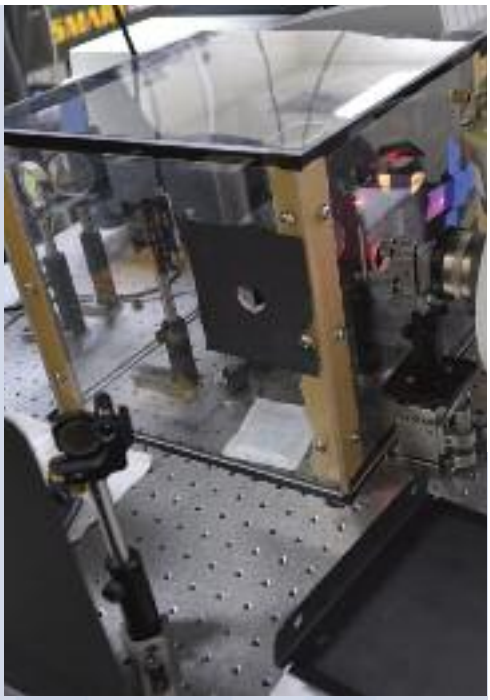
Also:
Diana Huffaker
Mona Jarrahi
Chan Joshi
Chee Wei Wong

Emeritus Faculty

Harold Fetterman

Plasma Electronics

Plasma Electronics covers a wide spectrum of activities that include electro-dynamics of charged particles in external fields, non-linear optics of plasmas, high energy-density plasmas, laser-plasma interactions, basic plasma behavior, computer simulations of laboratory and space plasmas and fusion plasmas. The applications being studied are plasma-based charged particle accelerators, free electron lasers, other plasma-based radiation sources, laser-fusion, astrophysical plasmas, plasma propulsion, gas lasers and plasmas for lighting. There are opportunities to do experimental, theoretical and computer simulations research in all these areas. Close collaborations exist with national laboratories at Livermore and SLAC and the group has in-house state-of-the art laboratories including the Neptune Laboratory that houses the world's most powerful CO2 laser. The group also has the Dawson II computational cluster for research on inertial confinement fusion, plasma accelerators and astrophysical plasmas.



Emeritus Faculty

Francis F. Chen

Chan Joshi

Warren Mori

Adjunct Faculty

Keisuke Goda

Pedram Khalili

Asad M. Madni

Yi-Chi Shih

Eli Yablonovitch

Signals & Systems

Communications and Networking

UCLA has a tradition in Communications and Networking research: for example, the first Internet packets were sent from UCLA and the Viterbi Algorithm was developed here. In an increasingly interconnected and online world, our research encompasses computer networks, social networks, wireless networks, on-chip networks and biological networks. Our work spans from fundamental questions in communications networking, autonomous vehicular networks, multimedia telecommunications, coding theory, algorithms, resource allocation, game theory, network economics, information theory and security, to applications in mobile computing, sensors and embedded systems, distributed control systems, media distribution, green computing, intelligent cities, smart grid, cognitive radios, emergency networks and mobile health.

Suhas Diggavi

Ali Mosleh

Gregory J. Pottie

Izhak Rubin

Ali H. Sayed

Lixia Zhang

Christina Fragouli

Emeriti Faculty

Nhan Levan
Paul K.C. Wang
Donald Wiberg

Kung Yao

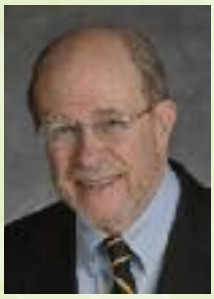
Also:
Danijela Cabric
Babak Daneshrad
Sam Coogan
Asad Madni
Ankur Mehta
Mihaela van der Schaar
Mani Srivastava
Paulo Tabuada
John Villasenor
Richard D. Wesel

Signal Processing and Machine Learning

We rely on signals to interact with the physical and virtual world. A challenge today is how to collect, analyze, store, and process large data in an efficient and scalable manner. Our signal processing research targets the inference, visualization, representation, and learning of a broad spectrum of signals related to media (including speech, video and social media networks), sensors (for medical, military, space, process control or environmental applications), communications and control networks (such as wireless and utility networks), and adaptive arrays (such as acoustic and radar). This applies to problems ranging in scale from the microscopic to Big Data. Research contributes to disciplines descended from both EE and CS roots, such as machine learning, statistical signal processing, stochastic modeling, graphical models, information theory, adaptation and learning algorithms, inference over networks, distributed signal processing, data analysis and distributed optimization.

Emeriti Faculty

Kung Yao



Alan Willson

Also:
Danijela Cabric
Asad Madni
Gregory J. Pottie
Ali H. Sayed
Mihaela van der Schaar
Mani Srivastava

Abeer Alwan

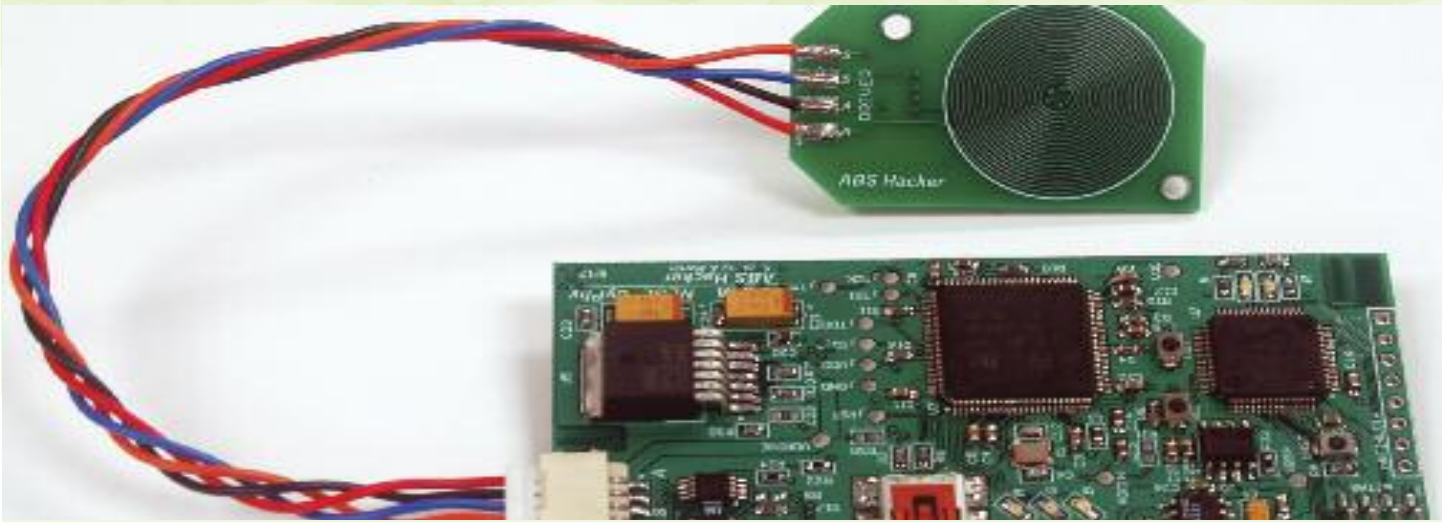
Lara Dolecek

William J. Kaiser

Stefano Soatto

Paulo Tabuada

John Villasenor



Control and Decision Systems

Control and decision systems research aims to develop the mathematical principles explaining how complex systems can behave correctly in uncertain environments. One key program strength is in cyber-physical systems that network together collaborating computational elements with physical elements. We work in improving their functionality, autonomy, and adaptability, analyze their performance and ensure their secure operation. Applications include autonomous vehicles, transportation networks, medical systems, robotics coordination, smart buildings and smart power grids. Another strength is in the intersection of economics with engineering.

Also:
Ankur Mehta
Ali Mosleh
Izhak Rubin
Ali H. Sayed

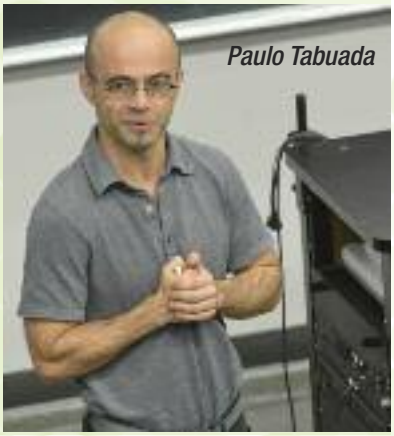
Panagiotis Christofides

Sam Coogan

Alan Laub

Mihaela van der Schaar

Jason L. Speyer



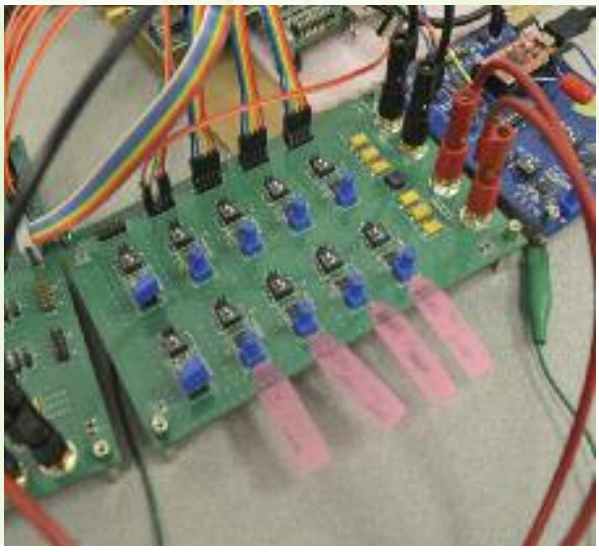
Adjunct Faculty

Also:
Asad Madni

Ezio Biglieri

Dariush Divsalar

Ingrid Verbauhwede




Information, Computation and Optimization Theory

Information theory research develops the fundamental limits of compression, encryption, and channel coding of data in a variety of networks, storage media and communications systems. Application areas include new types of storage systems, and more efficient and secure networks. Computation theory research characterizes the fundamental complexity of problems and the types of algorithms that can be used to solve them efficiently and/or approximately. Optimization theory research studies how minimizing cost functions inherent in problems spanning from economics to broad swaths of engineering can be formulated and efficiently solved.

Also:
Suhas Digavi
Lara Dolecek
Alan Laub
Ankur Mehta
Izhak Rubin
Ali H. Sayed
Mihaela van de Schaar
Paulo Tabuada

Emeritus Faculty

Stephen Jacobsen


Christina Fragouli


Stanley Osher


Vwani Roychowdhury


Lieven Vandenberghe


Richard D. Wesel

The Electrical Engineering Department Overview

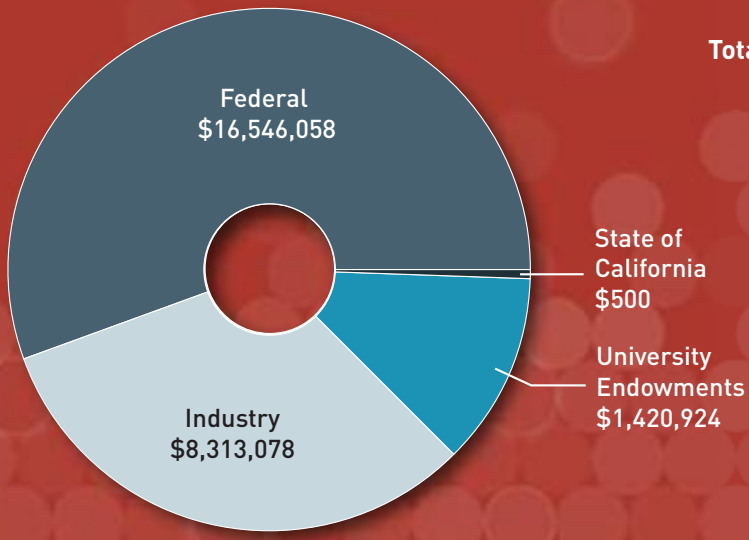
Faculty and Staff

Ladder Faculty	46
Courtesy Appointments	15
Emeriti Faculty	14
Adjunct	10
Lecturers	12
Staff	45

Recognitions

Society Fellows	47
NAE Members	14
NAS Members	3
National Academy of Inventors	2
Marconi Prize	1

Research Funding for 2014-2015



Total $26,362,398

* Additional $81,840 funding from sales and services

Research Centers

The Electrical Engineering Department contributes to the following Research Centers:

- Andersen School of Management — Easton Technology Management Center (ASM))
- California NanoSystems Institute (CNSI)
- Center for Development of Emerging Data Storage Systems (CoDES2)
- Center for Engineering Economics, Learning and Networks (CEELN)
- Center for High Frequency Electronics (CHFE)
- Center for Systems, Dynamics, and Control (SyDyc)
- Center of Excellence for Green Nanotechnologies (CEGN)
- CHIPS — Center for Heterogeneous Integration and Performance Scaling
- Expedition into Hardware Variability-Aware Software
- Function Accelerated nanoMaterial Engineering (FAME)
- Institute for Cell Mimetic Space Exploration (CMISE)
- Institute for Digital Research and Education (IDRE)
- Institute for Pure and Applied Mathematics (IPAM)
- Institute for Technology Advancement (ITA)
- Integrated Modeling Process and Computation for Technology (IMPACT+)
- Integrated Systems Nanofabrication Clean Room (ISNCR)
- Joint Institute for Regional Earth System Science and Engineering (JIFRESSE)
- Nanoelectronics Research Facility (NRF)
- Public Safety Network Systems (PSNS)
- Translational Applications for Nanoscale Multiferroic Systems (TANMS)
- Water Technology Research Center (WaTer)
- Western Institute for Nanoelectronics (WIN)
- Wireless Health Institute (WHI)

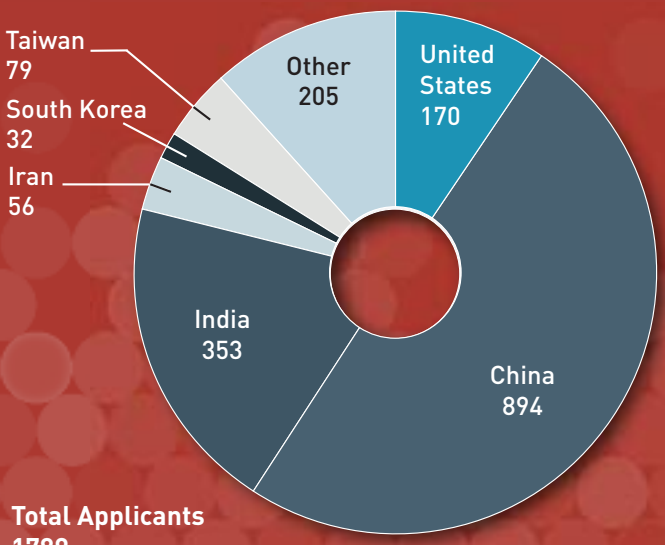
Undergraduate Students

Students Enrolled	684	
Applicants for Fall 2014	1814	
Admitted	424	
New Students Enrolled	183	
Average Incoming GPA	4.36	(weighted)
	3.93	(unweighted)

Graduate Students

Students Enrolled	497
Applicants for Fall 2014	2010
Admitted	409
New Students Enrolled	176
Median Incoming GPA	3.79

Graduate Applicants for Fall 2015



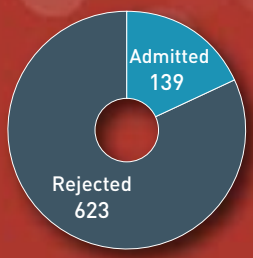
Total Applicants
1789

Graduate Student Fellowships (in US$)

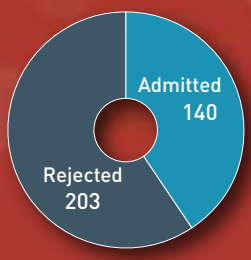
Department Fellowships	$776,917
Dean's GSR Support & NRT Matching Funds	$449,191
Non-Resident Tuition Support for Teaching Assistants	$291,972
Broadcom Fellowship	$137,490
Dissertation Year Fellowships	$105,624
Graduate Opportunity Fellowships	$99,864
MediaTek Fellowships	$72,564
Faculty Unrestricted Fellowships	$52,575
Ph.D. Preliminary Exam Top Score Fellowships	$51,384
Sandia Excellence in Science & Technology Fellowship	$40,000
Henry Samueli Partial Fellowships	$34,254
Dr. Ursula Mandel Fellowship	$30,000
Dean's Fellowship & Camp Funds	$29,000
IGERT Fellowship	$25,389
Northrop Grumman Fellowships	$23,015
Guru Krupa Foundation Fellowship	$22,116
Kalosworks	$14,148
Raytheon Fellowship	$13,176
Howard Hughes Medical Institute Research Fellowship	$11,290
Living Spring Fellowship	$10,309
Borgstrom Fellowship	$10,000
Rockwell Fellowship	$8,116
Conference Travel Funds	$7,300
Graduate Dean's Scholar Award	$5,000
Malcolm Stacey Fellowship	$5,000
Mindspeed Fellowship	$4,957
Total	**$2,330,651**

Graduate Students Admitted

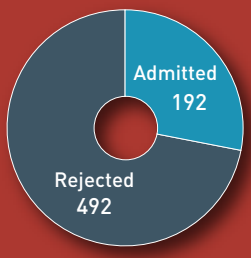
Circuits & Embedded Systems



Physical & Wave Electronics

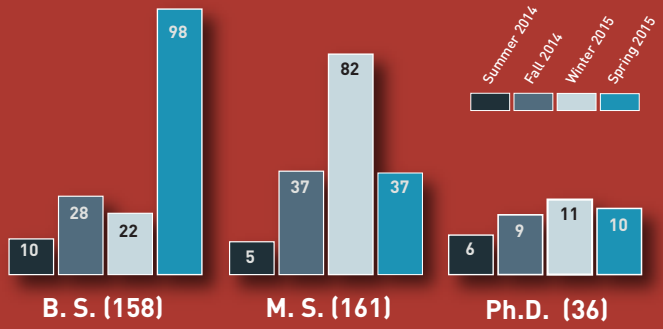


Signals & Systems



Total Admitted
471

Degrees Conferred in 2014-2015



Alumni Advisory Board

The mission of the Alumni Advisory Board is to provide critical and supportive advice to the UCLA Electrical Engineering Department in enhancing its leadership role in education and research.

Heba A. Armand
Group Product Manager, Avery Consumer Products

Phil Bangayan
Director of Marketing, NBC/Universal

Sharon Black
Special Projects Program Director, Raytheon

Leonard Bonilla
Retired Program Manager, Raytheon

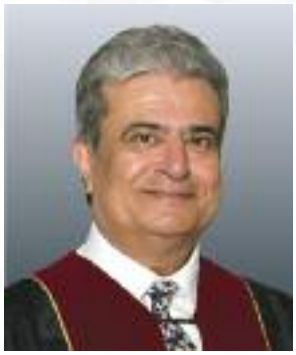
David Doami
Director, Program Manager, Northrop Grumman

Ray (Ramon) Gomez
Technical Director, Broadcom

William Goodin
Retired Associate Director of Alumni Relations, UCLA HSSEAS

Daniel Goebel
Senior Research Scientist, Jet Propulsion Laboratory

Robert Green
Attorney, Christie, Parker, and Hale, LLP



Asad Madni
EE AAB Chair
President, COO and CTO (Retired), BEI Technologies, Inc.

Students in Academia

Shiuh-hua Wood Chiang

Arthur Charles Densmore

Jere Harrison

Ata Mahjoubfar

Cem Tekin

Chung-Tse Michael Wu

Jie Xu

***Shiuh-hua Wood Chiang**, Ph.D., 2013*
Brigham Young University
Academic Advisor: Behzad Razavi
Shiuh-hua Wood was a Postdoctoral Scholar in the Communication Circuits Laboratory at UCLA in 2013. He was a Senior Design Engineer in the RFIC design group in Qualcomm, developing low-power circuits for Bluetooth transceivers. He joined the Department of Electrical and Computer Engineering of Brigham Young University in 2014. His research interests include RF/analog/mixed-signal integrated circuits for biomedical devices and communication systems.

***Arthur Charles Densmore**, Ph.D., 2015*
Department of Electrical Engineering
California State University, Long Beach
Academic Advisor: Yahya Rahmat-Samii
Arthur Densmore graduated with the 2014 Distinguished Ph.D. Dissertation in Physical Waves and Electronics Award as well as both the 2013 and 2014 EE Department Henry Samueli Excellence in Teaching Awards. He is the principal author of US Patent 5398035, Satellite-tracking millimeter-wave reflector antenna system for mobile satellite-tracking; He has joined General Dynamics SATCOM Division and holds a Part-Time Lecturer position in the Electrical Engineering Department at California State University, Long Beach.

***Jere Harrison**, Ph.D., 2014*
Department of Electrical Engineering, UCLA
Academic Advisor: Robert Candler
Dr. Harrison received his Ph.D. in 2014 from UCLA and has continued as a Postdoctoral researcher developing strong and compact particle beam optics with the UCLA Electrical Engineering and Physics departments. He has authored numerous research publications and patents in the areas of magnetic devices and micro-machining. His recent research interests include novel plasma and particle beam devices for x-ray and neutron production.

***Ata Mahjoubfar**, Ph.D., 2014*
Department of Electrical Engineering, UCLA
Academic Advisor: Bahram Jalali
Ata Mahjoubfar is currently a Postdoctoral Scholar at UCLA. He was the co-founder of OSA/SPIE student chapter at UCLA and its president in 2012. He is the author of more than 25 peer-reviewed publications. His research interests include ultrafast data acquisition and analytics, image and signal processing, machine vision and learning, imaging and visualization, biomedical technology, and financial engineering.

***Cem Tekin**, Ph.D., 2013 (Univ. of Michigan)*
Bilkent University, Ankara, Turkey
Postdoc Advisor: Mihaela van der Schaar
Dr. Cem Tekin's research spans the area of machine learning, data mining and game theory, with an emphasis on online learning and multi-armed bandit problems. His interests lie in both developing the theory in these areas and applying these findings in real-world engineering systems. Specifically, he focuses on online learning problems in big data with applications including real-time stream mining, social recommender systems, and personalized/smart healthcare. He has also developed multi-armed bandit algorithms for dynamic spectrum access and cognitive radio networks.

***Chung-Tse Michael Wu**, Ph.D., 2014*
Department of Electrical and Computer Engineering — Wayne State University
Academic Advisor: Tatsuo Itoh
Chung-Tse Michael Wu is currently an Assistant Professor at Wayne State University. Dr. Wu was the recipient of 2011 Asia Pacific Microwave Conference (APMC) Student Prize and the 2013 APMC Best Student Paper Award. He won the 2nd place award in the 2014 International Microwave Symposium (IMS) Student Design Competition. His research interests include applied electromagnetics, antennas, passive and active microwave components, microwave systems and metamaterials.

***Jie Xu**, Ph.D., 2015*
University of Miami
Advisor: Mihaela van der Schaar
Dr. Jie Xu is currently an Assistant Professor in the Department of Electrical and Computer Engineering at the University of Miami. His research spans the area of machine learning, data mining and game theory. His interests lie in both developing the theory in these areas and applying it in real-world engineering systems, such as communication networks, cyber-security systems, online social platforms and healthcare informatics.

Electrical Engineering Partnerships

The Electrical Engineering Department is dedicated to initiating and forging partnerships with industry, in which education and research in academia tightly connects to contributions in industry. The UCLA Electrical Engineering Department proudly announces the initiation of the Electrical Engineering Partnerships (EEP). The UCLA EEP works directly with partners in nurturing the talent pipeline through enhancing industry visibility, propagating industry's evolving needs into our courses and hands-on projects, providing access to resources within UCLA including state-of-the-art facilities, and exploring collaborative research opportunities. Support for the program is used for enhancing the department's laboratory and instructional capabilities, promoting hands-on experience for undergraduates, and aiding students in their academics and research. More details are available at the EEP website: ***http://www.ee.ucla.edu/industry.***

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MEDIATEK

This past year, MediaTek Inc. announced their support of the UCLA electrical engineering department with two graduate research fellows. The rigorous selection process from proposals written only by qualified Ph.D. candidates involves finalists presenting their proposals to MediaTek researchers. Two proposals with the highest technical merit and likelihood of success were selected. Hsinhung Alvin Chen, a graduate student of Professor Asad Abidi, will pursue research on *Adaptive Calibration of Time-Interleaved Analog-To-Digital Converter*, while Zuow-Zun (Joseph) Chen, a graduate student of Professor Frank Chang, has selected to investigate *A Low-Noise Sub-Sampling Fractional-N ADPLL*. The MediaTek Fellowship provides full graduate student researcher (GSR) support including nonresident tuition (NRT) for one academic year and a possible paid summer internship.

MediaTek, founded in 1997, is a pioneering fabless semiconductor company and a market leader in cutting-edge systems on a chip for wireless communications, multi-media, and network infrastructure. In 2013,the company was the fourth largest integrated circuits designer worldwide. Headquartered in Hsinchu, Taiwan, MediaTek recently opened offices in Santa Clara and San Diego, California.

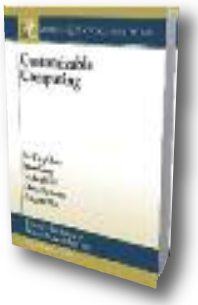
Hsinhung Chen

Zuow-Zun Chen

New Books by Faculty

Numerous textbooks for graduate and undergraduate instruction are authored by our electrical engineering faculty.

Francis Chen



Jason Cong

Hooman Darabi

Yahya Rahmat-Samii

Ali H. Sayed

King-Ning Tu

Paul Wang

Administration

Gregory J. Pottie	*Department Chairman*
Abeer Alwan	*Vice-Chair, Undergraduate Affairs*
Mona Jarrahi	*Vice-Chair, Graduate Affairs*
C.-K. Ken Yang	*Vice-Chair, Industry Relations*

Area Directors

Danijela Cabric	*Director, Circuits and Embedded Systems*
Benjamin Williams	*Director, Physical and Wave Electronics*
Izhak Rubin	*Director, Signals and Systems*

ABET Committee

Gregory J. Pottie	*Department Chairman*
Asad Madni	*Alumni Advisory Board Chair*
Abeer Alwan	*Professor and Vice-Chair, Undergraduate Affairs*
C.-K. Ken Yang	*Professor and Vice-Chair, Industry Relations*

Centers Directors and Committees Chairs

Yuanxun Ethan Wang, *Director, Center for High-Frequency Electronics*
Robert N. Candler, *Director, Nano-Electronics Research Facility*
Suhas Diggavi, *Chair, Recruitment Committee*
Lieven Vandenberghe, *Chair, Non-Tenure Committee*
Chandrashekar Joshi, *Chair, Tenure Committee*
Chair, Courses and Curriculum Committee

Annual Report 2014-2015

Editors/Coordinators
Gregory J. Pottie, *Professor & Chairman*
Jacquelyn T. Trang, *Chief Administrative Officer*

Design
Mauricio Feldman-Abe, *Principal Designer*

Writers
Executive Vice Chancellor and Provost
Scott L. Waugh
Professor Sam Coogan
Professor Ankur Mehta
Jonathan Webb, from BBC News
Professor Asad Madni
Professor Yahya Rahmat-Samii
Professor Mona Jarrahi
William Kisliuk, *UCLA Engineering Director of Marketing*
Matthew Chin, *UCLA Engineering Communications Manager*
Stuart Wolpert, *UCLA Media Relations and Public Outreach Senior Media Relations Representative*

Henry Samueli School of Engineering and Applied Science
Electrical Engineering Department
University of California
Los Angeles, CA 90095
www.ee.ucla.edu

UCLA Engineering
HENRY SAMUELI SCHOOL OF
ENGINEERING AND APPLIED SCIENCE
Birthplace of the Internet