UCLA

2015-2016
ANNUAL REPORT

Henry Samueli School of Engineering and Applied Science

ELECTRICAL ENGINEERING

UCLA Electrical Engineering:

Building an Innovation Community

Gregory J. Pottie
Chairman

In the past year, the UCLA Electrical Engineering Department has strongly focused on its mission of building an electrical engineering community that includes those who are not yet EE's, our undergraduates, graduate students, and alumni. This mission encompasses both research and teaching, to transform our society for the better. In this report are details of some research efforts to take on big societal challenges. I will highlight two of them here.

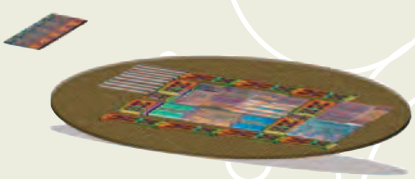
The semiconductor industry for several years has been contending with vastly increased costs of building systems on a chip, coupled with the impending end of CMOS scaling. Given that ICs underpin the entire information technology revolution (storage, processing and communication), ways have to be found to continue. The ambition of the new Center for Heterogeneous Integration and Performance Scaling (CHIPS) is to transform the industry to enable design of new highly capable systems with much less time and expense, through a re-thinking of the entire architecture. In another example, the healthcare system is consuming an ever-increasing and likely unsustainable share of national resources. Means have to be found to enable evidence-based medicine that can personalize care and deliver better outcomes without requiring additional trained medical personnel. The wireless health efforts of faculty in the EE department directly target this problem, with the application of information technology to provide end-to-end solutions.

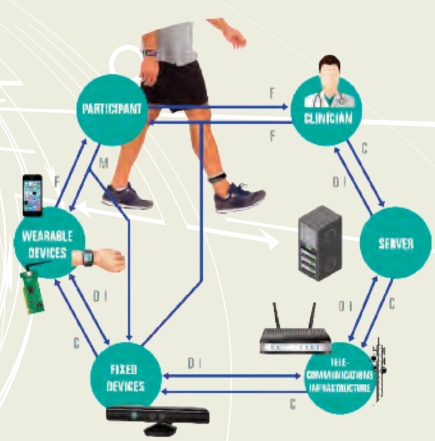
Further progress on these problems requires that more high-quality students be drawn to study EE, and once in EE programs, that they should be motivated to stay. Most students come to engineering because of a desire to build cool stuff (with a bonus if it is useful!) To address the retention issue, over the past several years the Department has been increasing the number of opportunities in the curriculum for students to pursue open-ended design projects. The capstone design course was extended to two quarters, a sophomore design course introducing students to EE was added, and in the past year, we have experimented with a freshman design course. These courses take advantage of low-cost kits now being supported by a broad range of companies, and have been highly popular. The freshman course is being scaled up to become a universal experience in UCLA engineering. We are now extending this approach with selected partner community colleges to increase the retention of engineering students and encourage more to pursue transfer to four-year colleges. The Department continues to support our outstanding IEEE and HKN chapters, who offer opportunities for students to pursue design work and engage in teaching practical skills. We are exploring new outreach efforts so that some of these opportunities also become available in partner community colleges.

Besides technical activities, undergraduate student organizations provide a home that makes a large campus like UCLA seem much smaller. In the past year, a new EE Graduate Student Association was formed to bring similar advantages for our graduate population. It will also serve to focus an expanded set of interactions with alumni for students to receive career and life advice from those who are further along. Our Alumni Advisory Board is expanding its mandate both in supporting these additional one-on-one interactions and initiating a new lecture series for our distinguished alums. Additionally, a new EE women's alumnae group met for the first time this past year, with the goal of supporting each other and our students.

In an era of increased atomization of society and distrust of institutions, universities are in a unique position to foster connections among individuals with common interests and experiences in order to build a stronger community and advance the general welfare. The UCLA Electrical Engineering Department takes this responsibility seriously, and invites participation by all our stakeholders in advancing this important mission. ***— Gregory J. Pottie***

Table of Contents





An Ecosystem of Integrated Physiological Monitoring Platforms for Personalized Medicine

Assistant professor **Sam Emaminejad's** vision is to improve our quality of life by developing an ecosystem of portable, wearable, and in the long term in-vivo physiological and environmental monitoring platforms. His goal is to enable personalized medicine through the collection of large data sets at population levels to support clinical investigations and ultimately generate predictive algorithms to understand the clinical needs of individuals and society as a whole.

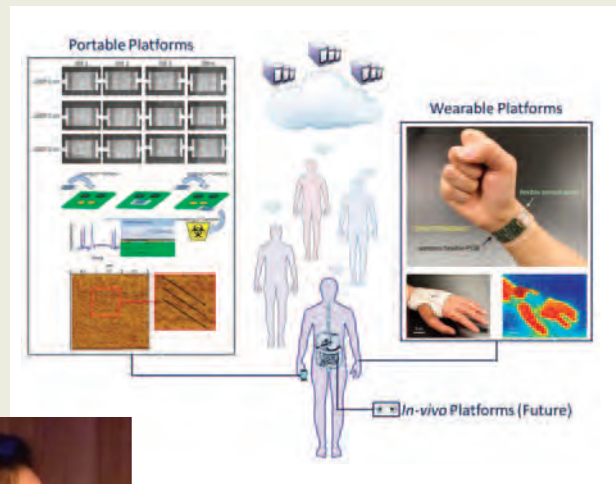
Internet of Things meeting personalized medicine: Interconnected biomarker sensors

The number of interconnected sensors is expected to increase beyond trillions of units over the next decade, representing about 1000 devices per person. The intersection of this trajectory with the pressing need for lowering healthcare expenditures necessitates a subset of these devices to be geared towards health monitoring of individuals to enable personalized medicine. Personalized medicine is transforming the field of clinical diagnosis by significantly lowering healthcare expenditures and providing predictive and preemptive care. In order to realize personalized medicine, we need to gain insight into the human physiology which is a very complex system. To unravel this complex system, we need to collect as much as relevant data as possible, so that once we mine through them, we can recognize patterns and correlations between different phenomena.

Sam Emaminejad

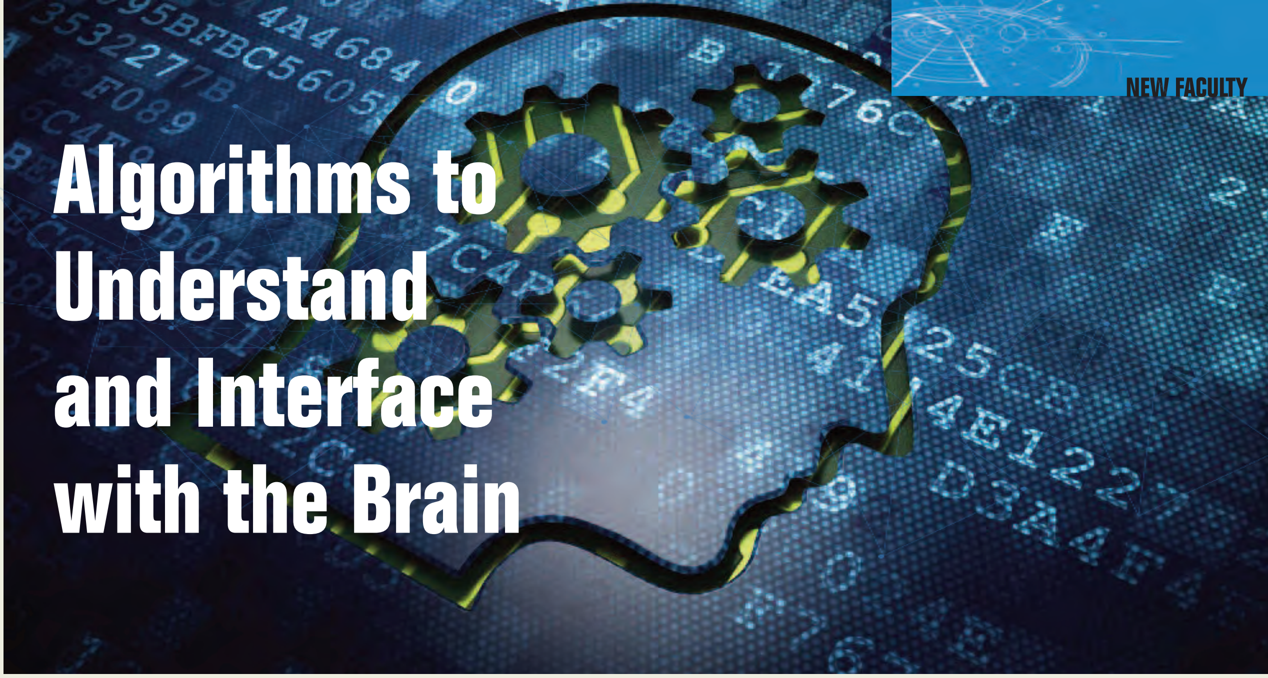
Engineering challenges and directions

Personalized medicine relies on biomarkers to gain a comprehensive view of the physiological status of individuals, such as electrolytes, metabolites, proteins, genes, and cells, whose abundance in human samples such as blood, sweat, saliva, and urine are indicative of the individual's health. In that regard, the development of continuous human biomonitoring platforms that can control, isolate, and sense target biomarkers in human physiological samples and their surrounding environments is a necessary step to enable personalized medicine. These core functionalities can be realized through MEMs and NEMs-based technologies, performing actuation and sensing at length-scales comparable to the size of the target biomarkers. A toolkit of sample processing and sensing operations needs to be developed and integrated in platforms optimized for the biological sample under analysis. These platforms need to meet various performance metrics in terms of multiplexing, sensitivity, selectivity, and response time. The key challenges including sample preparation, analyte transport, and signal transduction need to be addressed by novel sensing and actuation mechanisms in micro- and nanoscale. Furthermore, given the complexity of biological sample media and the multivariate mechanisms that are involved in the secretion of target biomarkers, full system integration, equipped with on-site calibration, signal conditioning and processing, is critical to ensure the accuracy of measurements. Additionally, complementary novel non/minimally-invasive strategies are required to access and interpret physiologically rich sources of information in biological samples (*e.g.* in sweat) that are not trivially available to us, yet contain exclusive information.



Impact

Professor Emaminejad is determined to maximize the impact of his research at UCLA to improve the well-being of society by incorporating the developed integrated platforms from his research program into large scale population and epidemiological studies. Specifically, he will gear these platforms towards the study of chronic diseases that disproportionately affect people of different races, socioeconomic conditions, and/or geographical locations. The large data sets that are collected through such studies, coupled with the application of data mining techniques will ultimately generate predictive algorithms for understanding our health status and clinical needs.



Algorithms to Understand and Interface with the Brain

Assistant professor **Jonathan Kao** seeks to understand how the brain processes information and aims to apply this knowledge for the design of biomedical devices that improve the quality of life for those with neurological injury or disease. His research integrates statistical signal processing, machine learning, neuroscience, and medicine and involves a multidisciplinary effort between engineers, neurophysiologists, and clinicians. Assistant professor Kao is focused on developing statistical techniques and algorithms for basic neuroscience and neural engineering. For basic neuroscience, the goal of these techniques is to elucidate computational principles in neural populations, while for neural engineering, the goal is to reliably decode signals from the brain for therapeutic benefit.

Neural signal processing

Recently, neuroscience has observed a paradigm shift in the way data is recorded. In traditional studies, neurophysiologists studied everyday behaviors (including encoding visual stimuli, decision-making, and movement generation) by recording one neuron at a time. While these single-neuron studies led to seminal insights in basic neuroscience, they paint an incomplete picture of how the brain works. We know that neurons perform computations as an interconnected network, and understanding these network computations requires measuring from many neurons at the same time. Recent technologies—including multi-electrode arrays (e.g., the Utah electrode array) and calcium imaging—enable neurophysiologists to record the population activity of hundreds of neurons simultaneously.

These datasets have highlighted an important challenge: they are complex, highly-dimensional, heterogeneous, and at times baffling. To make sense of this data requires neural signal processing: developing statistical signal processing and machine learning techniques to explain structure in neural population activity. Assistant professor Kao seeks to understand the activity of neural populations in a dynamical system framework. He is interested in investigating the dynamics of neural activity, which describe how these populations of recurrently connected neurons drive themselves through time in lawful ways. These dynamics have mechanistic implications for how neural populations process information, and are critical to advancing scientific understanding of how our brain makes decisions based on sensory evidence and then generates movements.

Neural prostheses

Assistant professor Kao also develops algorithms for neural prostheses, therapeutic devices that interact with the nervous system by either reading out neural activity (e.g., brain-machine interfaces, or BMI) or writing it in (e.g., cochlear and retinal prostheses). Assistant professor Kao has especially focused on developing BMI decoder algorithms for people with motor injury and disease, including paralysis and ALS. In BMIs, the activity of neural populations is recorded and subsequently translated, via a decoder algorithm, into the movements of a prosthetic device. His recent work involved designing new decoder algorithms that use techniques from machine learning and incorporate insights from basic neuroscience gained through neural signal processing. These algorithms resulted in the highest-performance and most robust BMIs to date. He aims to tackle other applications where neural prostheses could be life-changing, including seizure detection for epilepsy.

Finally, a major obstacle to the clinical translation of neural prostheses is the lack of simulator tools. In the case of BMIs, developing and testing a new decoder algorithm takes several months of neurophysiological experiments with animals. Assistant professor Kao aims to develop a simulator framework for BMIs that would allow for the rapid design and optimization of new decoder algorithms.

Jonathan Kao

Samueli Foundation Donates US $10 Million for Endowed Engineering Chairs

Susan and Henry Samueli

The UCLA Henry Samueli School of Engineering and Applied Science has received a US $10 million gift from the **Samueli Foundation** that will help establish as many as 20 new endowed faculty chairs. The matching gift follows the recent announcement of the school's plan to expand by 50 faculty members and 1,000 students over the next five to seven years.

The foundation was created in 1999 by Professor **Henry Samueli**, the co-founder of global semiconductor firm Broadcom Corp., and his wife, Susan. Henry Samueli said the gift is designed to encourage other alumni and donors to help propel the school's expansion. "The Samueli Foundation gift reflects the best of UCLA: dedicated alumni working with today's campus leaders to ensure a bright future for the university," said **UCLA Chancellor Gene Block**. "The Samueli family's profound commitment to UCLA and to engineering education will benefit our students, faculty and society for generations to come."

The gift offers a dollar-for-dollar match for donations toward the establishment of endowed chairs. For example, it will make it possible for other donors to sponsor a permanent chair in the name of their choice and to support faculty research in an area of interest to them with a gift of US$1 million, which would be matched by the foundation for the US $2 million total needed to fund the chair. Similarly, a term chair, an endowed position given to the chair holder for a specific period of time, normally requires a US $1 million gift, but can be made for US $500,000, which the foundation would match.

"UCLA already is home to one of the top engineering schools in the world," Henry Samueli said. "The next few years present an opportunity to take it to another level. We want to ensure that the most promising engineers working in the most dynamic fields continue to come to UCLA to teach and pursue research."

Jayathi Murthy, who joined UCLA Engineering as dean in January 2016, is spearheading the effort to expand the school's faculty and student body. Adding endowed chairs would significantly accelerate efforts to recruit and retain top faculty. "This is a visionary gift from donors who have already made extraordinary contributions to UCLA and the school of engineering," Murthy said. "We now have an unparalleled opportunity during this period of growth and transformation to elevate the school and become a world leader in emerging areas."

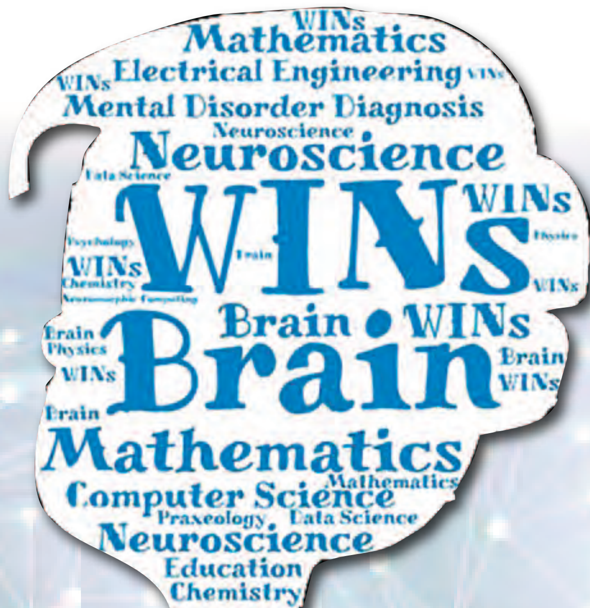
Professor Samueli earned his bachelor's degree in 1975, his master's degree in 1976 and his doctorate in 1980. He was a member of the engineering faculty in 1991 when he co-founded Broadcom with one of his students, Henry Nicholas. Broadcom employs more than 15,000 people around the world and was acquired by Avago Technologies Ltd in 2016. Samueli remains the company's chief technical officer and a member of the board. The engineering school is named for Henry Samueli in recognition of a US$30 million gift from the foundation in 1999. The engineering school at UC Irvine was also named for Samueli after a separate US$20 million gift from the foundation.

Henry Samueli is a member of the executive committee of the Centennial Campaign for UCLA, that seeks to raise US$4.2 billion in contributions for the university, and is scheduled to conclude in December 2019, during UCLA's 100th anniversary year.

WIN Institute of Neurotronics (WINs) Initiatives

by Kang Wang

The mission of the **WIN Institute of Neurotronics (WINs)** is aimed at further understanding of the brain and at developing neural technologies and intelligent neuromorphic systems. The Institute takes a two pronged approach. One is to construct neural technologies to monitor, predict and further understand brain functions and the other is through better understanding of the brain to develop cognitive, intelligent and decision making systems. The interdisciplinary research involved includes Neuroscience, Engineering, Mathematics, Physics, Computer Science, Data Science, Chemistry, etc.



The current research effort in WINs includes neuro-electro-dynamics, modeling and simulation, accelerated learning through understanding cognition and construction of advanced stochastic intelligent systems as well as development of nomadic monitoring and predicting technologies for further understanding brain activities. The impact of research is directed to benefit education, understand social behavior, improve human productivity and enhance the quality of life.

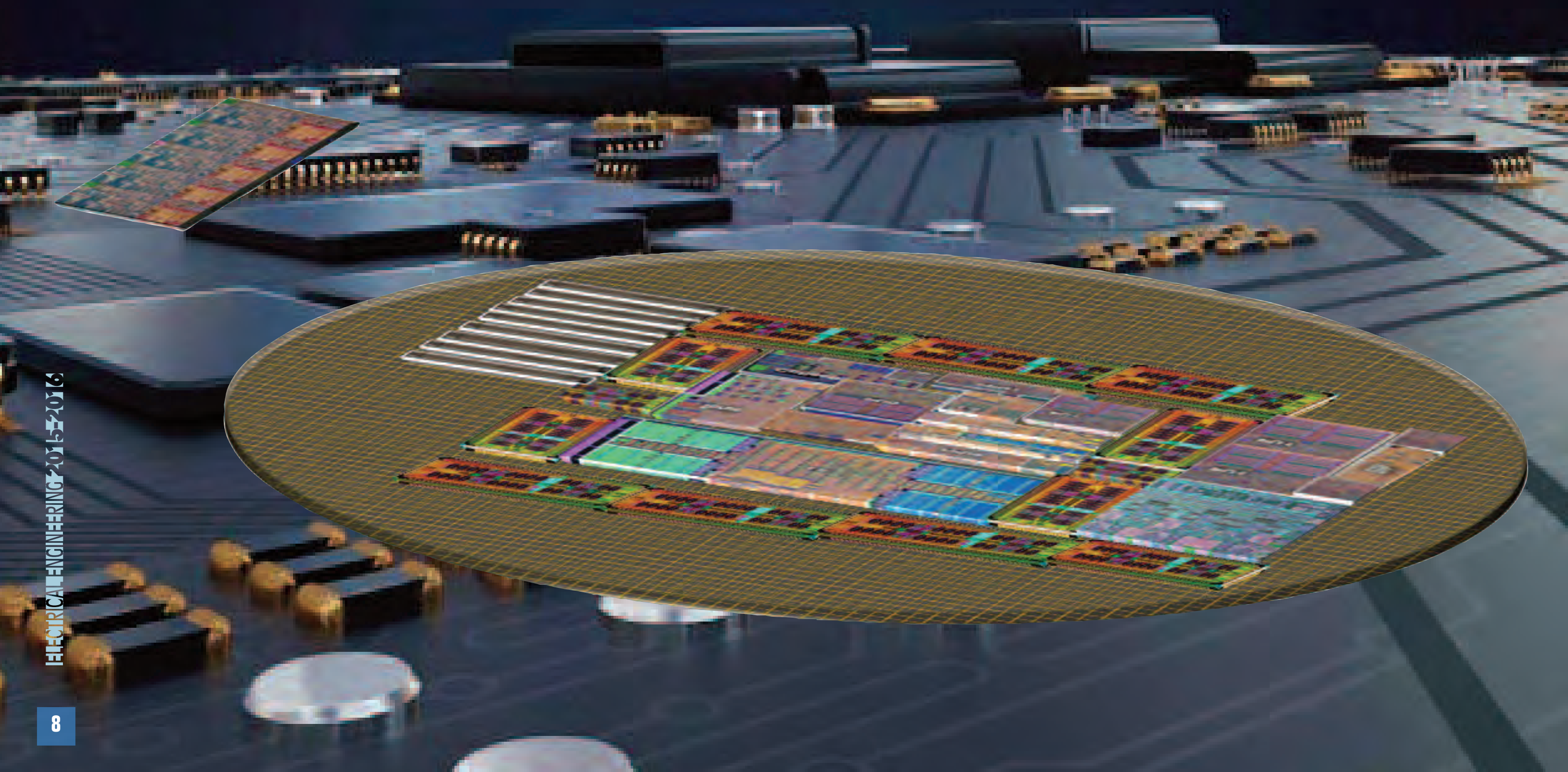
Center for Heterogeneous Integration and Performance Scaling

With the saturation of device scaling, the focus needs to shift to system level scaling and its attendant challenges. UCLA Engineering has established the **Center for Heterogeneous Integration and Performance Scaling (CHIPS)** in November 2015 to explore ways of scaling the package and board along the lines of what has been done with silicon over the last five decades and simplifying and speeding-up the way we build a System-on-Chip (SoC). CHIPS is a UCLA-led Consortium that includes several key Industry players as members—these include system companies, foundries and equipment companies—and is multi-disciplinary in its focus. A complete list of faculty members, visitors, research scholars and students, as well as recent publications can be found at the CHIPS website: **http://www.chips.ucla.edu/**

Current research at CHIPS is focused on developing a scheme to electrically and mechanically interconnect heterogeneous dielets on both silicon and biocompatible flexible interconnect fabrics at fine pitch using extremely simple metallurgies. CHIPS is also engaged in developing methods to partition complex systems into commonly used IP blocks that can be instantiated as hard dielets, as well as methods to reintegrate these dielets into complex systems. A particular focus of these applications is next generation computing including neuromorphic engines. CHIPS also works on power regulation and delivery for such systems, the integration of passives and super-deep Through Silicon Vias (TSVs), three Dimensional Integration and Interposer technology. CHIPS is also developing the Charge Trap Transistor (CTT) for new memory, neuromorphic and hardware security applications. The CHIPS approach is detailed here: **http://bit.ly/system-on-chip** .

Published in: *IEEE Transactions on Components, Packaging and Manufacturing Technology* (Volume:6, Issue: 7.)

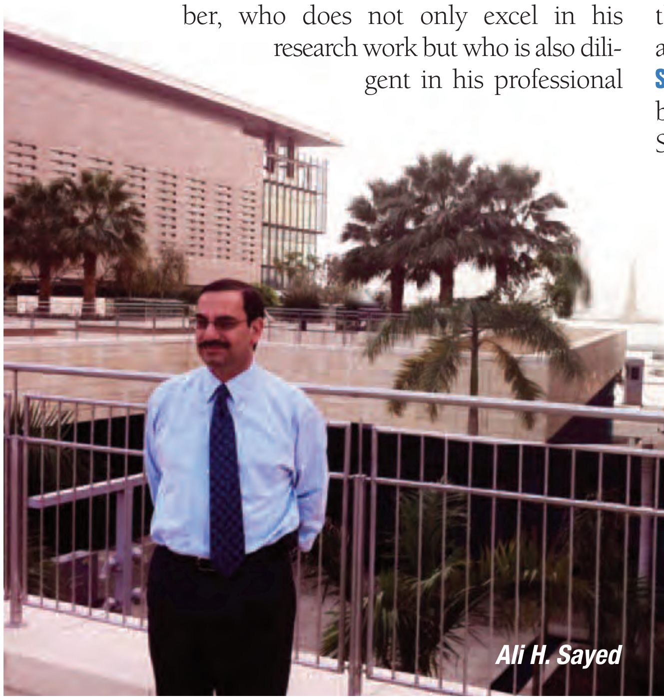
Distinguished Chancellor's Professor **Subramanian Iyer** is the Director of CHIPS.



Professor Sayed Elected President of IEEE Signal Processing Society and Received Several Awards

Distinguished Professor Ali H. Sayed, who directs the UCLA Adaptive Systems Laboratory *(http://www.ee.ucla.edu/asl)*, continues to garner recognitions from various societies for his research and educational achievements. An accomplished researcher and a prolific author, he is the author or co-author of six books and over 480 scholarly publications. He is recognized internationally for his leadership in the broad area of statistical signal processing and data analysis. His research involves several areas of inquiry including adaptation and learning, data and network science, information processing theories, and biologically-inspired designs. He has published authoritative textbooks on the subject of adaptation and learning. His text *Fundamentals of Adaptive Filtering* (2003) was recognized for its quality and awarded the 2005 Terman Award by the **American Society of Engineering Education**. His most recent monograph published in 2014 is on the topic of *Adaptation, Learning, and Optimization over Networks* (2014); an area that has been attracting expansive interest. Professor Sayed is also recognized by **Thomson Reuters** as a Highly Cited Researcher for his influential scholarship. He is one of three faculty members in the UCLA HSSEAS to receive this recognition; and one of 29 faculty members across all UCLA programs.

Professor Sayed is a multi-faceted faculty member, who does not only excel in his research work but who is also diligent in his professional and university service and in his mentoring and educational activities. He is among a few faculty members who have been recognized for all three aspects of their work: research, education, and service. In 2012, he was awarded the Technical Achievement Award from the **IEEE Signal Processing Society** for his "fundamental contributions to adaptive and statistical signal processing." In 2013, he was awarded the Meritorious Service Award for his "exemplary service to and leadership in the Signal Processing Society." Last year, he was awarded the 2015 Education Award for the "writing of scholarly and influential texts in the areas of adaptive systems and statistical signal processing." The award honors educators who have made pioneering and significant contributions to signal processing education. In 2014, he was also awarded the Athanasios Papoulis Award from the **European Association for Signal Processing** for his "fundamental contributions to the advancement of research and education." He was elevated in 2012 to the grade of Fellow by the **American Association for the Advancement of Science (AAAS)**, the publisher of the journal *Science*. He has also been awarded several Best Paper Awards.


Ali H. Sayed

Despite an active research agenda, Professor Sayed is engaged in serving the Signal Processing community in various capacities. Among other roles, he served as Editor-in-Chief of the leading journal in his discipline, the *IEEE Transactions on Signal Processing* (2003-2005), and is currently serving as President-Elect of the **IEEE Signal Processing Society** for the years 2016-2017, followed by a two-year term as President in 2018-2019. The IEEE Signal Processing Society is the first society established by the **Institute of Electrical and Electronics Engineers (IEEE)** and the world's premier international organization for signal processing scientists and professionals since 1948. It is also one of the largest IEEE societies with close to 18,000 members worldwide.

Professor Sayed has also been engaged in serving his department, school, and university. He served as Chairman of Electrical Engineering at UCLA (2005-2010) and has been a member of several School and University committees. Since 2015, he has been promoting a broad effort across campus to integrate data science activities into a consolidated domain, and to help showcase UCLA's distinguished leadership in this area across many programs in engineering, statistics, mathematics, social sciences, humanities, and life sciences.

Wireless Health Research

By William Kaiser & Greg Pottie

Since the early 2000's, UCLA EE Department researchers have been engaged with collaborators in the UCLA Geffen School of Medicine in developing information and wireless sensor technology into the everyday practice of medicine. The goal of the **Wireless Health Institute (WHI)** is nothing short of a radical transformation in how medical services are delivered and evaluated for efficacy.

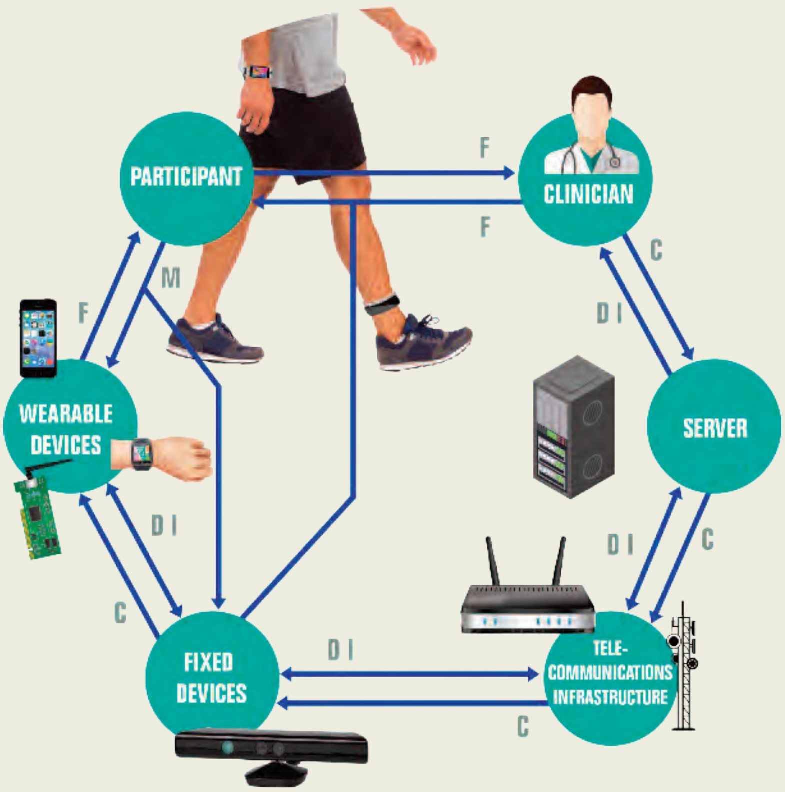
Part of our research aims to improve the quality of care provided to the 45 million partially disabled people in the US by developing inexpensive end-to-end sensor systems that reliably characterize the patient condition and provide effective guidance. Our initial focus has been on rehabilitation from neurological conditions. Informative, frequently updated feedback about skills practice is critical for patients participating in acute inpatient rehabilitation, where the quantity and quality of practice strongly influence the degree of motor function a given patient recovers. In outpatient care and clinical trials, however, the majority of skills practice occurs outside of direct clinical supervision. Any feedback patients receive tends to be derived from self-report, which cannot accurately characterize the quantity of patients' practice nor how performance changes over time and in response to features of the local environment in the home and community. Thus, networked sensor technology is required that can provide objective assessment and feedback.

Many of the predictions of the widespread applications of wireless sensor networks made at the advent of the millennium are now being made under the new label of the **Internet of Things (IoT)**. Smart homes, smart grids, flexible manufacturing, and in general the ability to search and manipulate the physical world in a manner similar to the cyber world are now in vogue. Many commercial systems are appearing. In the medical domain, the iWatch, FitBit, and many other devices are being marketed as being positive aids to healthy living. They can indeed perform such functions for healthy individuals, but the diversity of the patient population and the nature of the medical enterprise present difficult barriers. Consider the determination of whether and how a patient is walking. Most commercial devices operate by recording acceleration peaks, classifying a periodic series of such peaks over some threshold and within some frequency range as being walking. This works because most healthy individuals walk in much the same way. Proprietary algorithms perform this inference and then present results rather than raw data to the consumer. The situation is very different for patients suffering from neurological conditions such as a stroke. They may walk very slowly, or only a few steps at a time, falling outside the range of thresholds for frequency or acceleration. The gait may be shaky, there may be no heel strike, etc. A huge variety of gaits result, as patients attempt to ambulate in spite of a broad possible range of impairments. Moreover, the medically interesting questions for rehabilitative therapy are whether the therapy is quantitatively improving the frequency and duration of walking bouts, and whether it is improving the gait. Thus not only is it harder to recognize gait in patient populations, this is only the starting point of the inference task.

Besides the greater precision demanded of the inferences, the algorithmic tasks are made more difficult by the greater variations seen in the patient population. The most highly automated machine learning methods require vast amounts of data. For healthy individuals, the relatively small feature set needed to distinguish walking from other activities makes training fairly straightforward. But for impaired gaits, it is difficult to collect ground truth in the first place (clinical trials are required), and a larger feature set is needed. Since there will be relatively few instances of many types of gait available for training, a more model-based approach to inference algorithm construction is required, as these require far less training data. In other words, expert input must be leveraged for initial model construction, and experts again consulted when new gaits are encountered. In order for this to occur remotely in time or space from the data collection, this requires that the actual trajectory of motion be able to be reconstructed from the data for viewing and human interpretation. The model can thereafter be updated to deal with the new data, in effect using medical crowd-sourcing to enable improved classification performance over time. Yet reconstruction of the trajectories of human limbs using data from wearable low-cost inertial measurement units (IMUs) alone is by no means trivial, due to drift and noise in the measurements. We have succeeded in doing this at high accuracy for gait through the use of models, and are engaged in methods to do so for the upper limbs by making use of auxiliary sensors such as depth cameras.

A further challenge is to have continued engagement of the patient and caregivers with the prescribed medical IoT technology. Physical challenges are often accompanied by cognitive impairments, and many of the elderly have low acceptance of new technology. It may even be physically challenging to attach the device, let alone work through a menu on a small and hard to read screen. Thus, the devices must be very easy to use even for individuals in assisted living conditions, and provide useful and simple feedback. That is, value must be perceived compared to the limited store of available effort the patient possesses. Similarly, while medical professionals can handle complex tasks, they are exceedingly busy. Simple, high-value messages must be provided that yield a significant advance over how medically-relevant information is collected now, along with the ability to dig further into the data when unusual conditions are presented. Moreover, to the extent that the new capabilities seamlessly feed into the existing workflow in the hospital or clinical practice, acceptance of the new technology will be far greater.

The type of end-to-end m-IoT system we produce is sketched in **Figure 1**. Wearable and fixed sensing devices make measurements (**M**) and pass on data (**D**) and classification inferences (**I**) to each other and through the



Data flow in an end-to-end m-IoT system

telecommunications infrastructure to a server for storage and further processing. The processing enables the synergistic use of many types of devices, with different types of systems at the home and clinic. The clinician can issue commands (**C**) such as queries and reconfiguration requests that can propagate through the chain. The clinician, fixed devices, and wearable devices can all provide feedback (**F**) to the participant, who can also directly communicate with the clinician. The requirements for a m-IoT are: **1** low-cost collection of sufficient ground truth for medically relevant and reliable inferences of patient condition **2** ease of use for patients, caregivers and medical professionals and **3** rapid development of low-cost systems for specific medical conditions in the context of constantly advancing technologies, that enable many devices to interact synergistically. Satisfaction of all three of these constraints will result in systems that are of value to all stakeholders and that can evolve as commercial technology advances.

Consider again the problem of physical rehabilitation. While a variety of wearable inertial sensors are sufficient to summarize the behavior of healthy individuals (e.g., gross activity level, some degree of activity classification), outcomes of interest to rehabilitation clinicians, neurologists and those who care for patients with chronic cardiopulmonary diseases (e.g., indoor and outdoor walking speed and distance, variations in gait quality during daily challenges, smoothness of reach) are either not reliable or demand complex manual data processing and/or detailed review of the data by an expert clinician. To date, assessment with wireless sensors may aid the treatment of individual patients or small clinical studies, but cannot be scaled to the "gold standard" multi-center clinical trials that include hundreds or thousands of participants. The difficulty is that while individual system components may be low cost and reliable, every aspect of a system—study protocol, sensors, signal processing, data storage, search, and patient/clinician feedback—must be optimized to minimize burdens on patients and clinicians, as well as keep hardware costs acceptable. Dealing with all of these aspects together is required to produce the most efficient system to support patient-centered care and large-scale clinical trials. Our goal at WHI is to increase the value and efficiency of large-scale, multi-site clinical trials that treat subjects in clinic, community, and home environments, across diverse disease conditions. Such systems will provide real-world monitoring and outcome measurement tools that will inform clinicians about the type, quantity and quality of daily activities and improve the design of clinical trials that seek evidence-based interventions. That is, due to the end-to-end system focus, we will for the first time be able to compare the effectiveness of therapies, delivering improved patient care at lower cost.

Physical rehabilitation is only one of the focus areas of our research. We have developed the first acoustic system capable of identifying important events in the re-start of the digestive system following surgery, a wound-care device capable of identifying pressure ulcers, and systems for gauging the efficiency of heart valve function, all with non-invasive techniques.

A Cost-Effective Platform for Gout Diagnosis


Aydogan Ozcan

A team of UCLA researchers has designed a novel holographic imaging system to diagnose gout, the most common type of inflammatory arthritis in the United States affecting over 8 million adults, 3.9% of the population. This form of microscopy, based on lens-free on-chip microscopy, can achieve wide-field imaging of birefringent objects, those with double refraction (for example quartz), on an image sensor chip with high resolution. The new system is compact, cost-effective, and has the potential to allow for much broader implementation of screening by primary care clinicians.

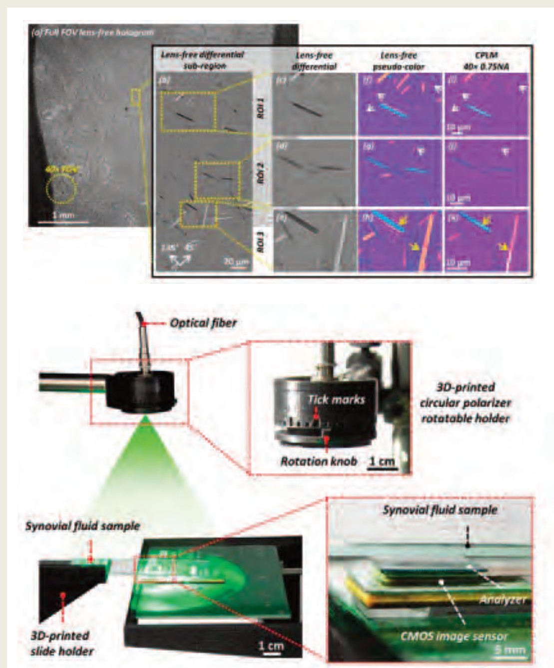
This work, described in *Scientific Reports* published by the **Nature Publishing Group**, was led by **Aydogan Ozcan**, Chancellor's Professor of Electrical Engineering and Bioengineering and Associate Director of the **California NanoSystems Institute (CNSI)** and **John FitzGerald**, Interim Chief of Rheumatology & Clinical Professor, Department of Medicine. Other leading authors of the manuscript include UCLA researchers Yibo Zhang and Seung Yoon Celine Lee, M.D.

The prevalence of gout has been gradually increasing by as much as threefold over the past five decades. The cause of gout is a combination of diet, medications and genetic factors. High levels of urate in the blood crystallizes in needle-like structures in the joints, tendons, and ligaments triggering severe inflammation.

"Our lens-free polarized microscope with its wide sample area, cost-effectiveness, and field-portability, can significantly improve the efficiency and accuracy of gout diagnosis, and can be deployed even at the point-of-care and in resource-limited clinical settings," said Ozcan.

The current method for gout diagnosis is the identification of the monosodium urate crystals in fluid from an affected joint under a compensated polarized light microscope (CPLM). Although this has been considered the gold standard since 1961, recent studies show that only 10% of primary care physicians performed polarizing microscope examinations. In addition, the use of CPLM has limitations. It is bulky, expensive, and has a relatively small field of view (FOV). Only a limited number of crystals in a sample can be identified, the examination can be time-consuming and also produce a non-reliable diagnostic due to operator-dependent bias. Lens-free on-chip microscopy is a potential solution to the efficiency and reliability issues of gout diagnosis.

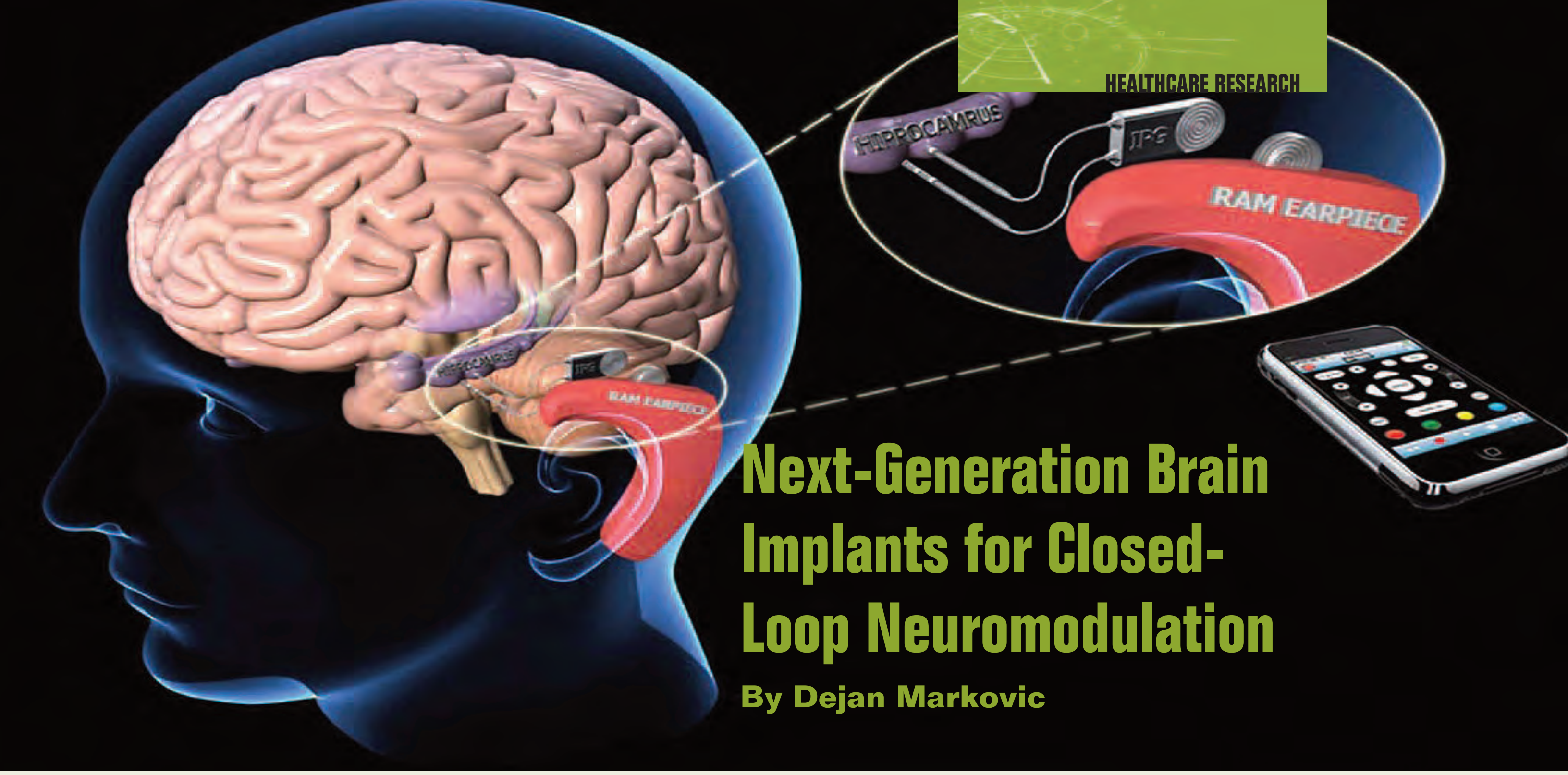
The UCLA designed computational microscopy can perform wide-field imaging without the need for lenses in a compact, cost-effective, and field-portable setup. In this design, light passes through a polarizer and is projected onto a patient's fluid sample placed on a microscope slide. The transmitted light from the sample continues to pass through another polarizer and reaches an image sensor chip that captures holographic diffraction patterns of the sample. These patterns are processed by a reconstruction algorithm running on a computer that generates images of the sample. This microscopy platform utilizes the entire active area (~20 mm^2) of the image sensor chip as the imaging FOV, which is approximately twice the size of a standard optical microscope.



Lens-free microscopy design developed at UCLA

"The performance of the computational polarization microscope was validated by imaging crystals made from a gout patient's tophus (large urate crystal deposit) and steroid crystals used as negative control, and three board-certified rheumatologists confirmed the image quality and the resolution of the diagnosis," said FitzGerald.

Future clinical applications of this platform could include diseases caused by crystals that can be detected by a conventional polarized light microscope; for example, ureteral stones can be diagnosed by detecting birefringent crystals in urine samples or other crystalline arthridities, such as calcium pyrophosphate dihydrate.

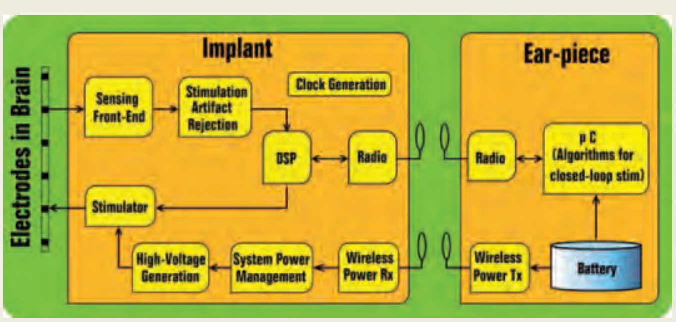


Next-Generation Brain Implants for Closed-Loop Neuromodulation

By Dejan Markovic

A mock-up of proposed brain implant.

According to a 2006 report by the World Health Organization, neurological disorders affect about one billion people worldwide. It is estimated that about 50 million of those affected suffer from epilepsy, and 24.3 million suffer from Alzheimer and other dementias. Most of these disorders do not have cures, but are chronically managed by different treatment modalities during the patients' lifespan. Neuromodulation — the process of regulating neuronal populations through electrical stimuli is one of these treatment modalities. Currently, neural stimulation is applied with no real-time feedback, thus losing its efficacy over time due to brain plasticity and other changes in the brain, requiring periodic recalibration of stimulation parameters. Open-loop stimulation may also have adverse effects like hallucinations, mania, depression, anxiety etc. Hence sending continuous electrical impulses without any mechanism to detect the effectiveness of therapy may be detrimental to the patient's mental health. Using recorded neural signals as feedback, the therapeutic benefits of neural stimulation can be maximized while mitigating the undesired effects that accompany open-loop stimulation. Feedback also allows the stimulation parameters to track the dynamics of the brain, thus maintaining the therapeutic effects over time. The next generation of neuromodulation systems requires miniaturized and fully implantable devices capable of closed-loop stimulation over long periods of time. Our research involves the design of such an implant, which can stimulate up to 8 independent sites in the brain, while recording from up to 64 sites to monitor brain activity during stimulation. All the required functions of neural stimulation, neural signal sensing, digital signal processing (DSP), power management, wireless power delivery and wireless data transmission are being integrated into a small titanium capsule, with approximate dimensions of 25mm x 6mm x 6mm.



System-level block diagram with designed components.

The system level block diagram shows the various blocks being designed by our group. The neural stimulator is designed to be highly programmable, with user-defined current amplitudes, pulse durations and inter-pulse delays. The neural recording front-ends have a large dynamic range to prevent saturation in the presence of stimulation artifacts, while achieving low-power and low-noise operation. An adaptive artifact rejection engine is implemented in the implant to estimate and subtract the stimulation artifact that appears at the recording sites. The DSP block serves as the controller and synchronizes the operation of all the blocks in the implant. The radio transmits the recorded neural signals to the ear-piece, and receives commands from the ear-piece to program the implant.

The implant is powered by a wireless link, which is designed for high efficiency over a large range of distance between the transmitter and receiver coils. The system-level power management block generates all the supply voltages required by the implant. A separate high-voltage generation block is also present to provide the large supply voltages required by the stimulators. The ear-piece contains a micro-controller where the algorithm for closed-loop stimulation is implemented. The ear-piece also houses a battery that powers the entire system.

Asad M. Madni Is the Recipient of Five Major Awards and Honors

Distinguished Adjunct Professor Asad M. Madni was awarded the **2016 Ellis Island Medal of Honor** by the **National Ethnic Coalition of Organizations**. The Medals are presented on historic Ellis Island to a select group of individuals whose accomplishments in their field and inspired service to the nation are cause for celebration. They recognize individuals who share their wealth of knowledge, indomitable courage, boundless compassion, unique talents and selfless generosity; all while maintaining the traditions of their ethnic heritage as they uphold the ideals and spirit of America.

The **Institution of Engineering and Technology** (UK), awarded Professor Madni its **2015 J.J. Thomson Prestige Medal** “for his distinguished career, spanning four decades, which has produced seminal contributions to the development and commercialization of ‘intelligent’ sensors, systems, instrumentation and signal processing.”

Upon nomination by the **Institute of Microengineering and Nanoelectronics (IMEN)**, the Universiti Kebangsaan Malaysia (UKM) awarded Professor Madni an **Honorary Doctorate Degree, Ph.D. (honoris causa)** in 2015 when Professor Madni delivered the commencement speech.

The **University of Texas San Antonio** awarded its first **Honorary Professorship** to Professor Madni. In this capacity, he will help guide doctoral and post-doctoral research; and will provide advice on research direction, faculty hiring and undergraduate and graduate engineering curriculum for the Electrical and Computer Engineering Department.

The University of Southern California’s **Viterbi School of Engineering** awarded the **Dean’s Faculty Award for Service** to Professor Madni. This is the first time that this honor has been awarded to a non-USC faculty member. Dean Yannis Yortsos stated that “we are honoring a highly distinguished individual whose contributions are internationally renowned and whose service to USC has had a major impact in the recognition and the advancement of the school and the Electrical Engineering department.”

Asad Madni with IET President Naomi Climer (above), at Universiti Kebangsaan Malaysia and with Gen. Martin E. Dempsey, Chairman of Joint Chiefs of Staff (below).

Alumnus Michael A. Jensen Appointed the Dean of BYU's College of Engineering

Brigham Young University Academic Vice President Brent W. Webb announced that **Michael A. Jensen** has been named the new dean of the Ira A. Fulton College of Engineering & Technology.

A professor in the Department of Electrical and Computer Engineering, Jensen begun his five-year term as dean in July 2016. He is replacing Alan R. Parkinson, who has been serving as dean since 2005. After 11 years as dean,, Parkinson will return to full-time teaching in the college.

"Michael brings a long history of superb teaching, internationally recognized research and strong administrative experience to his appointment as the dean of the Ira A. Fulton College," said Webb. "We are pleased that he is willing to lead the college into the next decade."

"Alan has demonstrated vision, strategic thinking and energy in his service as dean," said Webb. "He has exercised strong advocacy of the college and its programs and faculty, and he has brought keen insights to the university. The university is particularly grateful for his leadership in planning a new engineering building and raising funds for its construction."

Jensen has taught at BYU since 1994. From 2006-2012, he served as the chair of the Department of Electrical and Computer Engineering. He teaches courses in electromagnetics, high-frequency circuit design and signal processing for communications.

Jensen earned a doctoral degree in electrical engineering from the University of California, Los Angeles. He earned his master's and bachelor's degrees in electrical engineering from BYU.

Jensen's research focuses on designing antennas for wireless communications, characterizing propagation channels and developing advanced signal processing techniques for robust and secure communications. His publications in these areas include three book chapters, 75 journal articles and over 190 conference articles.

As a result of his work, he was awarded the H. A. Wheeler paper award in the *IEEE Transactions on Antennas and Propagation* in 2002 and the best student paper award at the 1994 IEEE International Symposium on Antennas and Propagation. He was elevated to the grade of **IEEE Fellow** in 2008.

Jensen is the president of the **IEEE Antennas and Propagation Society**. He has been the editor-in-chief and an associate editor of *IEEE Transactions on Antennas and Propagation*, and an associate editor for *IEEE Antennas and Wireless Propagation Letters* and *IEEE Antennas and Propagation Magazine*. He has also served as member and chair of the Joint Meetings Committee for the IEEE Antennas and Propagation Society, a member of the Administrative Committee for this same society, and has been vice-chair or technical program chair for seven different symposia.

He is the co-founder of two companies, one of which continues to do business, with eight offices worldwide.

The Ira A. Fulton College has more than 4,000 students majoring in engineering and technology disciplines.

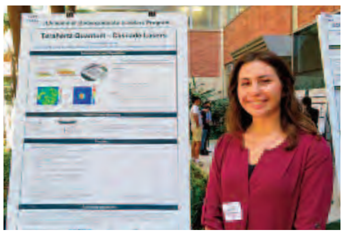
Michael A. Jensen

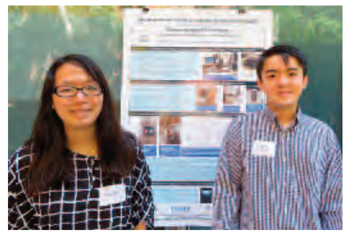
Fast Track to Success and Honors Programs

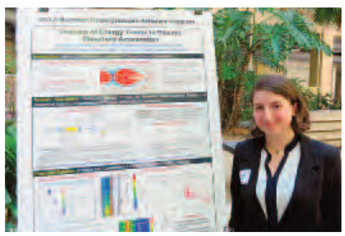
In 2015, the department introduced the program **Fast Track to Success**, enrolling 20 of the very best admitted freshman California and U.S. resident students to groom them to become future leaders in industry, academia and national laboratories.

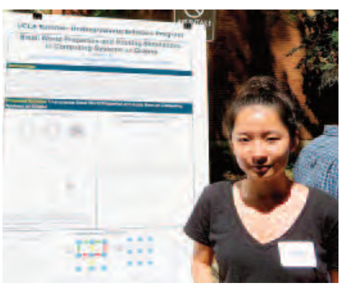
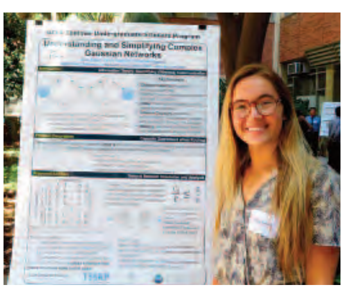
These students meet with their academic advisor once a month to talk about academic and social issues and opportunities within and outside of UCLA. They are advised to enroll in certain honors classes, in which they are guaranteed a spot. They have an opportunity to begin research with the Electrical Engineering faculty starting in the freshman summer. In 2016, 14 students were enrolled as interns supported by the **NSF's Research Experience for Undergraduates program**. The department also will begin early placement for some of these students in internships in industry.

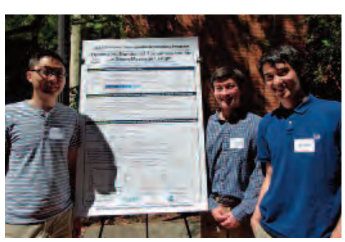
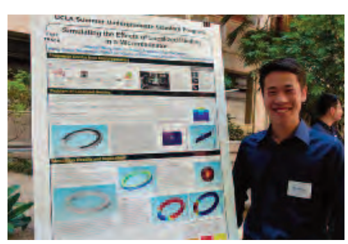
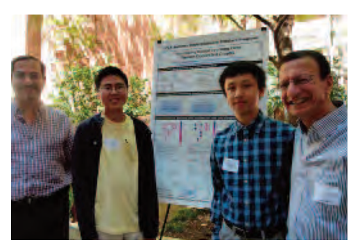
The Fast Track program committee includes Professors Chan Joshi (Director and the academic advisor), Greg Pottie (Chair), Abeer Alwan (Vice-Chair), Richard Wesel (Associate Dean), Ken Yang (Vice-Chair), Chee Wei Wong, Robert Candler and Dr. William Goodin.





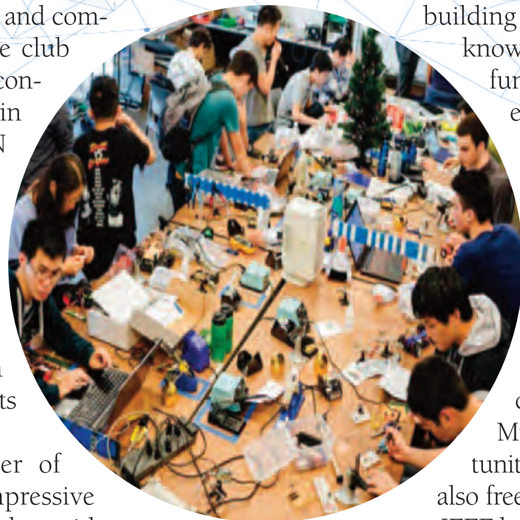





UCLA HKN

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. The club provides valuable service by conducting training sessions in MATLAB and Lab View. HKN members also provide tutoring services.

The club 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, with over 200 members currently participating in the student club.



UCLA IEEE Student Chapter

UCLA Institute of Electrical and Electronics Engineers (IEEE) 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, and fun projects that allow true hands-on experience outside the classroom.

The Open Project Space program focuses on 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 advanced students who want a challenging robotics experience, the Micromouse and Natcar projects are oportunities to build something crazy. Students are also free to come up with independent projects.

IEEE hosts several large events open to the wider engineering community, such as an annual fair showcasing local startups, as well as an all-day professional development workshop.

Electrical Engineering Graduate and Post-doc Society (EEGAPS)

EEGAPS is a new graduate student organization for graduate students at UCLA Electrical Engineering Department. The events organized by the student group is also open to postdocs in the department.

Activities held to date

The student volunteers in the group held weekly social events during the second half of the Spring 2016 quarter where graduate students and postdocs meet for an hour and chat. EEGAPS provides food and/or snacks using funds provided by the department. An average of 70 students and postdocs attended these social hour events.

Future plans

EEGAPS plans to expand its activities to guest speakers from industry and academia, networking events, company tours, off-campus activities, sports, etc.

These events will bring EE graduate students together to share their knowledge and experiences in a social setting. They will also familiarize students with local and national companies through industry-related events. EEGAPS will look into industry sponsors for funding most of these events.

2015-2016 Outstanding Student and Teaching Awards

Che-I "Jerry" Lien recipient of *Henry Samueli Excellence in Teaching Award for a Design/Lab Course*, with Professors **Mike Briggs** and **Greg Pottie**, and recommending students **Caroline Zhu** and **Robert Devlin**.

Jiacheng Pan, awarded the *Outstanding Master's Thesis Award in Circuits & Embedded Systems*, next to his advisor Professor **Asad Abidi** and Chairman **Greg Pottie**.

Lingnan Song, recipient of the *Outstanding Master's Thesis Award in Physical & Wave Electronics*, with Chairman **Greg Pottie**.

Jinsung Yoon received the *Outstanding Master's Thesis Award in Signals & Systems* with Chairman **Greg Pottie**.

The ***Outstanding Bachelor of Science Degree*** recipient, Nicolo Maganzini, with Chairman **Greg Pottie**.

The ***Christina Huang Memorial Prize*** recipient, Yun Zhang, with Chairman **Greg Pottie**.

Caroline Wang Zhu, **Sujith Jose**, **Alekhya Varma**, and **Andrew Chi Kit Chan**, the recipients of ***Engineering Achievement Awards for Student Welfare*** next to Chairman **Greg Pottie**. Not pictured: **Omar Levya**.

Abishek Manian, ***Outstanding Ph.D. Dissertation in Circuits & Embedded Systems,*** *Low-Power Techniques for CMOS Wireline Receivers.* Advisor: **Behzad Razavi**

Asael Papour, *Outstanding Ph.D. Dissertation in Physical & Wave Electronics*, *Fast Biomedical Imaging Using Fluorescence Lifetime and Unique Raman Signatures.* Advisor: **Oscar Stafsudd**

Yasser Shoukry Sakr, *Outstanding Ph.D. Dissertation in Signals & Systems, Security and Privacy in Cyber-Physical Systems: Physical Attacks and Countermeasures.* Advisors: **Paulo Tabuada** and **Mani Srivastava**

New Freshman Curriculum: Engineering E96 Engage Students

The Electrical Engineering Department has launched a new initiative dedicated to advance Freshman year students fundamental progress and to provide a sustaining motivation in their academic years ahead. The Engineering E96 course and a new curriculum approach directly address a long-standing, urgent, and unmet need. Our first course offerings have been successful with exceptionally positive outcomes and student assessment results reflect remarkable motivation for engineering design and engineering fundamentals.

Professors **Oscar Stafsudd** and **William Kaiser** have developed this course structure with course content spanning from novel optics, optoelectronics and through to the new **Internet of Things (IoT)** technology. In collaboration with Intel, the instructors have developed E96 course resources for the Intel Edison IoT platform that provide:

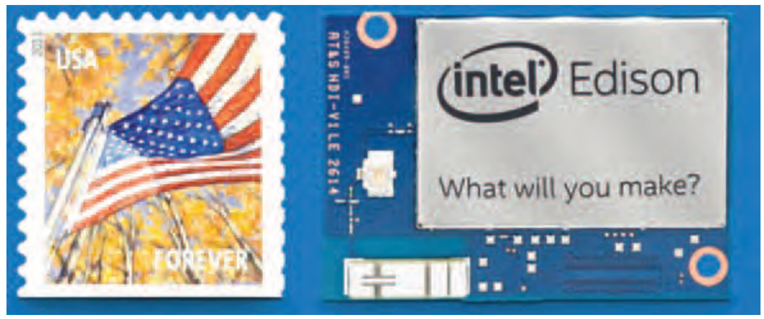
1. Accelerated student learning of fundamental computer engineering principles;

2. Inspiration and student engagement in computer engineering and engineering disciplines, enhancing student performance and retention;

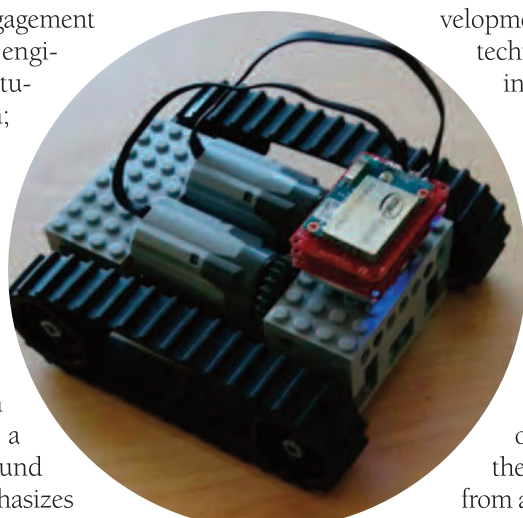
3. An introduction to and experience in engineering design and development.

The courses include lectures and laboratory sessions, with intense focus on student team development of novel projects. All projects assigned are designed to ensure that each team member comes out with a diverse skillset and background knowledge. The program emphasizes the development of novel systems with accurately specified objectives and schedule.

Every step is taken to provide support and building up student's motivation and inspiration. Undergraduate student mentors and a teaching assistant team up with faculty instructors, who ensure that every student progresses, making room for accommodating every student's background. Resources are in place, for example, to support students who may not have prior experience in programming or computer engineering.



The new Intel Edison Internet of Things (IoT) system supporting sensing, capable wireless networking, and advanced analytics capability. The E96 curriculum provides a broad set of resources supporting the Intel Edison.

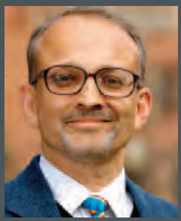


An Intel Edison IoT Robotic system developed by E96 students

Student teams not only pursue technical development, but also gain experience in formal technical presentations, as well as in creating documentation and technical final reports, which include presentations and video media. The reports and experiments are structured to provide each student with background knowledge that will be valuable in their academic future, in undergraduate research and when applying for internships.

Student projects in the E96 courses are based on concepts developed by student teams that embrace the team's interest. These projects ranged from astronomy instrument development to robotics. The course projects in IoT systems included the development of wearable devices for applications in healthcare and wellness, environmental and home monitoring, and novel motion sensing.

E96 continues to expand its enrollment capacity and student support. Its success has inspired other departments and institutions. Our team is providing full support to promote yet more valuable adoption and partnerships.



Professor Asad A. Abidi
National Academy of Engineering, 2007, for his contributions to the development of MOS integrated circuits for RF Communications.

Professor Mau-Chung Frank Chang
National Academy of Inventors
National Academy of Engineering

Adjunct Professor Dan Goebel
National Academy of Engineering, 2015. Senior research scientist, Jet Propulsion Laboratory. For contributions to low-temperature plasma sources for thin-film manufacturing, plasma materials interactions, and electric propulsion.

'Professor Tatsuo Itoh
National Academy of Inventors
National Academy of Engineering

Professor Chandrashekhar Joshi
National Academy of Engineering, 2014, as the founder of the experimental field of plasma accelerators. He is also a Fellow of the American Physical Society, IEEE and the Institute of Physics.

Professor Kuo-Nan Liou,
National Academy of Engineering,1999. Director of the Joint Institute for Regional Earth System Science and Engineering. Nobel Peace Prize, 2007, shared with Intergovernmental Panel on Climate Change.

Professor Asad M. Madni
National Academy of Inventors
National Academy of Engineering

Professor Stanley Osher
National Academy of Sciences, 2005, for "major contributions to algorithm development and applications in level set methods, high-resolution shock capturing methods, and PDE-based methods in imaging science.

NAI
National Academy of Inventors

Professor Mau-Chung Frank Chang
National Academy of Inventors
National Academy of Engineering

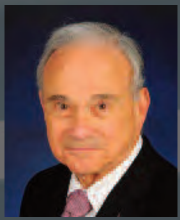
Professor Tatsuo Itoh
National Academy of Inventors
National Academy of Engineering

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. Professor Chang was Assistant Director at Rockwell Science Center where he developed and transferred AlGaAs/GaAs Heterojunction Bipolar Transistor (HBT) and BiFET (Planar HBT/MESFET) integrated circuits technologies. 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 electro-magnetic 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.

Distinguished Professor Yahya Rahmat-Samii
National Academy of Engineering, 2008, for his contributions to the design and measurement of reflector and hand-held device antennas.

Dr. Henry Samueli
National Academy of Engineering, 2003, for his "pioneering contributions to academic research and technology entrepreneurship in the broadband communications system-on-a-chip industry." Recipient of the Marconi Prize, 2012, and UCLA Medal, 2010.



Professor Jason Speyer
National Academy of Engineering, 2005, for "the development and application of advanced techniques for optimal navigation and control of a wide range of aerospace vehicles."

Professor Dwight Streit
National Academy of Engineering, 2001, for contributions to the development and production of heterojunction transistors and circuits.

Professor Eli Yablonovitch
National Academy of Engineering, 2003
National Academy of Sciences, 2003

Professor Alan N. Willson, Jr.
National Academy of Engineering, 2014 for "contributions to the theory and applications of digital signal processing."

NAI
NATIONAL ACADEMY OF INVENTORS

Professor Asad M. Madni
National Academy of Inventors
National Academy of Engineering

Professor C. Kumar Patel
National Academy of Inventors

Distinguished Adjunct 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 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.

Circuits & Embedded Systems

Ankur Mehta
author of the article about the Graduate and Post-doc Society (EEGAPS). See page 17

Faculty Pictured:
Jason Cong
Puneet Gupta
Ankur Mehta

Also:
Lei He

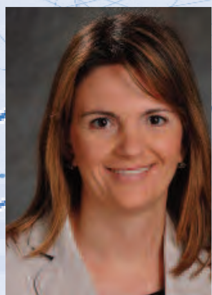
Design Automation for Computer Systems

We investigate methodologies and algorithms for the design of complex systems, including circuits and semiconductor technologies, robots, cyber-physical and energy systems, and the Internet of Things.

The effects of nanoscale semiconductor technologies span the entire hardware-software stack, and we investigate how technology changes in devices as well as semiconductor fabrication influence design (especially layout). We study digital, mixed-signal, and FPGA-based econfigurable integrated circuits in the context of emerging challenges of energy efficiency, security, reliability, variability and manufacturability. We also explore architecture and system software techniques to mitigate variability and reliability challenges of increasingly unpredictable circuit fabric.

Robotics and cyberphysical systems is a rapidly growing field that spans a range of engineering disciplines. We study how such a broadly scoped area can be rigorously codified, inventing representations for the formal definition and analysis of interdisciplinary design. With an eye towards manufacturability, we investigate methods of encapsulating engineering principles and distilling them into design automation algorithms.

Our research seeks to dramatically reduce cost, increase proliferation, and promote the democratization of technology by utilizing design intent in technology development and process control.



Dejan Markovic
See article *Next Generation Brain Implants for Closed-Loop Neuromodulation* on page 13

Faculty Pictured:
Danijela Cabric
Babak Daneshrad
Dejan Markovic
Subramanian Iyer

Also:
Jason Cong
Ali Sayed
C.-K. Ken Yang

Emeriti Faculty
Rajeev Jain
Gabor Temes
Jack Willis
Alan Willson

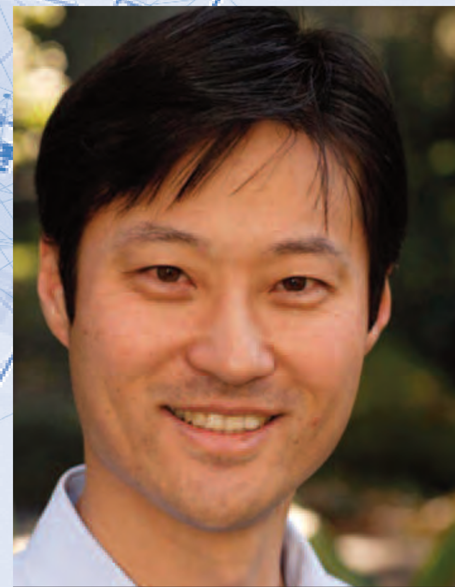
Energy-Efficient Digital Architectures and Circuits

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.

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



Ken Yang
Committee member for **Fast Track to Success and Honors Programs**. See page 16

Communication Circuits Faculty:
Asad Abidi
Wentai Liu
Sudhakar Pamarti
Behzad Razavi
Henry Samueli
C.-K. Ken Yang

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

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 affecting 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.

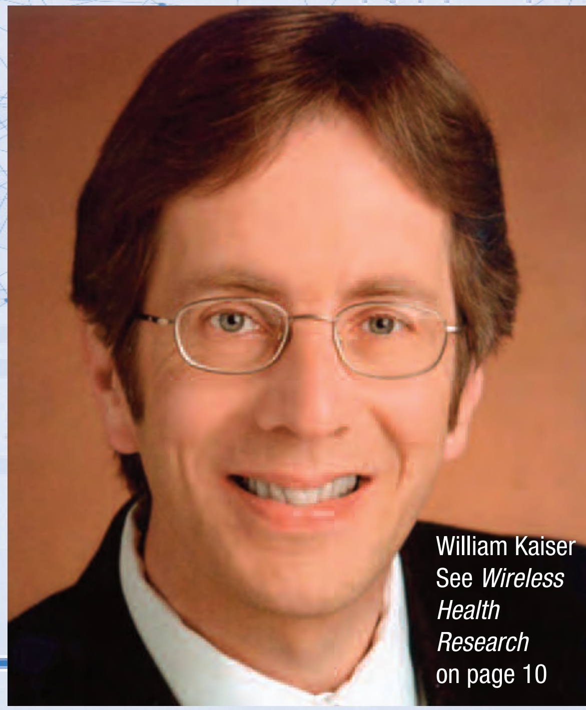
Sensor Information Acquisition, Processing, and Applications

Sensory information is foundational to modern electronic computing systems across a myriad of 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, Sam Emaminejad, William Kaiser, Aydogan Ozcan, Gregory Pottie, Mani Srivastava**

Faculty Pictured:
Lei He
William Kaiser
Majid Sarrafzadeh
Mani Srivastava

Also:
Puneet Gupta
Ankur Mehta
Paulo Tabuada



William Kaiser
See *Wireless Health Research* on page 10

Embedded and Mobile Computing and Cyber-Physical Systems

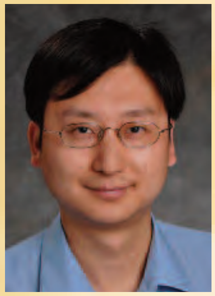
We focus on foundational hardware and software technologies and architectures for computing and communication capabilities necessary for emerging embedded, mobile, and cyber-physical systems. Such systems are found in emerging application domains of critical socio-economic importance, such as robotics, 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 operations, 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.

Circuits and Embedded Systems Adjunct Faculty (right):
Hooman Darabi
Shervin Moloudi

Physical & Wave Electronics

M.-C. Frank Chang
elected NAI member in 2015.
See page 20



Faculty Pictured:
M.-C. Frank Chang
Tatsuo Itoh
Kuo-Nan Liou
Yahya Rahmat-Samii
Y. Ethan Wang

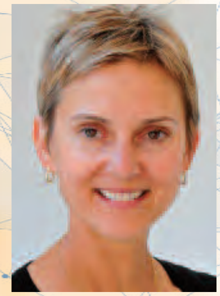
Also:
Robert Candler
Mona Jarrahi
Warren Mori
Aydogan Ozcan
Benjamin Williams

Emeritus Faculty
Frederick Schott

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.



Kang Wang
See article
WIN Institute of Neurotronics (WINs) Initiatives
on page 7



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 nano-fabrication facility, and device characterization equipment with capability from DC to over 100GHz.

Faculty Pictured:
Robert Candler
Chi On Chui
Sam Emaminejad
Diana Huffaker
Mona Jarrahi
Dwight Streit
Kang Wang
King-Ning Tu
Chee Wei Wong
Jason C. S. Woo

Also:
Subramanian S. Iyer

Emeriti Faculty
Fred G. Allen
Harold Fetterman
Dee Son Pan
Chand Viswanathan

Aydogan Ozcan
See *A Cost-Effective Platform for Gout Diagnosis* on page 12

Faculty Pictured:
Katsushi Arisaka
Warren Grundfest
Bahram Jalali
Jia-Ming Liu
Aydogan Ozcan
Oscar Stafsudd
Benjamin Williams

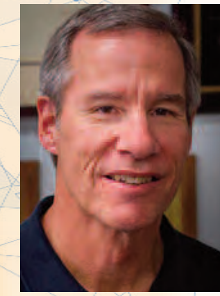
Also:
Diana Huffaker
Mona Jarrahi
Chan Joshi
Chee Wei Wong

Emeritus Faculty
Harold Fetterman

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.

Chan Joshi,
Director and academic advisor for the **Fast Track to Success and Honors Programs**.
See page 16



Plasma Electronics Faculty:
Chan Joshi
Dan Goebel
Warren Mori

Emeritus Faculty
Francis F. Chen

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 UCLA's state-of-the art laboratories including the Neptune Laboratory that houses the world's most powerful CO^2 laser. The research group also has the Dawson II computational cluster for research on inertial confinement fusion, plasma accelerators and astrophysical plasmas.

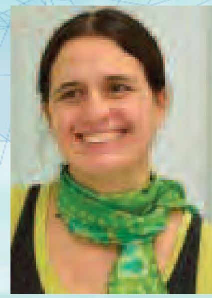
Physical & Wave Electronic Adjunct Faculty: *Keisuke Goda, Pedram Khalili, Asad M. Madni, Yi-Chi Shih, Zachary Taylor, Eli Yablonovitch*

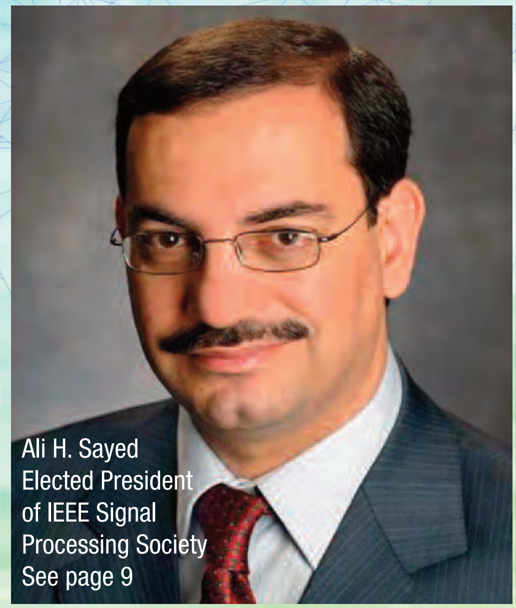





Signals & Systems


Gregory J. Pottie
See *Wireless Health Research* on page 10




Ali H. Sayed
Elected President of IEEE Signal Processing Society
See page 9

Faculty Pictured:

Gregory J. Pottie
Izhak Rubin
Christina Fragouli
Ali H. Sayed
Ali Mosleh
Lixia Zhang

Emeritus Faculty

Nhan Levan
Paul K.C. Wang
Donald Wiberg
Kung Yao (below)

Also:

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

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.

Abeer Alwan
Committee member for **Fast Track to Success and Honors Programs**.
See page 16

Signal Processing and Machine Learning

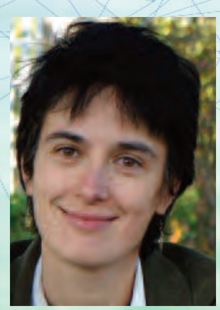
We rely on signals to interact with the physical and virtual world. A challenge today is how to collect, analyze, store, and process large data in an efficient and scalable manner. Our signal processing research targets the inference, visualization, representation, and learning of a broad spectrum of 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.

Faculty Pictured:
Abeer Alwan
Lara Dolecek
Allie Fletcher
Jonathan Kao
Stefano Soatto
Paulo Tabuada
John Villasenor

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

Emeritus Faculty
Kung Yao
Alan Willson **(left)**




Faculty Pictured:
Panagiotis Christofides
Sam Coogan
Alan Laub
Mihaela van der Schaar
Jason L. Speyer

Also:
Ankur Mehta
Ali Mosleh
Izhak Rubin
Ali H. Sayed
Paulo Tabuada
Lieven Vandenberghe

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.




Signals & Systems Adjunct Faculty
Ezio Biglieri
Dariush Divsalar
Allie Fletcher
Ingrid Verbauwhede

Also:
Asad M. Madni

Richard D. Vesel
Committee member for **Fast Track to Success and Honors Programs**. See page 16

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.

Faculty Pictured:
Suhas Diggavi
Stanley Osher
Vwani Roychowdhury
Lieven Vandenberghe
Richard D. Wesel

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

Emeritus Faculty:
Stephen Jacobsen

The Electrical Engineering Department

Faculty and Staff

Ladder Faculty	45
Courtesy Appointments	18
Emeriti Faculty	13
Adjunct Faculty	11
Lecturers	11
Staff	45

Recognitions

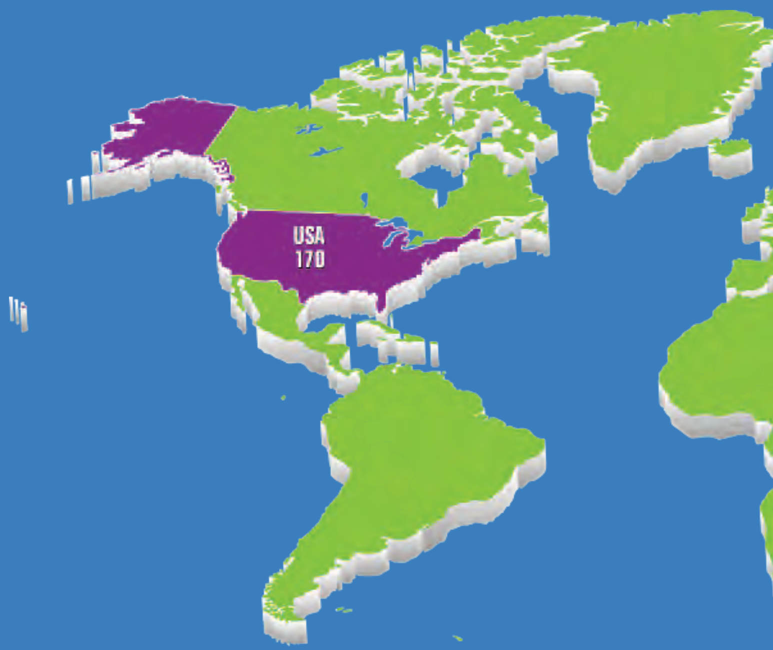
Society Fellows	47
NAE Members	15
NAS Members	3
National Academy of Inventors	4
Marconi Prize	1

Research Centers

The Electrical Engineering Department contributes to the following Research Centers:

- Anderson School of Management — Easton Technology Management Center (ETMC)
- California NanoSystems Institute (CNSI)
- Center for Development of Emerging Data Storage Systems (CoDES2)
- Center for Domain-Specific Computing (CDSC)
- Center for Engineering Economics, Learning and Networks (CEELN)
- Center for Heterogeneous Integration and Performance Scaling (CHIPS)
- Center for High Frequency Electronics (CHFE)
- Center for Systems, Dynamics, and Control (SyDyc)
- Center of Excellence for Green Nanotechnologies (CEGN)
- Function Accelerated nanoMaterial Engineering (FAME)
- 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)
- Variability Expedition, Variability-Aware Software for Efficient Computing with Nanoscale Devices (VE)
- Water Technology Research Center (WaTer)
- Western Institute for Nanoelectronics (WIN)
- Wireless Health Institute (WHI)

Graduate Applicants



Graduate Students Admitted

Total Applicants	Total Admitted
1789	470

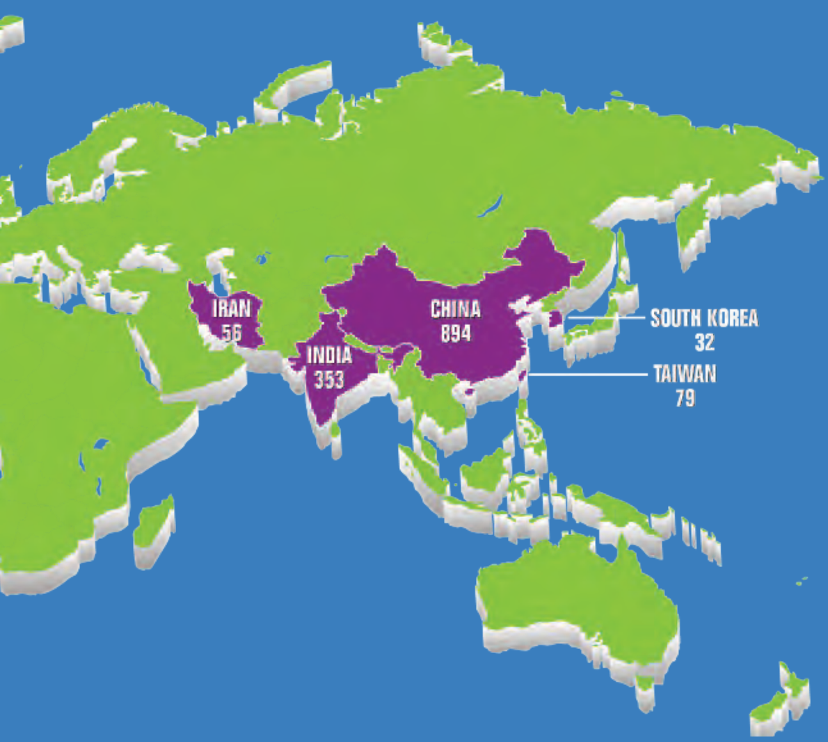
Undergraduate Students

Students Enrolled	566	
Applicants for Fall 2015	1337	
Admitted	265	
New Students Enrolled	88	
Average Incoming GPA	4.43	*(weighted)*
	3.96	*(unweighted)*

Graduate Students

Students Enrolled	343
Applicants for Fall 2015	1789
Admitted	470
New Students Enrolled	231
Median Incoming GPA	3.77

for Fall 2016

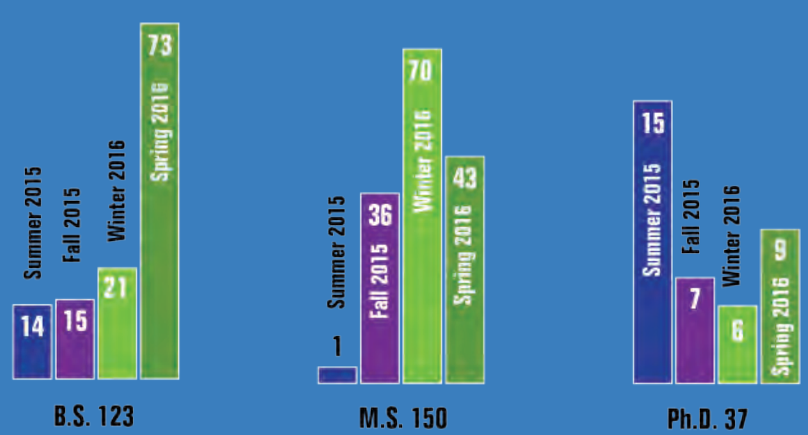


Graduate Student Fellowships

Department Fellowships	$776,830
Non-Resident Tuition Support for Teaching Assistants	$322,176
Dean's GSR Support & NRT Matching Funds	$259,072
Dissertation Year Fellowships	$179,150
Broadcom Fellowships	$126,798
Graduate Opportunity Fellowships	$122,088
Henry Samueli Partial Fellowships	$103,798
Faculty Unrestricted Fellowships	$98,183
Qualcomm Innovation Fellowships	$75,553
Guru Krupa Foundation Fellowships	$49,831
Ph.D. Preliminary Exam Top Score Fellowships	$47,031
Sandia Excellence in Science & Technology Fellowship	$40,000
Kalosworks	$36,610
Living Spring Fellowship	$34,623
Dean's Fellowship & Camp Funds	$29,000
Dr. Ursula Mandel Fellowship	$15,000
Raytheon Fellowship	$10,309
Will Rogers Memorial	$10,000
Conference Travel Funds	$7,350
MediaTek	$6,900
TOTAL	**$2,350,302**

Degrees Conferred in 2015-2016

Signals & Systems Applicants



Alumnae Advisory Committee

Thanks to the leadership of Professor Abeer Alwan and our accomplished alumnae, a new and vibrant organization has been created this year. The UCLA EE Alumnae Advisory Committee aims to educate and enable female students of all ages to pursue academic and career opportunities in electrical engineering. The key mission of the committee is to unite alumnae to support one another, and to foster a community of outreach and development for girls interested in science and technology, from the time they start elementary school through university and beyond.

Grace Evita King
Co-Chair
Attorney with Pillsbury Winthrop Shaw Pittman LLP

Ani Garabedian
Co-Chair
Communication Systems Engineer at Northrop Grumman

Kelsey Curtis
Chair of the Subcommittee on Student Mentoring
Engineer at Infineon Technologies

Melissa Erickson
Chair of the Bay Area Chapter
Sr. Technical Program Manager at Amazon Lab126

Caitlin Gomez
Chair of the Subcommittee on K-12 Outreach
Radiation Oncologist

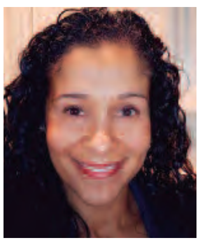
Guadalupe Zaragoza
Co-Chair Subcommittee for Alumnae Networking
Principal Systems Engineer at Raytheon

Judy Gilmore
Co-Chair Subcommittee for Alumnae Networking
Systems Engineer at Advanced Concept Technologies

Alumni Advisory Board

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

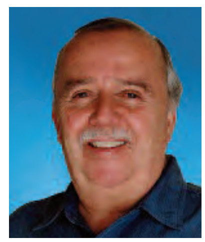
New for this year, the Board is lauching the **Distinguished Alumni Lecture Program** featuring alumni who will enlighten our community. Some lecturers will focus on insights from their fields of expertise, while others will offer guidance on topics of practical interest, such as launching and funding a technology-based business and protecting intellectual property rights.



Heba A. Armand
Group Product Manager, Avery Consumer Products

Phil Bangayan
Director of Marketing NBC/Universal

Sharon Black
GPS & Navigation Systems Director Raytheon



Leonard Bonilla
Retired Program Manager Raytheon

David Doami
Director, Programs Northrop Grumman

Ray (Ramon) Gomez
Sr. Technical Director Broadcom

William Goodin
Alumni Relations Coordinator UCLA HSSEAS

Robert Green
Attorney, Lewis Roca Rothgerber Christie, LLP

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

See Awards and Honors on page 14

Dan Goebel Wins 2016 UCLA Engineering's Professional Achievement Award

Adjunct Professor and Alumni Board Member Dan Goebel is the 2016 winner of **UCLA Engineering's Professional Achievement Award**. A senior research scientist at the **Jet Propulsion Laboratory**, Goebel is internationally recognized for his expertise in electric propulsion, microwave sources, advanced plasma sources and high voltage engineering. His work has led to the development of propulsion technologies used in NASA Dawn mission to Mars and Jupiter, space stations and satellites. Goebel holds 43 patents, is the author of nearly 300 papers, and his many honors include membership in the **National Academy of Engineering**.

Electrical Engineering Partnerships

The Electrical Engineering Department has been forging new partnerships with industry over the past year with its Electrical Engineering Partnerships (EEP) program. The UCLA EEP tightly couples academic education and research with the needs of industry by working directly with partners in nurturing our pipelines of talent both at the undergraduate and graduate levels. We enhance visibility to our student activities with industry through open houses and research reviews, and we propagate industry needs with our students through hands-on projects, material in courses, industry lecturers, and collaborative research opportunities. EEP also provides linkages for partners to access UCLA's state-of-the-art facilities. These activities are possible through the support of our partners. More details are available at the EEP website: *http://www.ee.ucla.edu/industry*.

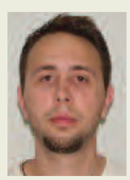
THE AEROSPACE CORPORATION | MEDIATEK | NORTHROP GRUMMAN | BROADCOM | QUALCOMM | LOCKHEED MARTIN | Raytheon

Broadcom Fellowship Recipients 2016-2017

Six electrical engineering doctoral students were awarded 2016-2017 Broadcom Fellowships which will fund their proposed or ongoing research projects this year.

BROADCOM

Hari Chandrakumar
Implantable neural recording front-ends for next-generation neuro-modulation systems
Advisor: Dejan Markovic



Dejan Rozgic
Hardware accelerator for simultaneous, real-time neuronal recording of large ensembles for brain imaging
Advisor: Dejan Markovic

Jieqiong Du
An 8-PAM/64-QAM multi-band serial link with energy efficient cancellation of inter-band interferences
Advisor: M.-C. Frank Chang

Chien-Heng Wong
A 40GHz CDR-less RF-based wireline transceiver with embedded reference clock
Advisor: M.-C. Frank Chang

Hani Esmaeelzadeh
Fast start-up programmable clock sources
Advisor: Sudhakar Pamarti

Dihang Yang
A dual-loop wide-bandwidth fractional-n synthesizer with ultra-low sigma-delta quantization noise
Advisor: Asad Abidi

UCLA HSSEAS Electrical Engineering

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*
Izhak Rubin	*Director, Signals and Systems*
Benjamin Williams	*Director, Physical and Wave Electronics*

ABET Committee

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

Center Directors and Committee Chairs

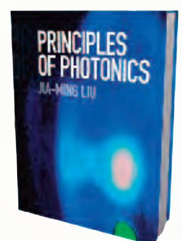
Robert N. Candler, *Director, Nano-Electronics Research Facility*
Suhas Diggavi, *Chair, Recruitment Committee*
Warren Mori, *Chair, Tenure Committee*
Sudhakar Pamarti , *Chair, Non-Tenure Committee*
Lieven Vandenberghe,*Chair, Courses and Curriculum Committee*
Yuanxun Ethan Wang, *Director, Center for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

New Books by Faculty

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

Panagiotis Christofides


Lara Dolecek



Jia-Ming Liu

Ingrid Verbauwhede

Annual Report 2015-2016

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

Design
Mauricio Feldman-Abe, *Designer*

Writers
Matthew Chin, *UCLA Engineering Communications Manager*
Assist. Professor Sam Emaminejad
Professor Subramanian Iyer
Professor Chan Joshi
Assist. Professor Jonathan Kao
Professor William Kaiser
Professor Asad M. Madni
Professor Dejan Markovic
Professor Ankur Mehta
Professor Aydogan Ozcan
Professor Gregory J. Pottie
Professor Ali H.Sayed
Professor Oscar Staffsud
Professor Kang Wang
Stuart Wolpert ,*UCLA Media Relations and Public Outreach Senior Media Relations Representative*

UCLA Engineering

HENRY SAMUELI SCHOOL OF
ENGINEERING AND APPLIED SCIENCE

Birthplace of the Internet

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