2022-2023

ELECTRICAL AND COMPUTING ENGINEERING

UC San Diego

JACOBS SCHOOL OF ENGINEERING

Electrical and Computer Engineering

Table of Contents

3 Letter from the Chairs

5 ECE By the Numbers

6 Faculty Honors

10 Electrical and Computer Engineering Faculty

16 Research Highlights

26 Our ECE Community

35 Student Research Highlights

40 Student Organizations and Outreach

42 ECE Awards

44 Teaching and Learning Innovations

47 Alumni

50 In Memoriam

LETTER FROM THE CHAIRS

Welcome to the UC San Diego Department of Electrical and Computer Engineering! We are pleased to announce that our department continues to grow, both in the number of faculty and research funding, and this is reflected in our #14 ranking among Electrical Engineering departments. We are extremely proud of our faculty members, who have distinguished themselves with a wide range of recent honors including sizable grants from NIH, IARPA, and other agencies, major awards from IEEE societies and other professional organizations, best paper awards, and other important recognition both within and outside of the UC system.

Our world class research continues to expand into new areas and advance the state-of-the-art for new and emerging applications. Recent highlights include beam steering technologies for 5G phased arrays, as well as for WiFi and Bluetooth signals, advances in robotic surgery and robotic navigation, and secure computing and communication. New developments in health applications include implants for monitoring communication between brain cells, smartphone-based Alzheimer's Disease testing, and massively parallel computing for analyzing the evolution of the SARS-CoV-2 genome. We are also advancing hardware technologies such as single-photon detection methods for quantum applications, and new miniaturization techniques for power electronics.

Students are engaged at all levels of our research. Our Summer Research Internship Program (SRIP) provides opportunities for undergraduate and MS level students to become involved in world-class research with our renowned faculty. As an example, some students develop control and monitoring methods for autonomous UAV flight and other robotic systems, and participate in a wide range of other projects.

We are continually advancing our pedagogical approaches, including implementing flipped classroom techniques, and the development of multiple new project-based courses. Student learning is enhanced through peer instruction, hands-on group activities, and a combination of self-paced lecture videos and direct in-person instruction. These teaching innovations have contributed to UC San Diego being recognized as a top public research university. Within these pages, we invite you to take a deeper look at some of our successes over the past year.

Bill Lin, PhD
Chair

Dan Sievenpiper, PhD
Vice Chair

#10

The UC San Diego Jacobs School of Engineering has ranked #10 in the nation in the influential U.S. News & World Report Rankings of Best Engineering Schools

ECE By the Numbers

64
Faculty

1,390
Undergraduate Students

1,156
Graduate Students

825 | MS Students
331 | PhD Students

440
Incoming Graduate Students

382 | MS Students
58 | PhD Students

17,000+
Alumni

$37M
Research Expenditures

#13
In Computer Engineering, the 2022 U.S. News and World Report National Rankings

#14
In Electrical Engineering, the 2022 U.S. News and World Report National Rankings

Faculty Honors

Dinesh Bharadia
IARPA Grant

Intelligence Advanced Research Projects Activity (IARPA) agency has awarded a $6 million grant to Dinesh Bharadia and his collaborators to develop a secure classified data transmissions system using smart radio technology. The goal of the project is to develop smart radio systems to detect and characterize suspicious radio frequency signals, or RF anomalies, in complex RF environments.

Shadi Dayeh
NIH Grant

NIH has awarded a $12.25 million grant to Shadi Dayeh and his collaborators to develop and enhance brain-sensing and brain-stimulating platform technologies to enable treatment of drug-resistant epilepsy. The nation-wide team, led by Professor Dayeh as the Principal Investigator, includes researchers at Massachusetts General Hospital and Oregon Health & Sciences University.

Sujit Dey
ICDH 2022 Best Paper Award

Sujit Dey along with his students, Jared Leitner, Brian Khan, and Po-Han Chiang, won the Best Student Paper Award at the 2022 IEEE International Conference on Digital Health (ICDH) held in Barcelona for their paper entitled, “An mHealth Lifestyle Intervention Service for Improving Blood Pressure using Machine Learning and IoMTs.”

Tara Javidi
Academic Council Chairs Award Mid-Career Leadership

Tara Javidi has been given the Academic Council Chairs Award for Mid-Career Leadership, which is a UC system wide accolade of great significance. The UC system wide Academic Council voted unanimously to honor Professor Javidi for this distinction, which recognizes individuals whose records demonstrate an exceptional ability to work effectively across University constituents and who show promise for further service to the Senate.

TILOS Award Co-PI

MURI Award Co-PI

Farinaz Koushanfar
MURI Award PI

Farinaz Koushanfar, along with Tara Javidi, have been awarded one of four highly competitive MURI projects recently approved for additional funding by Congress. Professor Koushanfar is the Principal Investigator of this prestigious award, where she led a multi-university multidisciplinary team, with Co-PIs from UC San Diego, Northeastern University, UC Santa Barbara, and University of Michigan, to win this award for their proposal entitled, “AutoCoMBOT: Autonomy in Cyberspace through robot learning and Man-BOT Teaming.”

Andrew Kahng
TILOS Award PI

The UC San Diego Team, led by Andrew Kahng as the Principal Investigator, has won a $20 million award from the National Science Foundation to pursue foundational breakthroughs in artificial intelligence. UC San Diego is the lead for this new AI institute, together with Yale, MIT, Penn, UT Austin, and National University as sub-awardees. Other ECE faculty on the team include Tara Javidi as a Co-PI, Farinaz Koushanfar, Nikolay Atanasov, and Xiaolong Wang.

Hanh-Phuc Le
Solid State Circuits Society Distinguished Lecturer

Hanh-Phuc Le has been nominated and appointed as a Distinguished Lecturer (DL) of the IEEE Solid-State Circuits Society (SSCS) DL Program for a 2-year term from January 2022 to December 2023. The SSCS DL Program’s goal is to provide experts in the Society’s areas of interest (integrated power electronics for Professor Le) to speak at chapter meetings and regional seminars.

Florian Meyer
NSF CAREER Award

“Bayesian Graph Signal Processing for Machine Perception”

Aims to establish new machine perception methods that make optimal use of all the available information to provide unprecedented performance in challenging scenarios. The key principle that will enable the use of a large number of sensors with high data rates, is to systematically exploit graph structures in the mathematical formulation of perception problems.

ISIF Young Investigator Award

The ISIF Young Investigator Award grants international recognition for outstanding contributions to the art of information fusion by a young society member. Professor Meyer’s publication record and his contributions to graph-based localization and tracking are the basis for the award.

Faculty Honors

Siavash Mirarab

NIH MIRA Award

Siavash Mirarab has received an NIH Maximizing Investigators' Research Award (MIRA) for his proposal, "Biology-aware machine learning methods for characterizing microbiome genotype and phenotype." The overall goal of Professor Mirarab's $1.72 million award is to provide breakthrough research on algorithms and machine learning methods to analyze huge amounts of microbiome data.

Anne Fox Endowed Fellowship

Siavash Mirarab's student, Uyen Mai, has been selected as the recipient of the Marye Anne Fox Endowed Fellowship. Mai is the only student in the Jacobs School of Engineering to win this award in this UC San Diego campus wide competition.

Tina Ng

National Academy of Inventors

Tina Ng has been elected into the National Academy of Inventors for her work as a leading researcher in the field of flexible printed electronics. Professor Ng has demonstrated a highly prolific spirit of innovation in creating or facilitating outstanding inventions that have made a tangible impact on the quality of life, economic development, and welfare of society.

NSF Mid-Career Advancement Award

For Tina Ng's proposal entitled, "MCA: Fabrication of Organic Structural Supercapacitors." The overall goal is to provide breakthrough research on energy storage technologies based on structural supercapacitors, which will potentially provide high peak power for rapid charging and extend device lifetime to minimize maintenance costs.

Alon Orlitsky

Aaron D. Wyner Distinguished Service Award

Alon Orlitsky is the recipient for 2022, in recognition of his numerous and impactful service contributions to the IEEE Information Theory Society. In particular, Professor Orlitsky initiated the Information Theory and Applications Workshop (ITA) in 2006 and has been one of its main organizers since.

Gabriel Rebeiz

IEEE MTT-S Tatsuo Itoh Prize

Gabriel Rebeiz and his student, Omar El-Aassar, have been awarded the 2022 Microwave and Wireless Components Letters Tatsuo Itoh Prize of the IEEE Microwave Theory and Technology Society (MTT-S) for their paper entitled, "A 120-GHz Bandwidth CMOS Distributed Power Amplifier with Multi-Drive Intra-Stack Coupling."

IMS Competition Award

Gabriel and his student, Siwei Li, have been awarded 2nd place in the 2021 International Microwave Symposium Student Paper Competition for their paper entitled, "An Eight-Element 140GHz Wafer-Scale Phased-Array Transmitter with 32dBm Peak EIRP and >16Gbps 16QAM and 64QAM Operation."

Edward Wang

Honorable Mention ACM CHI

Edward Jay Wang and his student, Colin Barry, were selected to receive an Honorable Mention for Best Paper, "At-home Pupillometry using Smartphone Facial Identification Cameras," at the ACM CHI 2022 conference.

Google Research Scholar

Edward Jay Wang has been selected as a Google Research Scholar for his proposal entitled "Smartphone BP Monitoring for Hypertension Care in Low Resource Communities."

NIH R21

Edward Jay Wang has received an NIH R21 award for his work around transforming smartphones into pocket-sized personal health monitors. This award is part of a national push towards combating the debilitating effects of Alzheimer's Disease through the use of digital technologies.

Alexander Vardy (1963-2022)

ISIT Paper Award

Alexander Vardy and his student, Hanwen Yao, won the Jack Kiel Wolf ISIT Student Paper Award for their paper entitled, "A Deterministic Algorithm for Computing the Weight Distribution of Polar Codes," at the IEEE International Symposium on Information Theory.

Please see page 50 for In Memoriam

2022-2023 Electrical and Computer Engineering Faculty

Nick Antipa
Assistant Professor

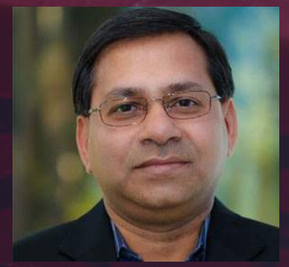
Nikolay Atanasov
Assistant Professor

Saharnaz Baghdadchi
Assistant Teaching Professor

Dinesh Bharadia
Assistant Professor

Pamela Cosman
Distinguished Professor

Shadi Dayeh
Professor



Sujit Dey
Professor

Shaya Fainman
Distinguished Professor

Massimo Franceschetti
Professor

Eric Fullerton
Distinguished Professor

Ian Galton
Professor

Vikash Gilja
Associate Professor

Drew Hall
Associate Professor

Tzu-Chien Hsueh
Assistant Professor

Tara Javidi
Professor

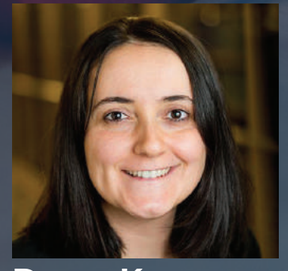
Andrew Kahng
Distinguished Professor

Mingu Kang
Assistant Professor

Pradeep K. Khosla
Chancellor, UC San Diego, Distinguished Professor

Young-Han Kim
Professor

Farinaz Koushanfar
Professor



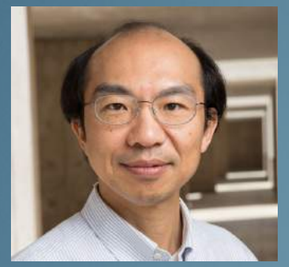
Duygu Kuzum
Associate Professor

Hanh-Phuc Le
Assistant Professor

Bill Lin
Chair, Department of ECE, Professor

Zhaowei Liu
Professor

2022-2023 Electrical and Computer Engineering Faculty



Yu-Hwa Lo
Distinguished Professor

Vitaliy Lomakin
Professor

Patrick Mercier
Associate Professor

Florian Meyer
Assistant Professor

Larry Milstein
Distinguished Professor

Siavash Mirarab
Associate Professor

Shayan Mookherjea
Professor

Karcher Morris
Assistant Teaching Professor

Tse Nga (Tina) Ng
Associate Professor

Truong Nguyen
Distinguished Professor

Kenji Nomura
Associate Professor

Alon Orlitsky
Professor

Piya Pal
Associate Professor

George Papen
Professor

Albert P. Pisano
Dean, Jacobs School of Engineering

Jorge Poveda
Assistant Professor

Bhaskar Rao
Distinguished Professor

Ramesh Rao
Professor

Gabriel Rebeiz
Distinguished Professor

John Sanford
Professor of Practice

Curt Schurgers
Teaching Professor

Nambirajan Seshadri
Professor of Practice

Yuanyuan Shi
Assistant Professor

Paul Siegel
Distinguished Professor

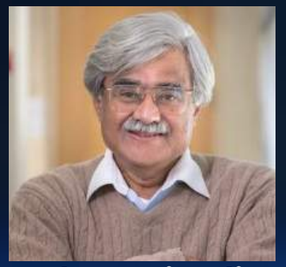
2022-2023 Electrical and Computer Engineering Faculty

Daniel Sievenpiper
Professor

David Sworder
Professor

Yuan Taur
Distinguished Professor

Behrouz Touri
Associate Professor



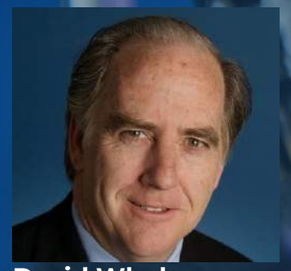
Mohan Trivedi
Distinguished Professor

Yatish Turakhia
Assistant Professor

Nuno Vasconcelos
Professor

Edward Wang
Assistant Professor

Xiaolong Wang
Assistant Professor

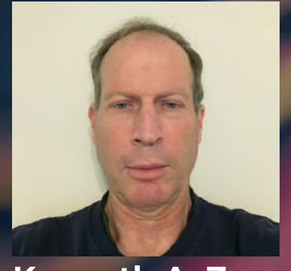


David Whelan
Professor of Practice
Professor

Pengtao Xie
Assistant Professor

Michael Yip
Associate Professor

Paul K. Yu
Distinguished Professor



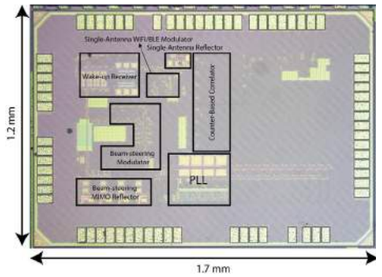
Kenneth A. Zeger
Professor

Xinyu Zhang
Associate Professor

Yang Zheng
Assistant Professor

Beam-steering Ambient WiFi and Bluetooth Signals For Ultra-Low-Power IoT Devices

Wireless security cameras, wearable devices, pet health tracking systems, wireless earbuds, augmented reality glasses, and more, are all starting to take hold in today's marketplace. However, there is a major problem faced by many of these Internet of Things (IoT) applications: power consumption. Most of these devices are designed to be small and portable, and yet consume so much power that they have to be plugged into the wall (e.g.,

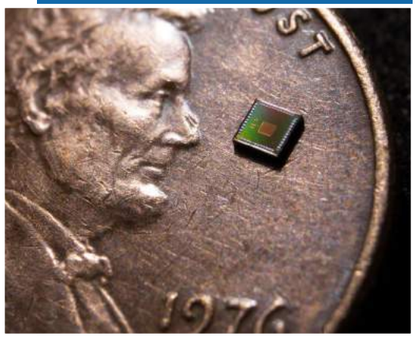


wireless security cameras), or the devices are so small they don't have room for a large battery, and as a result their battery life is poor (e.g., wireless earbuds). A key culprit for this is the relatively high power consumption of the radio circuits that enable wireless communication. WiFi, and even Bluetooth Low Energy – despite "Low Energy" being in the name of the standard – often dominate the overall power of such devices, and thus such devices either require wall power or have a short battery life.

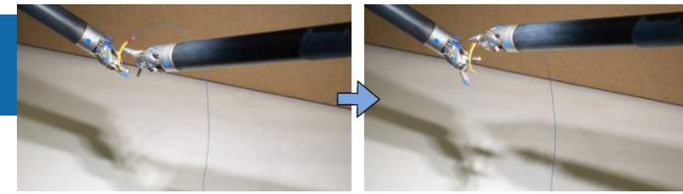
Research in Electrical and Computer Engineering, led by Patrick Mercier and Dinesh Bharadia and their team of graduate students, envision a future where devices like wireless security cameras don't have to be plugged into the wall and can be placed anywhere, or at least where the battery life of other IoT devices can be 100 times longer. The key to enabling this vision involves not generating the WiFi or Bluetooth signals on the IoT device itself, but rather, leveraging the fact that smartphones and routers, which either have a large battery or are already plugged into the wall, do a very capable job of generating these signals already. By hitch hiking on top of these existing transmissions, the IoT device can avoid the power consumption of expensive circuits operating at GHz frequencies.

The way to achieve this is a technique called backscatter communication – whereby an incident WiFi or Bluetooth signal arrives at an antenna and, depending on what impedance is loading the antenna on the IoT device – a certain portion of the signal will be re-radiated back to the environment. By dynamically controlling what kind of impedance is connected to the antenna, additional data can be modulated on top of the incident signal. Professor Mercier and Professor Bharadia's previous work showed that WiFi communication can be achieved at ~1,000 times lower power than conventional approaches using this technique – a major improvement towards enabling the next-generation IoT vision.

The key challenge in backscatter communication, however, is range: since there is no active transmitter on the IoT device, the re-radiated signal is weak, and will only go so far before being lost to noise (e.g., 10 meters in previous work). In their most recent work, Professor Mercier and Professor Bharadia's team developed techniques to leverage multiple antennas – like what are present in high-end WiFi routers or smartphones – and a technique called beam-steering to concentrate reflected energy to a desired location, a smartphone or router, for example. Normally, such MIMO techniques require precise control of the phase of a multi-GHz signal, which can consume significant amounts of power. In this latest work, their team demonstrated that this can be achieved with only microwatts of power, thereby keeping the ~1,000 times power reduction in place, while increasing the range from 10 to 50 meters. They also demonstrated techniques to enable backscattering of Bluetooth signals, for a ~100 times power reduction. These results represent a major step forward to making backscatter communication, and as a result small, tetherless IoT devices, a reality.



Robotic Surgery



Robotic surgery has drawn more attention over the last two decades as it provides several benefits, including high-precision motions, less blood flow, and faster wound recovery in multiple procedures. Because of these benefits, nowadays, more surgeries are done by a surgeon teleoperating with a well-developed surgical robot. In addition to teleoperated surgeries, surgical robots with integrated perception and controller systems such as the Da Vinci surgical system enable autonomous surgery. Autonomous surgery aims to relieve the burden of surgeons from long-hour operations and the problem of uneven medical resource distribution, as a shortage of surgeons becomes an issue in some diverse socioeconomic and under served areas. However, even with advanced surgical robotic systems, automating surgical procedures remains challenging since it requires careful coordination between the perception and controller systems.

One of the research directions at the Advanced Robotics and Controls Lab (ARCLab), directed by Professor Michael Yip, focuses on automating surgical procedures, such as suturing. The two critical components for a surgical robot to perform autonomous suturing are perception and planning abilities. The perception abilities include tool localization and scene reconstruction, where the former simultaneously tracks the poses of multiple surgical instruments, and the latter reconstructs the 3D spatial relationship between the tools and the tissue to be sutured. The planning abilities require a robot to use the information obtained from perception and decide its actions to complete the task of closing a wound.

The research team at ARCLab has developed several essential techniques to enhance robot perception in autonomous suturing. These techniques include real-time tracking of the 6D pose (position and orientation) of surgical manipulators and suture needles. Localizing a surgical manipulator in a suturing scene can be difficult since the environment is observed through an endoscopic camera, and only a part of the cable-driven manipulator can be seen through an image. Without seeing a joint of the manipulator, one cannot estimate the error of its encoder reading caused by the cable-driven mechanism. To address the issue, the errors of the joint-encoder readings from those unobservable joints are combined into a single lumped error, and a Particle Filter is used to track that lumped error.

A Particle Filter is also used to track the 6D pose of suture needles. However, unlike tracking surgical manipulators, tracking suture needles relies entirely on endoscopic image data since no extra sensor is available for estimating their poses. Hence, a unique observation model is designed to measure the distance between detections of a needle and ellipse projections of its estimated pose. Measuring this distance requires no association between detections and their 3D positions on a needle, which is suitable for tracking with markerless needle segmentation.

With the localization information provided from perception, a surgical robot can by itself plan a sequence of actions required by suturing. At ARCLab, this ability has been developed for suture needle regrasping, which is to regrasp a suture needle at a proper pose using dual robot arms. This task is essential for suturing since properly grasping a needle can vastly reduce the potential damage to tissues. Due to the geometry and dynamic properties of a suture needle, the configuration of a surgical manipulator and a needle can change a lot when executing the planned actions. These configuration changes can lead to unsafe robot motions, so real-time action adjustment is necessary. Hence, a reinforcement learning policy is learned to react rapidly to environmental changes by observing the current state of the surgical tools. Moreover, the current state is described egocentrically instead of relative to a global frame. This description allows the policy to work successfully even when the robot base is moved or when a different surgical manipulator is used.

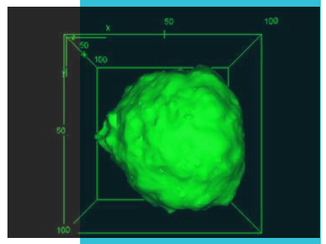
The research mentioned above serves as a foundation for achieving autonomous suturing. Other relative research at ARCLab includes deformable tissue reconstruction and manipulation, tool-tissue interaction modeling, and suture path planning. All these projects integrate surgical guidelines into advanced engineering techniques in perception and planning to make robots a safe agent for surgical treatment.

Research Highlights

Biological Cell Analysis

Cells are the basic units for life; conditions of cells reveal important information about health and diseases. The pharmaceutical industry uses cell lines to produce biologic drugs for a wide range of diseases such as cancers and immune diseases, and the field of medicine uses genetic engineering and gene editing for cell therapies. With the advances in sequencing technologies and bioinformatics, the field of biomedicine has moved from analyzing a cell population to single cells with high throughput. Furthermore, scientists are interested to learn not only the behaviors of individual cells, but cell-cell interactions and communications in tissues and micro-environments. All of the above require new technologies across many disciplines, including photonics, electronics, microfluidics, signal/image processing, and AI/deep learning.

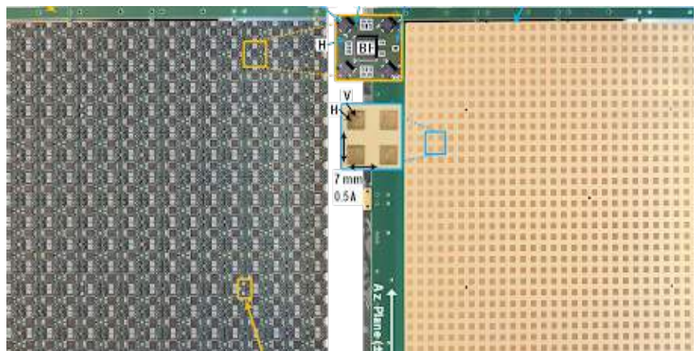
The biomedical device and system group, led by Professor Yuhwa Lo, has pioneered the research, development, and technology transition in next generation biological cell analysis and processing tools that are critical to medicine. Supported by several NIH grants and through close collaborations with the biotech industry, Lo's group has pioneered the development of the world's first benchtop microfluidic flow cytometers and cell sorters, the workhorse for single cell analysis. Recently, Professor Yuhwa Lo's group employed innovative optical and electronic designs, microfluidics, FPGA, and convolutional neural network (CNN), to image, analyze, and sort individual cells at a record speed. The system produces more than 1,000 3D cell images per second, which is 1000 times faster than any commercial 3D-imaging microscope. It becomes the only system capable of interrogating more than ten million cells by their 3D tomography in an hour, offering possibilities for clinical applications and development of new therapeutics.



For translational research, an earlier version of cell analysis tool in Lo's lab has been commercialized and become a popular tool in biotech industry. More than 300 systems using the technologies from his lab have been sold to 16 countries. Users include nearly all major pharmaceutical companies and top universities (Harvard, MIT, Stanford, UC Berkeley, etc.). The system has also been used to develop drugs and vaccines for Covid-19.

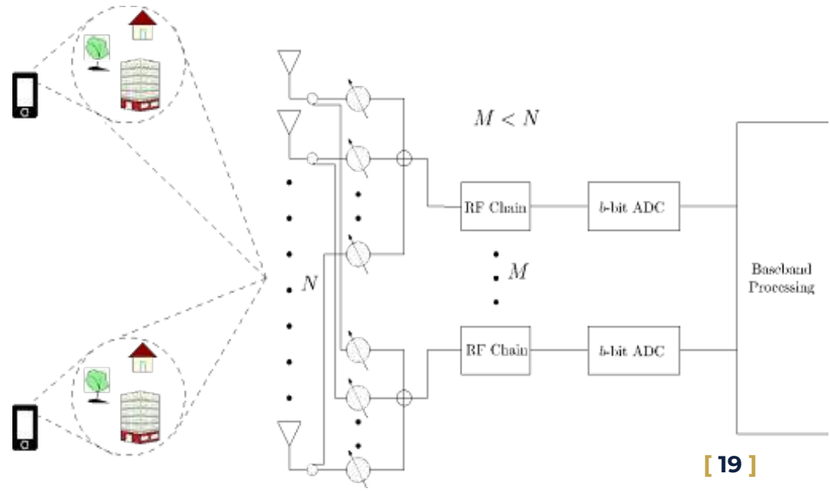
Affordable SATCOM and 5G Phased-Arrays at UC-San Diego

Professor Gabriel Rebeiz's group has been pioneering the development of affordable SATCOM (satellite communications) and 5G phased-arrays based on silicon technologies since 2005. These systems integrate the entire phased-array on a single low-cost printed-circuit board which includes the antennas, silicon beam former chips, all the necessary control electronics. The board is assembled using automated high-volume manufacturing techniques, making it very low-cost in large numbers, and is also calibrated using fast far-field procedures. UC San Diego and the Rebeiz Group pioneered this approach for phased-arrays since 2005 and developed the first silicon phased-array chips (called beam former chips) based on the 2x2 quad approach, and the first single-PCB phased-arrays. This has lowered the cost of phased-arrays by a factor of 50-100x, making them affordable and for commercial use in SATCOM and mm-wave 5G. Since then, the same ideas and techniques have been used by companies such as SpaceX/ Starlink for their SATCOM LEO (low-earth orbit) terminals (known as "Dishy"), Collins Aerospace, Viasat, Boeing and others for their airborne phased-array terminals on commercial and defense aircraft, and Qualcomm, Nokia, Samsung, Ericsson and several other companies for their low-cost 5G phased-arrays at 28 GHz and 39 GHz. It is no exaggeration that every affordable phased-array built today follows the silicon beam formers and single-PCB design approach developed at UC San Diego. Professor Rebeiz is continuing his work with the development of wideband phased-arrays for X/Ku/Ka-band SATCOM and on 140 GHz 6G phased-arrays.



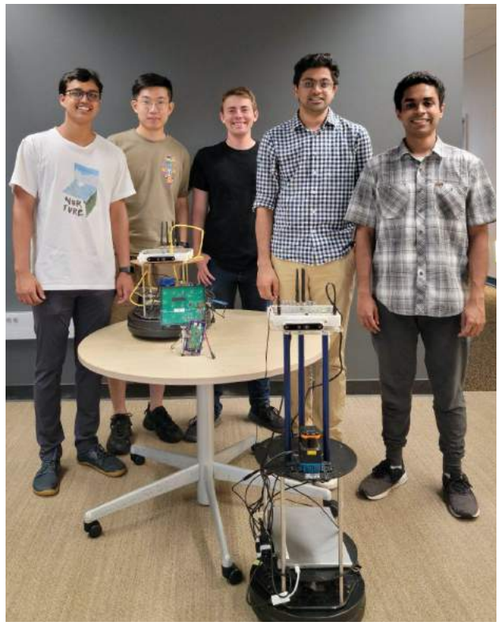
Nested Arrays, Reconfigurable Surfaces and Machine Learning for Next Generation Wireless Systems

Next generation wireless systems (6G vision) are expected to support applications such as extended reality (XR), Internet of Everything, telemedicine, connected autonomous systems with positioning and drive control, and more. These future systems will be built on the bedrock of the mmWave band and terahertz (THz) band (from 30 GHz up to 10 THz), with the wide spectrum supporting the high rates and accurate positioning. Professor Bhaskar Rao and his research group are involved in addressing physical layer challenges that arise with operating at these frequencies. His group has active collaborations with colleagues Professor Piya Pal, Professor Dinesh Bharadia, and researchers from the University of Oulu, funded by grants from the National Science Foundation and the Center for Wireless Communications at UC San Diego. Hardware complexity and channel reliability pose significant challenges for design of systems at these high frequencies. Fortunately, the smaller wavelength at these high frequencies supports having a large number of antennas within a small form factor, thereby enabling very large transmit and receive antenna elements to be packed to small physical dimensions. The spatial degrees of freedom enable for beam forming and spatial multiplexing at an unprecedented scale. Unfortunately, this results in significant hardware complexity and power consumption calling for design trade-offs. This is already evident with the recent hybrid transceiver architectures that are being proposed with combined analog and digital processing as shown in the figure. The smaller numbers of RF chains, at present usually one, greatly reduces the sensing accuracy and increases the channel acquisition and beam alignment time. This is exacerbated by the higher path loss experienced at the higher frequencies. To overcome these challenges, the research adopts a synergistic approach where innovations in architecture and algorithm (model-based and data-driven) complement each other via judicious exploitation of structure (array geometry and modeling aided by powerful inference frameworks [sparse Bayesian learning (SBL) and machine learning (ML)] techniques. An important consideration in the research is co-design sensing strategies (array geometries, beam formers) and estimation algorithms, which can be especially effective for combating path-loss without increasing hardware complexity. Also, the work embraces nonlinearities to lower hardware complexity and cost opening the way for solutions using modern data driven and deep learning approaches. To improve the reliability of the channel at these high frequencies, the research considers channel morphing using appropriately placed and adaptively controlled specialized reconfigurable intelligent surfaces (RISs).



Using Everyday WiFi to Help Robots See and Navigate Better Indoors

Researchers at the UC San Diego department of Electrical and Computer Engineering have developed a low-cost, low-power technology to help robots accurately map their way indoors, even in poor lighting and without recognizable landmarks or features.



The technology consists of WiFi sensors to help the robot map its destination. It is a new approach to indoor robot navigation. Most systems rely on optical light sensors such as cameras and LiDARs. In this case, the so-called "WiFi sensors" use radio frequency signals, rather than light or visual cues, to see so they can work in conditions where cameras and LiDARs struggle—usually in low light, changing light, and repetitive environments such as long corridors and warehouses. Additionally, using WiFi, the technology could offer an economical alternative to expensive and power-hungry LiDARs, the researchers noted.

The beauty of this work is that we can use these everyday signals to do indoor localization and mapping with robots. The system consists of a robot that has been equipped with WiFi sensors, which are built from commercially available WiFi transceivers. These devices transmit and receive wireless signals to and from WiFi access points in the environment.

What makes these WiFi sensors special is that they use this constant back-and-forth communication with the WiFi access points to map the robot's location and direction of movement. This two-way communication is already happening between mobile devices like your phone and WiFi access points all the time—it's just not telling you where you are. Our technology piggybacks on that communication for localization and mapping in an unknown environment.

A team of researchers from the Wireless Communication Sensing and Networking Group, led by UC San Diego Electrical and Computer Engineering Professor Dinesh Bharadia, presented their work at the 2022 International Conference on Robotics and Automation (ICRA), a top-tier robotics conference. The team of ECE researchers consists of Ph.D. students Aditya Arun (Lead), Roshan Ayyalasomayajula and undergraduate student William Hunter. The extended team who works on WiFi sensing consists of Kanishka Roy, Wenshuo Zang, Yizheng Yu, and Sureel Shah. Future work is looking to explore the use of these wireless sensors in tandem with cameras to provide an inexpensive mapping technology.

$6M IARPA Grant to Secure Wireless Data Communication

A team co-led by Professor Dinesh Bharadia at UC San Diego has been awarded a $6 million grant from the Intelligence Advanced Research Projects Activity (IARPA) to secure data transmissions using smart radio technology. The project funded by IARPA would not only help develop solutions for intelligence and defense agencies, but also for everyday people, since most of our communications today are wireless. Wireless systems, including WiFi and 5G systems, are long overdue for security and privacy features, which are currently non-existent.

It is very easy today for anyone to mimic your WiFi Access Point, know everything you send over the world wide web, and worse yet, get access to all your data, and you wouldn't even know it. The grant is part of a new program by IARPA—dubbed Securing Compartmented Information with Smart Radio Systems (SCISRS)—that aims to protect sensitive data communications from being breached in government facilities and "in the wild."

The goal of the project is to develop smart radio systems to detect and characterize suspicious radiofrequency signals, or RF anomalies, in complex RF environments. These RF anomalies include:

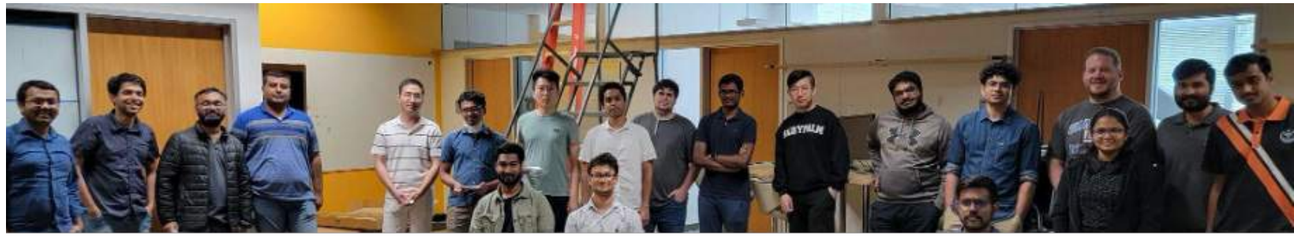
- Low probability of intercept signals (signals that are hard to see because they are buried in noise and masked by stronger signals)
- Altered or mimicked signals (these signals attempt to appear benign—for example, they can look like signals from a cell tower or your neighbor's WiFi—but are actually soliciting communication with your devices)
- Unintended emissions (signals that are not meant to be transmitted and inadvertently carry sensitive information; sources for these emissions include screens, video monitors, computer mice and KVM switches on keyboards)

The UC San Diego team will design and build algorithms that can identify RF anomalies by continuously scanning a wide range of radio wavelengths in near real-time and with high accuracy. The team will use signal processing techniques to expose weak, and potentially anomalous RF signals. The researchers would also use deep learning techniques and machine learning to characterize the signals in the environment and classify anomalies in the sea of signals: finding a needle in a haystack.

Professor Bharadia is a faculty member with the Department of Electrical and Computer Engineering and director of the Wireless Communication, Sensing and Networking Group (WCSNG), working with a large team of postdocs, Ph.D. and Master's students to develop the solution, including Postdoc Srivatsan Rajagopal; Ph.D. students Richard Bell, Hadi Givehchian, Venkatesh Sathyanarayanan, Byungjun Kim, Raghav Subbaraman, Raini Wu and Masters students Kevin Anderson, Radhika Mathuria, Hari Prasad, Pratik Ratadiya, Sreevatsank Kadaveru.

Other investigators on the team include ECE Adjunst Professors Fredric J. Harris, an expert in digital signal processing, and Peter Gerstoft, a machine learning expert and data scientist at Scripps Institution of Oceanography. UC San Diego researchers will work with JASR Systems, which will develop an efficient implementation of the algorithms, then test the implementation of these systems on the RF testbed at UC San Diego.

UC San Diego and JASR Systems will work toward securing our everyday communications by developing world-class solutions for identifying malicious and nefarious behavior with our wireless communications. As a future extension, they hope to develop a low-cost solution that anyone can readily acquire to detect such nefarious activities.



A New Brain Implant to Study How Different Regions of the Brain Communicate

Learning and memory are cognitive functions central to human behavior. Learning and memory requires communication between different functional regions in the brain. However, very little is known about the nature of this communication. Understanding the mechanisms and functional coordination in the brain that underlie learning and long-term memory storage is crucial for investigating fundamentals of information processing in the brain and for developing targeted treatments for neurological diseases affecting learning and memory. Answering this important question relies upon our ability to image neural activity across the entire brain simultaneously along with recordings from deep structures such as the hippocampus. However, conventional silicone based brain implants are not suitable for this purpose since large probe shanks made of rigid materials block the imaging with the microscopes. The Neuroelectronics Group led by Professor Duygu Kuzum have recently developed a new flexible, insertable, transparent microelectrode (Neuro-FITM) implant that monitors the activity of different parts of the brain at the same time, from the surface to deep structures—a first in the field.

The Neuro-FITM implant is made up of a thin, transparent, flexible polymer strip fabricated with an array of micrometer-sized gold electrodes, onto which platinum nanoparticles have been deposited. Each electrode is connected by a micrometers-thin wire to a custom-printed circuit board. Professor Kuzum's lab worked with Komiyama lab at UC San Diego to perform brain imaging studies in transgenic mice to monitor the activity of different parts of the brain at the same time. The motivation for this study was getting to the root of how different cognitive processes, such as learning and memory formation, occur in the brain. Such processes involve communication between the hippocampus and cerebral cortex. But how exactly does this communication happen? And which brain region initiates this communication: the hippocampus or the cerebral cortex? These types of questions have been left unanswered because of the lack of suitable technologies to-date. Using Neuro-FITM implants in transgenic mice, Professor Kuzum's Neuroelectronics group have shown that diverse patterns of two-way communication occur between two brain regions known to play a role in learning and memory formation—the hippocampus and the cerebral cortex. They have also shown that these different patterns of communication are tied to some high frequency brain oscillations called sharp-wave ripples, which occur in the hippocampus during sleep and rest. Their experiments revealed that communication between the hippocampus and cerebral cortex is two-sided: sometimes the cortex initiates communication, other times it's the hippocampus. Professor Kuzum's group found that the hippocampus communicates with at least eight different parts of the cerebral cortex every time sharp-wave ripples occur. Furthermore, each of

these eight cortical activity patterns is tied to a different population of neurons in the hippocampus. These findings enabled by the Neuro-FITM technology suggest that a selective and diverse set of communication links between different brain regions is fundamentally important for cognition and behavior that rapidly adapt to changing environments. Professor Kuzum's group will continue to innovate new brain implant technologies to investigate circuit function and information processing in the brain. This research can also help to bridge critical gaps between artificial intelligence-driven models for learning (such as deep networks, recurrent networks, and adversarial networks) and how the brain "really learns." Understanding the brain computation has the potential to reshape current practices in machine learning.

Cognitive Testing for Alzheimer's Disease using Mobile Smartphone Pupillometry

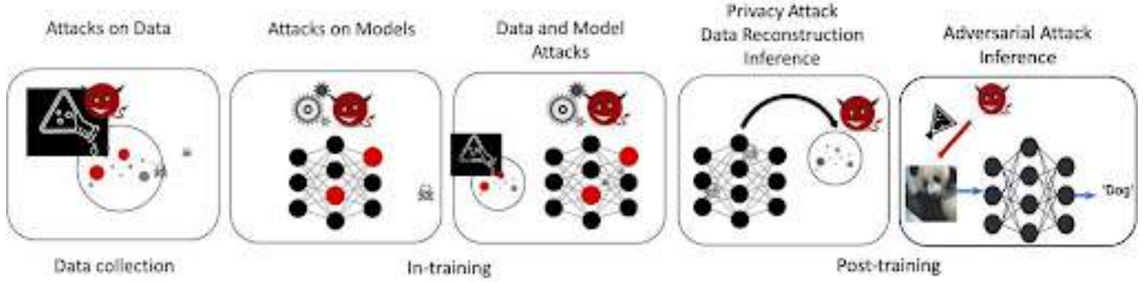
Researchers at the UC San Diego Digital Health Technologies (DigiHealth) Lab, led by Professor Edward Jay Wang, have developed a smartphone app that could allow people to screen for Alzheimer's disease, ADHD and other neurological diseases and disorders—by recording closeups of their eye. The app uses a near-infrared camera, which is built into newer smartphones for facial recognition, along with a regular selfie camera to track how a person's pupil changes in size. These pupil measurements could be used to assess a person's cognitive condition. The technology is described in a paper presented at the ACM Computer Human Interaction Conference on Human Factors in Computing Systems (CHI 2022), which received an Honorable Mention for Best Paper Award, awarded only to the top 5% of submissions.

Pupil size can provide information about a person's neurological functions, recent research has shown. For example, pupil size increases when a person performs a difficult cognitive task or hears an unexpected sound. UC San Diego ECE researchers collaborated with Professor Eric Granholm at the UC San Diego Center for Mental Health Technology (MHTech Center) to develop an affordable and accessible solution. Funded by the National Insititute of Aging, the app developed by the UC San Diego team uses a smartphone's near-infrared camera to detect a person's pupil. In the near-infrared spectrum, the pupil can be easily differentiated from the iris, even in eyes with darker iris colors. This enables the app to calculate pupil size with sub-millimeter accuracy across various eye colors. The app also uses a color picture taken by the smartphone's selfie camera to capture the stereoscopic distance between the smartphone and the user. The app then uses this distance to convert the pupil size from the near-infrared image into millimeter units.

This is backed by a scientific premise, demonstrated by MHTech collaborators that pupillary responses provide a digital biomarker of cognitive effort required to perform tasks before someone's cognition is obviously impaired. In this test, older adults are asked to remember numbers that are read to them. As more numbers are remembered, their pupils dilate more and more, until they can no longer remember any more. What is measured is not just how many numbers someone can remember, but "how hard" they had to try, which can be measured by how much their pupils dilated. Someone requiring more effort to achieve the same score as another person, showing a bigger pupil dilation, is therefore, at higher risk for decline.

A scalable smartphone assessment tool that can be used for large-scale community screenings could facilitate the development of pupil response tests into minimally-invasive and inexpensive tests to aid in the detection and understanding of diseases, like Alzheimer's disease. The importance on clinical relevance is a key aspect of the research being conducted at UC San Diego's DigiHealth Lab.

Robust Private Computing for Distributed and Collaborative AI Systems



The UC San Diego Adaptive Computing and Embedded Systems (ACES) Lab, under the direction of Professor Farinaz Koushanfar, specializes in maintaining the privacy and robustness of contemporary massive distributed data and sophisticated modern learning algorithms. Such distributed and collaborative AI algorithms are required for the contemporary emerging scenarios such as federated learning, block chains, and distributed finance. In the emerging realms, distributed entities contribute their data and computing resources to achieve the desired objectives. One or more distributed computing server(s) (a.k.a., Oracle, central node, or gateway) collect, aggregate, or combine the results from the distributed nodes. There are several benefits to such distributed and/or collaborative computing, including retaining the data at the source, democratizing computations, and localizing the computations to avoid the high cost of longer-range communications for server-centric computing. There is an inherent trade-off between privacy, robustness (to attacks), security, and usability.

To address the standing challenges in safety and robustness of the distributed computing and collaborative learning domains, the ACES Lab researchers devise novel methods based upon the co-design and optimization of data, compute, algorithms, and security/cryptography protocols.

A set of recent research work from the ACES Lab address the pressing challenges due to the poisoning of data/models which can stem from untrusted parties with intentional malicious goals, or clients with unintentional integrity, noisy, or missing information. Another suite of work in the lab aims at thwarting AI vulnerabilities by providing inputs that cause system misbehavior, also known as adversarial attacks. Yet another challenge addressed by the ACES Lab researchers is model-stealing and privacy concerns for both AI data providers and model builders. Professor Koushanfar's lab has made foundational contributions to the design and practice of cryptographically secure multi-party computations, which enable scaling of secure computations for modern distributed blockchains and zero-knowledge proofs.

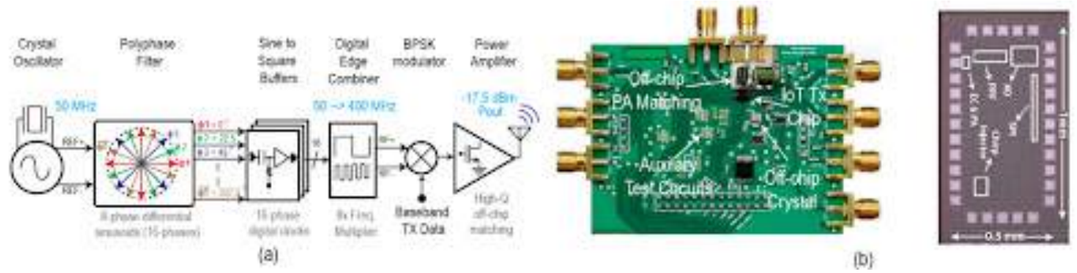
The ACES Lab is the first to propose co-design and acceleration of AI algorithms for robust AI. The contributions of the ACES researchers include introduction of watermarking-based solutions that embed unforgeable signatures in the AI models, as well as methodologies for machine learning on encrypted data. For this latter problem, Professor Koushanfar's research has introduced theoretical and practical contributions to realize a platform for large-scale secure computation. Her patent-pending AI on encrypted data inventions define the state-of-the-art in this competitive field.

Low-Power Short-Range IoT Transmitters

Recent years have seen a considerable influx of miniaturized interconnected electronic devices for a wide range of applications (e.g., connected health, smart homes, smart cities, etc.) collectively referred to as the Internet of Things (IoT). Low power consumption is critical to extending battery lifetimes in these devices and is often limited by the wireless transmitter. Contrary to conventional radios used in cell phones that communicate with base stations located miles away, many IoT transmitters only need to communicate over a short-range (~1-2 meters) to a nearby base station, such as a smartphone or a smartwatch. Because of this, the power amplifier that drives the antenna is no longer power-hungry. Instead, the frequency synthesizer generating the radio-frequency (RF) carrier is the power bottleneck. Like conventional radios, the synthesizer must maintain frequency accuracy irrespective of manufacturing, supply voltage, and environmental temperature variation.

This posed a longstanding technological hurdle when one wanted to push power consumption down to the ultra-low power regime because, with well-established frequency synthesis techniques, lower power was associated with a compromise in accuracy and robustness. Researchers at the UC San Diego, led by Electrical and Computer Engineering Professor Drew Hall, developed a new circuit technique to overcome this hurdle. They devised a calibration- and regulation-free synthesis technique where a polyphase filter is integrated directly within a crystal oscillator followed by an edge combiner. This generates the RF carrier at a fraction of the power while meeting phase noise and spectral mask constraints. To demonstrate this technique, they designed an ultra-low power transmitter that operates in the MedRaio/ISM band (~405 MHz). Their wireless transmitter exhibits excellent robustness to process variation, consistent performance across temperature (-30 to 90 °C), and complete insensitivity to voltage variation. All these, while achieving the best energy-efficiency (67 pJ/bit) and lowest power (67 µW) among reported sub-1 mW narrowband transmitters!

#1 UC San Diego was named number one public university by Washington Monthly rankings.

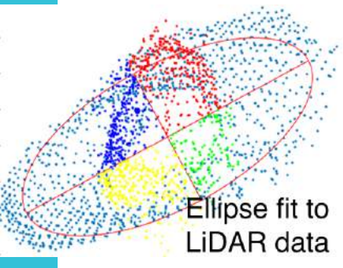


OUR ECE COMMUNITY

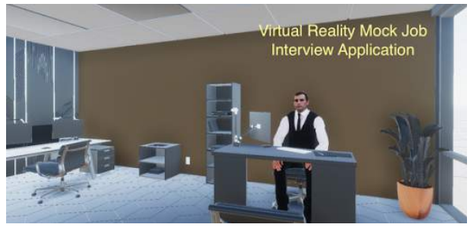
A Summer Internship and Development of VR- and ML-based Tools Help Neurodiverse Young Adults Transition to Work

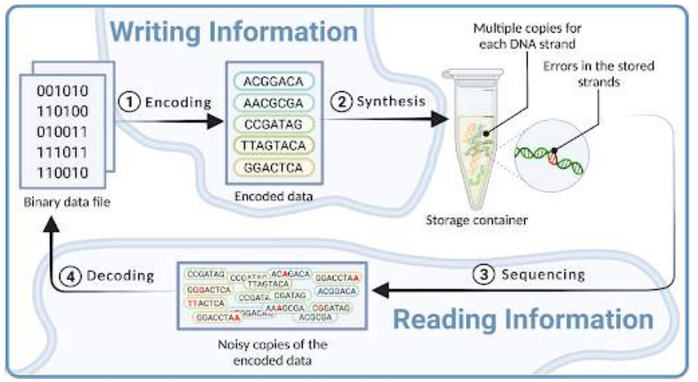
Because of a range of social interaction and communication differences, high-functioning young adults with autism spectrum disorder (ASD) have staggeringly high unemployment rates despite often holding college degrees, average to high IQs, and various useful skills. Most computer-based assistive technologies for ASD focus on children rather than on high-functioning young adults. Effective training and tech tools for this population has great potential for economic benefits, due to the large number of individuals with ASD aging into adulthood each year.

Funded by a California workforce development grant and $2.6 million from the National Science Foundation, Prof. Pamela Cosman runs the Neurodiversity in Tech (NDTech) Summer Internship program and develops tech tools that can help high-functioning autistic young adults transition to work. In summer 2022, sixteen young adults took part in the NDTech internship, working in teams to develop educational video games while gaining experience with tools and procedures that are standard in the video game industry (e.g., Git, Jira, Discord, Unity), and getting behavioral coaching from on-site coaches. The interns also benefited from technical advice and career mentoring from mentors from Ubisoft, a top-10 video game company. The games created in Summer 2022 were StarSwap, a match-3 type game based on stellar evolution, Inter-fur-ence, where a space cat zooms around delivering food while switching radio channels to maintain good signal quality, and the Labyrinth at Oxkintok, in which players learn about Mayan culture while exploring an archaeological site in a puzzle-based Escape-Labyrinth game.



The research connected to the internship includes an AR system that measures head nodding and shaking, and a VR mock job interview application, in which users answer questions and interact with a virtual interviewer. The VR system measures gaze location to the interviewer's eyes and mouth and social modulation of gaze (depending on the subject's role as speaker or listener). The system is the first to allow automatic measurement of social modulation of gaze, and it uncovered various significant differences in the way ASD and neurotypical individuals interact with the avatar. The VR app aims to allow solo situational practice with personalized feedback on gaze and body orientation for dyadic and triadic conversations. An additional project, with both Profs. Sujit Dey and Pamela Cosman, uses two LiDAR sensors to obtain point clouds of upper body positions during live conversations; neural networks are used on the sequence of point clouds to estimate body and head orientation.





Coding Theory for DNA Storage: Synthesis, Retention, and Reconstruction

New information storage technologies are needed to accommodate the growing deluge of data being collected and generated by modern society. In the past decade, several experiments have demonstrated that deoxyribonucleic acid (DNA) – the molecule that carries the genetic information of living organisms – is a potentially viable storage medium. DNA-based storage would have many attractive features: unprecedented data density, a recording format that will not become obsolete, archival durability over thousands of years, and easy data replication. On the other hand, DNA storage requires fundamentally new methods for encoding data into DNA sequences to make the storage process efficient and reliable.

A team of researchers from UC San Diego, Duke University, and Technion-Israel Institute of Technology has received a $1.2 million dollar grant from the National Science Foundation to tackle this problem. The aim of the newly funded project is two-fold: to understand the mathematical limits on the efficiency, reliability, and information density of DNA-based storage; and to develop novel data encoding and decoding algorithms to help achieve those limits. The research will focus on coding methods that address critical problems in the writing and reading of information in a DNA storage system: efficient synthesis of DNA sequences, stable retention of stored sequences, and reliable data retrieval and reconstruction via sequencing and decoding.

Specific objectives of the project are: (1) establish fundamental information-theoretic limits on the storage capacity of DNA using mathematical abstractions of the DNA recording process, (2) develop source coding techniques to minimize the time needed to encode data into synthesized arrays of DNA strands, (3) design coding algorithms to efficiently enforce constraints on the allowed nucleotide patterns in synthesized DNA strands to ensure their long-term retention, and (4) develop reconstruction algorithms and error-correcting codes that can recover a set of DNA sequences from an unordered collection of copies that may be corrupted by insertions, deletions, and substitutions of nucleotides.

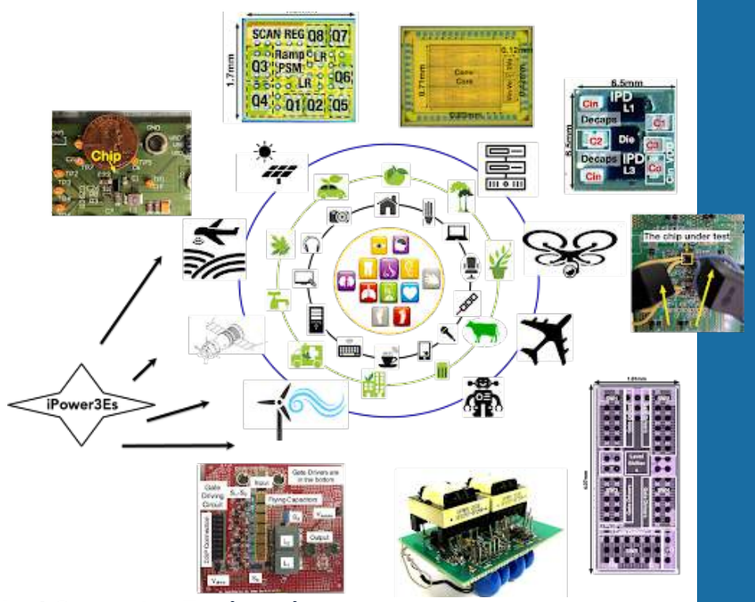
The project develops tools to address classical problems in coding theory and information theory that underlie many aspects of the research. These include the construction of optimal codes for finite-state communication channels with symbol costs, the design of optimal short length codes that correct multiple insertion and deletion errors, the development of efficient coding techniques that asymptotically approach the capacity of a communication channel with deletion errors, and the analysis of algorithms and codes that enable reconstruction of a sequence from multiple noisy observations, either exactly or within a small list of candidate sequences.

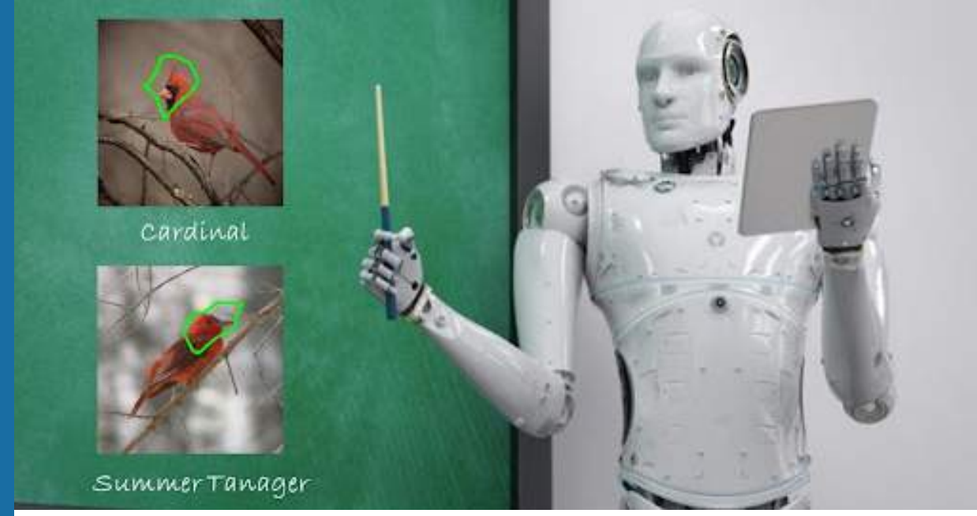
Professor Paul Siegel of the Center for Memory and Recording Research (CMRR) will serve as the principal investigator for the project. Co-principal investigators include Dr. Ryan Gabrys of the Naval Information Warfare Center (NIWC) Pacific and the Qualcomm Institute (QI), a leader in the field of coding for DNA storage systems; Professor Henry Pfister of Duke University, an author of award-winning papers in the theory of capacity-achieving error-correcting codes; Professor Ido Tal of Technion, a pioneer in the design and decoding of polar codes and contributor to the 5G wireless standard; and Professor Eitan Yaakobi of Technion, an expert in DNA storage and recent recipient of a 2 million euro individual consolidator grant titled "Coding for DNA Storage" from the European Research Council (ERC). Professor Alex Vardy, who passed away in March 2022 (see "In Memoriam"), was also a co-principal investigator on the project. The research builds on recent work by the investigators and benefits from a long history of fruitful collaborations among them, originating in part from their overlapping periods of affiliation with UC San Diego at CMRR and QI.

Key Drivers of Next-Generation Power Electronics: Miniaturization and Integration

Power delivery and management is the most ubiquitous and critically important part in all electronic devices and systems from low power to high power, smartphones to data centers, battery-powered components to renewable-energy-powered grids, and from stationary systems to aircrafts. Applying techniques in power electronics, this indispensable sub-system is responsible for interfacing with an energy source, e.g. battery or grid, while providing the right voltage, current, and power to every individual sub-block of the system, whether it is a display, a processor, a sensor, or a motor. As more functionalities are added to the system to satisfy human needs and to improve the overall efficiency, the complexity of power management keeps increasing to the point it is recently recognized as a serious bottleneck in system space utilization and size. At the same time, the stress for the system to be lighter, smaller, more efficient, and lower cost of ownership adds critical challenges to designing power management for next-generation systems.

To tackle the challenges in power delivery and management, the Integrated Power Electronics and Energy Efficient Systems (iPower3Es) group led by Professor Hanh-Phuc Le sets the main goal to create and supply integrated/ miniaturized power for all applications in need. Believing the future of power electronics lies in miniaturization and integration, Dr. Le positions the group research in integrated power electronics, which is at the boundary of integrated circuits and power electronics. The group develops new power converter topologies, control, circuit techniques, and utilizes advanced fabrication process and packaging. Active projects include fast and smart charger for mobile battery, efficient vertical power delivery for high-performance processors, integrated converters using integrated inductors and silicon capacitors, GaN power converter for 5G communication systems, extremely high-voltage miniaturized power converter and driver for soft robot actuators, and miniaturized modular power converter for next-generation induction motors. The research is supported and sponsored by government agencies, including National Science Foundation (NSF) and Office of Naval Research (ONR), and leading industry companies in the field both directly and through Semiconductor Research Corporation (SRC), Center for Wireless Communications (CWC) at UC San Diego, and Power Management Integration Center (PMIC), an NSF Industry-University Cooperative Research Center.





Machine Teaching

Deep learning has enabled various breakthroughs in almost all areas of computer vision, including a new generation of systems that solve problems like image classification, object detection, or image segmentation with performance comparable to or even superior to that of humans. This success is in great part due to the availability of very large and well-curated datasets that are carefully labeled on crowd-sourcing annotation platforms, like Amazon MTurk. Labeled data enables the use of supervised learning, where the learning system is trained with both the image and its label. While this framework is extremely powerful, it constrains the application of vision systems to problems where annotators are easy to find by crowd-sourcing. This is viable for problems involving everyday objects, such as the cars or faces to be recognized by smart driving or face recognition systems. However, it is not true for expert domains, such as medical or biological imaging. In these domains, labeling requires annotators with extensive background knowledge, such as the biologists required to classify bird images into species like ‘Cardinal’ or ‘Summer Tanager’. Hence, while data collection can still be easy, labelling is extremely expensive, preventing the collection of the large-scale datasets needed to design effective vision systems. While there is extensive research in less label-intensive learning approaches, such as self-supervised or semi-supervised learning, these are still much less effective than supervised learning, especially for the fine-grained concept classes that populate expert domain problems.

To address this challenge, research in the Statistical Visual Computing Lab (SVCL) led by Professor Nuno Vasconcelos is exploring an alternative solution, that turns the problem on its head: rather than simply learning from human labels, the AI is used to train human annotators. This approach, known as machine teaching, starts from a small dataset labeled by an expert, and uses a deep learning system to discover the set of most informative examples, known as the curriculum, to teach humans to identify each concept of interest. The curriculum is then used to teach crowd-sourcing workers the set of concepts needed to label the images of the expert domain. For example, the machine teaching system highlights the fact that, to distinguish the bird species ‘Cardinal’ and ‘Summer Tanager,’ the annotator should focus on certain patterns of appearance of the birds’ heads. The scalability of the crowd-sourcing platform is then leveraged, by training a large number of workers, who can then label a large dataset. The SVCL team has demonstrated the effectiveness of machine teaching methods for labeling expert images and its superiority for the scalable training of recognition systems over approaches like self-supervised or semi-supervised learning. Beyond machine teaching algorithms, SVCL research has also proposed other frameworks for human-machine collaboration. These methods are all pioneer attempts to solve the challenge posed by the data limitations of expert domains to scalable recognition systems. In the future, this type of technology could also be brought to the classroom, enabling new types of interactive learning applications.

New Sensor Grids Record Human Brain Signals in Record Breaking Resolution

A team of engineers, surgeons and medical researchers led by Prof. Shadi Dayeh has published data from both humans and rats demonstrating that a new array of brain sensors can record electrical signals directly from the surface of the human brain in record-breaking detail. The new brain sensors feature densely packed grids of either 1,024 or 2,048 embedded electrocorticography (ECoG) sensors. For comparison, clinical ECoG grids most commonly used in surgeries today typically have between 16 and 64 sensors, although research grade grids with 256 sensors can be custom made.

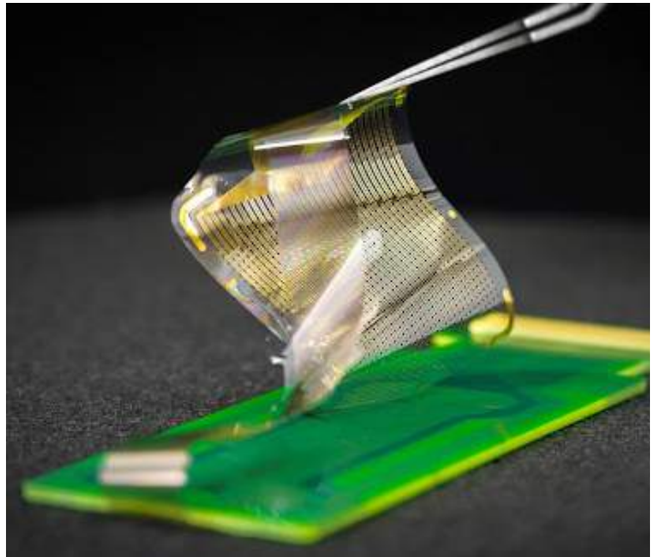
Being able to record brain signals at such high resolution could improve surgeons' ability to remove as much of a brain tumor as possible while minimizing damage to healthy brain tissue. In the case of epilepsy, higher resolution brain-signal recording capacity could improve a surgeon's ability to precisely identify the regions of the brain where the epileptic seizures are originating, so that these regions can be removed without touching nearby brain regions not involved in seizure initiation. In this way, these high-resolution grids may enhance preservation of normal, functioning brain tissue.

The human brain is always moving. With each heartbeat, for example, the brain moves with the pulsating blood flowing through it. The new platinum nano-rod brain sensor grids are ten micrometers thick, approximately one tenth the size of a human hair and 100 times thinner than the one millimeter thick and clinically approved ECoG grids. The thinness and flexibility allows the sensor grids to move with the brain, enabling a closer connection and better readings. In addition, the grids are manufactured with small, ring-shaped holes that allow cerebral spinal fluid to pass through. In this way, these perfusion holes support a better interface between the sensor grid and the brain surface by allowing the sensor to easily and safely displace the fluid. This design yields a sensor grid that forms a close and stable connection with the surface of the brain, improving signal quality.

One of the challenges of removing brain tumors is that the presence of the tumor triggers changes in the brain, including changing what areas of the brain are involved in what functions. These changes make it critical for the surgical team to make a personalized map of the patient's brain – "functional maps" – in order to decide where to cut and where not to cut while removing as much of the tumor as possible.

The team demonstrated that these functional maps can be made extremely precise using their platinum nano-rod ECoG sensors. In particular, the team developed functional maps in four different people who were asked to do a number of activities, including hand grasping. With this information, the researchers reconstructed the actual location of this key landmark in the brain as well as the neural correlates in the brain that correspond to finger sensation and hand grasping. The newly delineated curvilinear functional boundary unique to each patient's brain is superior to the often extrapolated and linear boundary that is determined from today's one-centimeter-spaced clinical grids.

The new grids uncovered the short and local as well as long and broad range brain waves associated with brain function all at the same time. This high- spatial and time-varying (dynamic) picture of the brain activity was documented in several supplementary movies including a short video composed by the National Science Foundation (NSF).

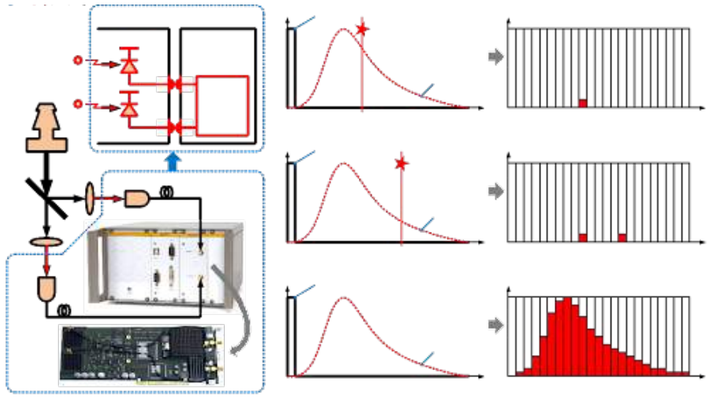


Universal Single-Photon Detection Technique for Quantum Applications

Time-correlated single-photon counting (TCSPC) systems [1], which contain time-to-digital conversion (TDC) integrated circuits, have become the key functionality in a variety of emerging quantum technology. The state-of-the-art TDC designs all have pros and cons in certain performance aspects; therefore, depending on the emphasis on speed or resolution, the required TDC specifications can be roughly categorized into two major areas of the TCSPC applications. First, quantum imaging/sensing, time-resolved spectroscopy, positron emission tomography (PET), fluorescence-lifetime imaging (FLIM), time-of-flight (TOF) sensing, and light detection-and-ranging (LiDAR) primarily exploit high-speed and small-area TDC techniques with the downsides of lower resolution, lower accuracy and higher clock-generation power. Second, quantum-bit-state probability amplitude measurements, quantum cryptography, molecular imaging, and live-cell/tissue microscopy mainly employ high-resolution TDC techniques with the downsides of lower conversion-rates, higher calibration complexity, and high-order digital filtering. In the long run of quantum-technology development, the demand for supporting both high-speed and high-resolution with low power/area consumption will be the common direction of all TCSPC applications.

Research by Professor Hsueh in the ECE Integrated Communication Circuits Lab (ICCL) at UC San Diego introduced a two-step TDC architecture, incorporating the concept of variance reduction (VR) into the random sampling-and-averaging (RSA) technique [2], [3] to realize a universal RSA-based TDC architecture for both categories of high-speed and high-resolution TCSPC applications. To achieve this goal, the research team first induced negative auto-covariances in a received random variable of the single-photon detections to perform self-antithetic variance reduction (SAVR) by a proposed module-T random oversampling technique [3] with negligible power overhead, then created cross-covariances between two random variables of the single-photon detections to further perform control-variate variance reduction (CVVR) by parallelizing two modulo-T random oversampling techniques. So far, the mathematical algorithms of these VR techniques have been theoretically proven; meanwhile, the signal processing and mixed-signal integrated circuit (IC) of the RSA-based TDC architecture have been thoroughly derived and under the hardware implementation of a modern silicon-photonics (SiPh) process and integration technology to perform the universal single-photon detections with sub-picosecond resolution, scalable dynamic range, calibratable linearity, high noise-immunity, and fast conversion-rates for both high-speed and high-resolution emerging quantum technology.

[1] W. Becker, Advanced Time-Correlated Single Photon Counting Techniques, Berlin, Germany: Springer, 2005.
[2] T.-C. Hsueh et al., "An on-die all-digital power supply noise analyzer with enhanced spectrum measurements," IEEE J. Solid-State Circuits, vol. 50, no. 7, pp. 1711–1721, July 2015.
[3] T.-C. Hsueh et al., "Random sampling-and-averaging techniques for single-photon arrival-time detections in quantum applications: theoretical analysis and realization methodology," IEEE Trans. Circuits and Syst. I: Reg. Papers, vol. 69, no. 4, pp. 1452–1465, April 2022.



Open Source Hardware Research Infrastructure Making an Impact in Next-Generation Wireless Communication and Sensing Systems

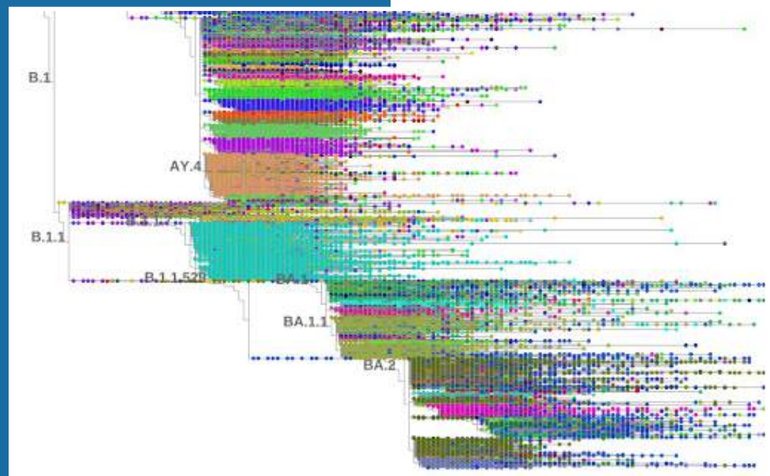
Supported by a $2 million NSF CISE Community Research Infrastructure (CCRI) grant, Professor Xinyu Zhang, along with Professors Dinesh Bharadia, Sujit Dey, and Gabriel Rebeiz, have been developing an open-source platform called M-Cube to facilitate research in 5G vehicular networking and automotive sensing. M-Cube enables experimental research on millimeter-wave (mmWave) technologies--the cornerstone for 5G wireless communication and automotive radar sensing. A mmWave radio/radar uses electronically steerable directional beams, generated by large antenna arrays, as communication/sensing medium. Programmability is critical for mmWave experimental research, especially in real-time vehicular networking/sensing. Yet, to date, programmable mmWave devices are either too costly, or lack a reasonably-sized antenna array which is critical for real-time beam-steering operations. M-Cube is filling this gap with a low-cost software radio/radar featuring a large antenna array (256 elements on a 5cmx10cm plane, Fig. 1). By designing a novel radio/radar architecture, M-Cube transforms a commodity mmWave radio into a versatile software radio/radar. Compared with state-of-the-art software radio platforms, M-Cube brings the per-node cost down by almost two orders of magnitude, and increases the phased-array size by an order of magnitude. A 2020 research paper from Professor Zhang's team, which describes the M-Cube hardware, won the Best Paper Award in ACM MobiCom, the most prestigious research venue in the area of wireless systems and mobile computing.

Using M-Cube, Professor Zhang's team has also been constructing a mmWave vehicle-to-everything (V2X) testbed on the UC San Diego campus (Fig. 2). The feasibility of mmWave V2X connectivity has long been questioned. One major doubt lies in how the highly directional mmWave links can sustain under high mobility. Professor Zhang's team deployed an experimental testbed to mimic a typical mmWave V2X scenario, to enable microscopic investigation of the mmWave V2X channel and the link. Each testbed node is a modified M-Cube node, powered by solar panels and backup batteries, mounted on lampposts. With extensive measurement studies, the team debunked some common misperceptions of mmWave V2X networks. The measurements pointed to possible ways to realize efficient and reliable mmWave networks under high mobility, while maintaining the simplicity of standard network protocols.
In the past two years, Professor Zhang's team has been distributing the M-Cube software radio to the research community and industry partners, through free equipment loans and paid fabrication services. To date, researchers from more than 12 research institutions in the US and EU have been using M-Cube to explore the frontier of mmWave communication and sensing. Such such a fully programmable mmWave platform is instrumental for a wide range of topics for beyond-5G wireless networks and wireless sensing systems.

Pandemic-Scale Phylogenetics

At Professor Yatish Turakhia's lab, undergraduate researcher Cheng Ye developed a highly-efficient and massively parallel software to refine a comprehensive phylogenetic tree of all available SARS-CoV-2 (the COVID-19 pathogen) genomes. This tree is a visual representation of the inferred evolutionary relationships between the genome sequences of the pathogen collected from infected people worldwide.

Ye and Professor Turakhia's innovations have profoundly impacted pandemic-related research. The SARS-CoV-2 phylogenetic tree maintained with the help of their software forms the basis of naming new variants (for e.g., "B.1.1.529" is a phylogenetically-derived scientific name given to the starting Omicron lineage). Scientists across the globe are also making use of this tree to flag the emergence of new variants, monitor circulating variants in real-time and analyze local outbreaks.



Ye's software is being used to improve the accuracy of the most detailed phylogenetic representation that we currently have for studying the ongoing SARS-CoV-2 evolution. As of early August 2022, this phylogenetic tree consists of over 12 million SARS-CoV-2 genome sequences at its tips (see attached figure), with tens of thousands of new sequences being added to it daily. This tree is being maintained by a lab at UC Santa Cruz that Professor Turakhia closely collaborates with and where he obtained his postdoctoral training. The ability to refine a daily-updated comprehensive SARS-CoV-2 phylogenetic tree is currently unique to the software developed by Ye and was made possible through fundamental innovations in data structures and algorithms for handling the optimization problem at pandemic-scale.

Ye was awarded the ECE Best Undergraduate Research Award 2022 for his work. The manuscript describing this work published in the Bioinformatics journal [1], its associated press release [2], a transcript of Cheng Ye's interview about his research journey [3] and a web tool for visualizing a public version of the aforementioned SARS-CoV-2 phylogenetically tree [4] have been referenced below. More recently, Ye and Kyle Smith, another undergraduate student researcher at Professor Turakhia's lab, also contributed to a large-scale study on SARS-CoV-2 recombination that was published in the Nature journal [5].

References:
[1] https://doi.org/10.1093/bioinformatics/btac401
[2] https://jacobsschool.ucsd.edu/news/release/3473
[3] https://jacobsschoolofengineering.blogspot.com/2022/06/cheng-ye-ece-best-undergraduate.html
[4] https://cov2tree.org/?treenomeEnabled=true
[5] https://www.nature.com/articles/s41586-022-05189-9

Automated Surgical Procedures for First Response Scenarios

In Professor Yip's lab, an active area of research has been automating surgical procedures for first response scenarios. Junmin Wu, as part of the Student Research Internship Program (SRIP), is working on robot control algorithms for automating suturing of lacerated tissues. This problem can be formulated as a constrained optimization problem, where the goal is to optimize a robot's handling of a needle suture path while satisfying some constraints related to tissue deformity. More specifically, Junmin aims to estimate the dexterity of robot arms that are used to control and predict the deformation of the tissue during suturing.

Sensing and Control for Autonomous UAV Flight

Undergraduate students from Professor Nikolay Atanasov's lab designed a visual-inertial sensor made of two FLIR Chameleon 3 global-shutter cameras and one VectorNav VN-100 inertial measurement unit (IMU). The sensors were linked together with 3D printed parts and a circuit board designed by the students to deliver power and achieve synchronization between the cameras and the IMU, as well as communication with the on-board Intel NUC computer. After calibrating the sensors and attaching them to the drone, a visual-inertial odometry (VIO) algorithm responsible for estimating the position, orientation, and velocity of the robot was compiled on the on-board computer. Using the VIO state estimation, a geometric control algorithm was deployed to achieve stable autonomous hovering and trajectory tracking with minimal drift.

2022 SUMMER RESEARCH INTERNSHIP PROGRAM BY THE NUMBERS (SRIP)

77	38	39	129
Total Students	Undergraduate	Graduate	Total Projects
65 | Male 12 | Female	31 | Male 7 | Female	34 | Male 5 | Female	

AI Learning from Mistakes

Artificial intelligence (AI) systems are becoming more prevalent in helping humans in various applications by enhancing their speed and precision. Since these machines play a crucial role in our daily lives, they can raise some safety concerns and questions regarding their potential negative social impacts in the real-world mission-critical (e.g., disease diagnosis or medical imaging) and safety-critical (e.g., fully autonomous vehicles) applications. In the past few decades, Machine Learning (ML), as a subset of Artificial intelligence (AI), has received much attention due to its ability to automatically enable machines to learn new concepts from the given examples. Fortunately, these efforts in this area of research have achieved almost as close as human-level performances with encouraging results in various applications. However, traditional machine learning (ML) mainly relies on the manual designs of learning tasks, datasets, model architectures, optimization algorithms, and hyperparameters proposed by scientists. These techniques can be extremely time-consuming and, most of the time, are not the optimal or the most effective solutions. One way to tackle this issue is to treat these machine learning (ML) models like humans by borrowing humans' learning skills to assist these machines in learning more efficiently. Humans are one of the most intelligent learners with the ability to learn new tasks and adapt them to the unseen ones by utilizing different skills. One of these practical learning skills is Learning from Mistakes (LFM), where the learners focus more on the topics where mistakes were made to deepen their understanding. Four students (Bhanu Garg, Li Zhang, Pradyumna Sridhara, and Ramtin Hosseini) from the Electrical and Computer Engineering students Bhanu Garg, Li Zhang, Pradyumna Sridhara, and Ramtin Hosseini, under the supervision of Professor Pengtao Xie at the UC San Diego Jacobs School of Engineering, investigated whether this human learning skill can be used in machine learning by proposing a novel machine learning method called Learning From Mistakes (LFM), where the learner enhances its ability to learn by focusing more on the mistakes during modification. Prof. Xie and his students demonstrated that this learning technique (LFM) could be formulated as a three-level optimization problem: 1) learner learns; 2) learner re-learns focusing on the mistakes, and; 3) learner validates its learning. In their paper, they develop an efficient algorithm to solve this optimization 1 problem, and they apply it to Neural Architecture Search (NAS), which is a subset of AutoML, on various image classification tasks to demonstrate the effectiveness of their work. This work was published and presented at the Association for the Advancement of Artificial Intelligence (AAAI) 2022 conference.

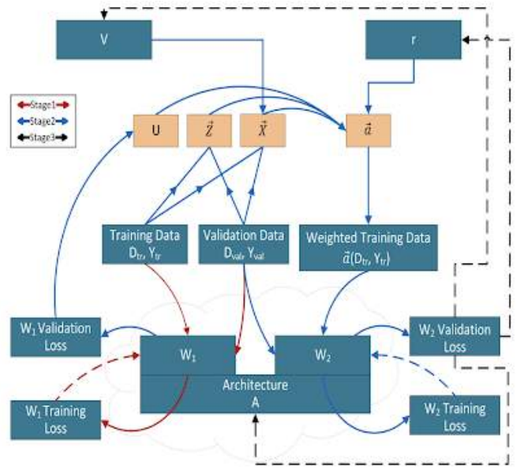
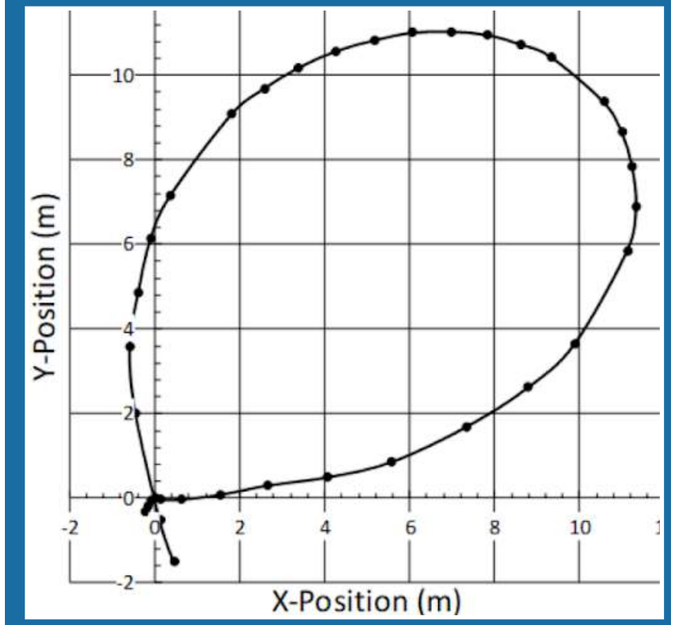


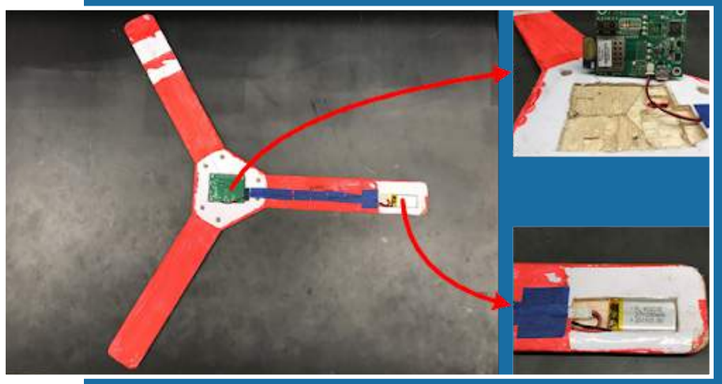
Figure 1: The overall process flow of our method when applying to NAS. The red arrows indicate stage 1 processes, blue arrows indicate stage 2 processes, and black arrows indicate stage 3 processes.

Flight Dynamics of Boomerangs

Professor Prasad Gudem's research group worked on methods to acquire real-world data of the three dimensional flight trajectory of a boomerang. Through the Summer Research Internship Program (SRIP), undergraduate ECE students Gino Carfano and Hector Murguia Gastelum, used an Ultra-Wide Band (UWB) wireless tracking system to accurately track the flight trajectory of a boomerang. UWB is a radio technology defined to have a signal bandwidth over 500MHz or at least 20% of its center frequency. In 2002, the FCC approved the unlicensed use of the 3.1 – 10.6GHz spectrum for deployment of UWB wireless technology with the critical specification of an emission limit of -41.3dBm/MHz (75nW/MHz). This limit was imposed to avoid interference with the current deployment of licensed radios. UWB technology offers several key advantages over cellular (2G/3G/4G/5G-FR1) and WiFi (802.11a/b/c) – greater immunity to multipath, superior penetration through materials, and tolerance to narrowband interference, etc. Moreover, unlike GPS which is limited to 10m level accuracy under "static" conditions, UWB systems are capable of achieving accuracy levels below 10 cm under "dynamic" conditions. The accuracy of UWB systems along with better penetration through materials such as wood and plastic make it the ideal choice for tracking boomerangs.

For the SRIP, a commercial UWB position location system by Decawave was used by the students to accurately track the position of the boomerang during flight. The tracking system consisted of 18 MDEK1001 modules, 16 of which were configured as anchors, one as a tag, and one as a listener. The setup of a UWB positioning system is very similar to that of GPS as both systems use trilateration to determine location. The anchors in a UWB system behave similarly to satellites in GPS. These devices are deployed in static known locations and create a region that can track a separate device, a tag. One tag and one small LiPo battery were embedded in small compartments in a boomerang and did not alter the boomerang's weight distribution. These small compartments built for the electronics were sealed to minimize the impact on the aerodynamics of the boomerang. The tag's position information was relayed to the listener device and captured on a PC. The measured data of the flight trajectory of the boomerang was obtained and used in the recently published AIAA paper titled, Flight Dynamics of Boomerangs: Impact of Drag Force and Drag Torque.





Learning Continuous Grasping Function with a Dexterous Hand from Human Demonstrations

Learning to perform the art of grasping with a multi-finger hand has been a long-standing problem in robotics. Using a dexterous hand instead of a parallel gripper offers the robot the flexibility on operating with daily life objects like humans do, but also largely increases the difficulty given the large Degree-of-Freedom of the dexterous hand.

Students from Professor Edward Wang's lab proposed to learn Continuous Grasping Function (CGF) with a dexterous robotic hand. To mimic the continuous human motion, they utilized human grasp trajectories from videos to provide demonstrations and supervision in training. By training CGF with generative modeling on large-scale human demonstrations, it allows generalization to grasp multiple objects with a real Allegro robot hand.

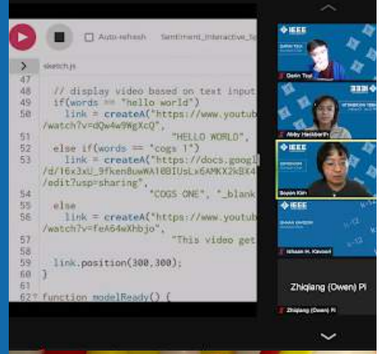
In their framework, given the 3D hand-object trajectories from human videos, the researchers first perform motion retargeting to convert the human hand motion to the robotic hand motion to obtain the robotic manipulation demonstrations. Then the CGF is learned via generative modeling with a Conditional Variational AutoEncoder (CVAE) by reconstructing the robotic hand motion with demonstrations.

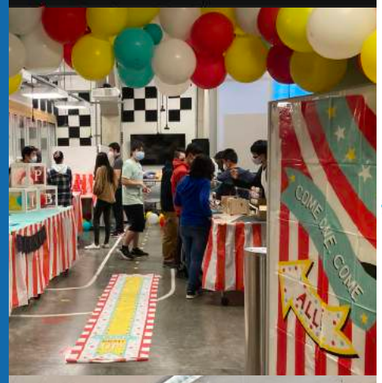
During testing, given a test object, the researchers first generate a large number of diverse, human-like grasping trajectories. Then these trajectories are executed in the simulator and the successful ones are deployed to the real world with an Allegro hand attached on an X-Arm 6 robot. Compared with previous works, the proposed method achieves better sim-to-real generalization with more natural and human-like motion, which leads to a better success rate.

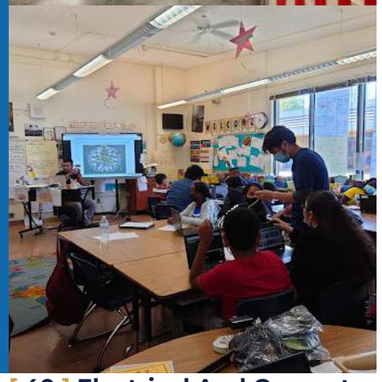
2022 ENGINEERING PSYCHIATRY RESEARCH PROGRAM BY THE NUMBERS (EPRP)

9	8	1	8
Total Students	Undergraduate	Graduate	Total Projects
6 | Male 3 | Female	7 | Male 1 | Female	1 | Female	

Student Organizations & Outreach







ECE Undergraduate Student Council (ECE USC)

The greatest ECE Undergraduate Student Council hosted event in 2021-2022 was the In-n-Out fueled social & Wheel Of Fortune Competition! It was organized to end the school year off with a fun bang as an ECE family, and to promote community building between the leaving and incoming organization officers.

Institute of Electrical and Electronics Engineers (IEEE)

A highlight of 2021-2022 for IEEE was their outreach efforts catered to middle and high school students. At their p5.js Workshop, they spent time making a sentiment detector based on text inputted. They even collaborated with PiB and CS Foreach to host two 3D Printing Workshops, where each middle or high school student had the opportunity to create a design of their choice. This included a keychain, coaster, dice, and more!

ECE Graduate Student Council (ECE GSC)

The ECE GSC hosted a suite of excellent events, including the ever popular coffee hours, Lunar New Years, Diwali, Eid, and the smash hit Trivia Nights! They have greatly expanded our career content as well, adding ECE 290 seminars for the whole year with both academic and industry speakers.

Project in a Box (PiB)

PiB's Virtual Outreach Program with the San Diego Public Library System was another success in 2021-2022, sending physical kits to participants, and holding monthly Zoom sessions where PiB tutors walked through building the kits and introductory STEM concepts with the participants. They also engaged with the UC San Diego community through the ECE Family Program, where they sent physical kits to alumni, staff, and faculty for their children to build and learn from. During the Spring Quarter, they collaborated with SHPE to host a workshop for 90 high school students at the Empower conference.

Eta Kappa Nu (HKN)

HKN led the ECE/CSE/MAE 198 classes for Winter and Spring Quarters in 2021-2022. These classes focused on developing lessons to teach the fundamentals of these branches of engineering and the parts of an RC Car. These lessons included: Intro to Engineering Design, Basics of Circuits, Bluetooth Communications, Intro to DSP, Finite Element Analysis, Intro to CAD, Gears and Motors, Embedded Programming, UI/UX Design, and Autonomous Driving. In the Spring quarter, they provided these lessons to students at Herbert Hoover High School, Liberty Charter High School, and Chollas Mead Elementary School.

Association for Computing Machinery (ACM)

In 2021-2022, ACM collaborated with Women in Computing to initiate individual projects for a group of 30 under-represented high school girls. They created a curriculum for those with little to no coding experience, and taught the students how to create a portfolio website and host it to a domain that they could use and be proud of. The project was structured such that iteration and personalization was encouraged, and those who wished to improve or expand the site could do so on their own.

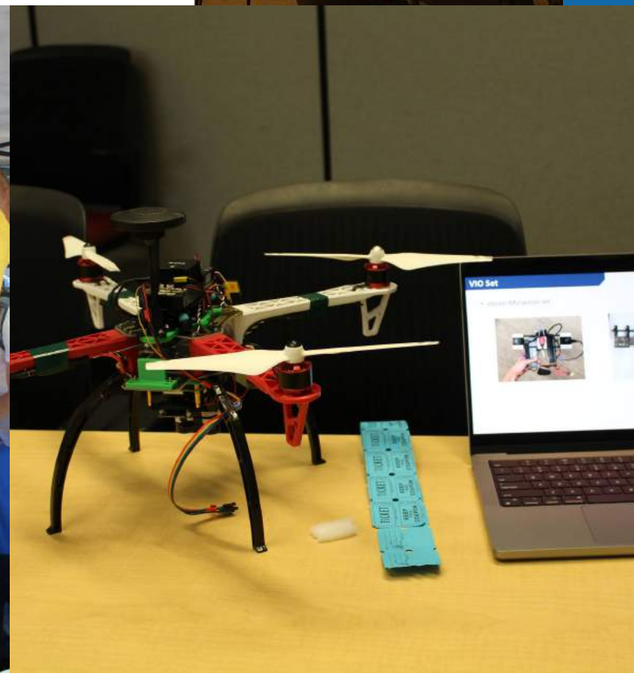
ECE Day 2022

Every year, the ECE Student Organizations host ECE Day, an event that was created to give both incoming and prospective ECE students a taste of what the Department of Electrical and Computer Engineering has to offer. This year marked the first ECE Day in-person since 2019. The success of ECE Day 2022 can be attributed to the hard work of ECE's Student Organizations: HKN, IEEE, Project in a Box, ECE Undergraduate Student Council, and ACM, paired with collaboration and support from the ECE Alumni Advisory Board.

ECE Day 2022 was packed to the brim with events. The day kickstarted with a showcase of Signal & Image Processing labs, and an interview with Professor Yatish Turakhia, giving his advice for the Computer Engineering major. In addition, HKN hosted a talk with ECE Alumni discussing the depth curriculum and navigating which depth is best for yourself.

Sprinkled throughout the day were technical workshops held by each of the student organizations ranging from hardware oriented tasks like Project in a Box's Robotics workshop, to ACM's software oriented workshop.

ECE Day concluded with the ECE Alumni Awards dinner and keynote speech delivered by UC San Diego ECE alumni Gioia Messinger, who shared her life story along with advice for the next generation of engineers. Her call to action- never hesitate on the opportunities, as success waits only for those who go out and take it.



ECE Awards

Booker Memorial Honors Award Winners

In the spirit of Dr. Henry G. Booker's educational philosophy, the department recognized the following students for their hard work, dedication and commitment to academics. Additionally, recipients maintained a GPA of 3.7 or above in all ECE courses.

Aditi Anand
Jonathan Barnes
Chase Bastian
Jon Bibat
Yotam Blum
Stuart Boynton
Krystal Chan
Spencer Chang
Amanda Le Chau
Bo-Ruei Chen
Sunny Chu
Alexander Dagman
Gourab Dastider
Maryam Dehaini
Andrew Fino
Nicholas Fries
Ya Gao
Maxime Ghesquiere
Nidhi Giridhar
Zijia Guo
Joseph Hsieh
Yichen Jiang
Krishna Karthik
Zihao Kong
Joseph Kubes
Joseph Langley
Alexander Lazaroiu
Calvin Lee
Darren Lee
Bohan Lei, Bohan
Yaret Leon
Mahmoud Maarouf
Zhe Mo
Shoh Mollenkamp
Nathan Nakamura
Alessandro Narelli
Tommy Nguyen
Kathryn Oleksak
Anthony Palazzolo
Olivier Rogers
Ahmad Said
Evan Serrano
Naiwen Shi
Ho Luen Siu
Rasya Soeroso
Isabel Suizo
William Sun
Justin Sun
Johnathan Tran
Abhishek Vasudevan
Lars Vlahakis
Yitian Wang
Yueqi Wang
Raini Wu
Gerald Xie
Jiawen Xu
Haoru Xue
Chengxiang Xue
Jeffrey Yang
Edward Yau
Cheng Ye
Fei Yin
Jianchang Yu
Qingyuan Zhang
Emily Zhuang
Xiaoye Zuo

Dr. William S.C. Chang Best Dissertation Award
Nancy Ronquillo

"Active and Dynamical Information Acquisition with Applications in Communication Systems"

Harry Wieder Electronic Materials Excellence Award
Chi-Hsin Huang

Best TA
Prasad Kamath - ECE 161B

Ilya Petrov - ECE 25

Tirthasarathi (Tirtha) Lodh - ECE 125B

Best Tutor
Girish Krishnan - ECE 25

Tanvir Hussain - ECE 5

Po Hsiang Huang - ECE 196

Best Undergrad Research Award
Cheng Ye

ECE Undergraduate Student Award for Excellence
Raini Wu

Undergraduate Student Service Awards
Sarp User
Branson Beihl
Joel Bisarra
Kyle Hu
Tim Jiang

Graduate Student Service Awards
Sriveena (Veena) Chittamuri
Saygin Artiran
Lulua Rakla
Manas Bedmutha
Xinyu Chen
Forrest Valdez

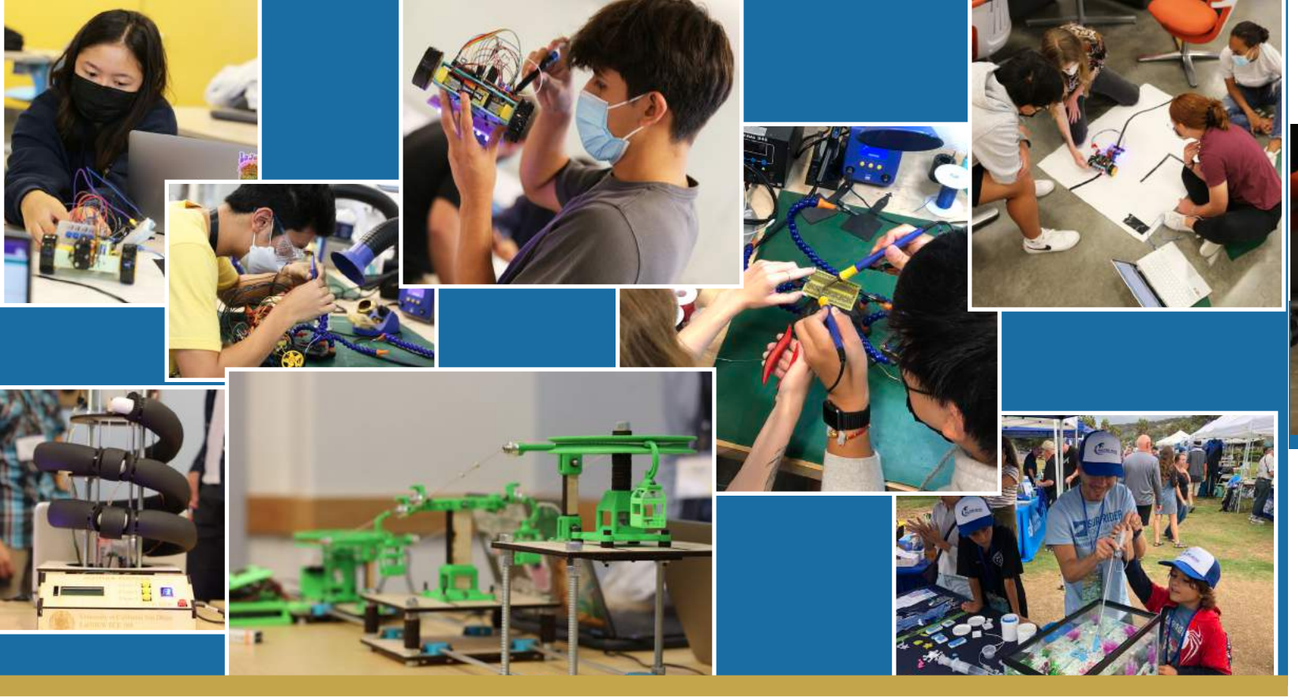
Alumni Service Awards
True Xiong '05

Mark Hayworth '81

Seyhan Karakulak
MS '07, PhD '10

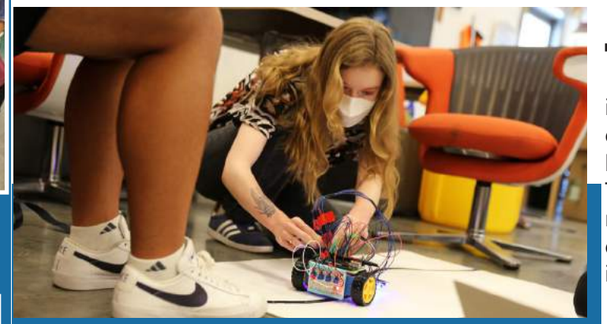
Best Teacher Award
Undergraduate:
Curt Schurgers

Graduate:
Bhaskar Rao



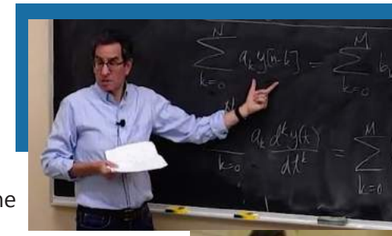
TEACHING & LEARNING INNOVATIONS

Teaching and Learning Innovations

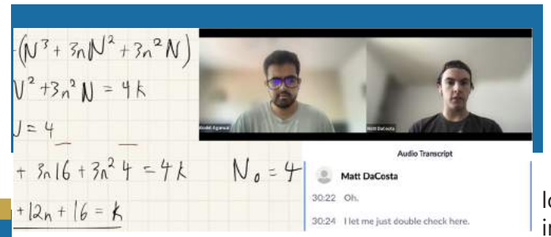


To support students in their learning, instructors throughout the ECE department have continued to integrate innovative approaches into their classes. A key component of these approaches is the idea of active learning, a topic that is well-studied in the Scholarship of Teaching and Learning (SoTL). It emphasizes that we learn more effectively by actively processing and applying new concepts, rather than being mere passive recipients of the information.

Flipped Classroom



One approach to integrating active learning into traditional lecture-style classes is to take the focus away from the teacher and put it back on the student, in what is called "flipping the classroom." In a flipped classroom, students acquire the basic information in advance rather than in lecture as is done traditionally. This can be done, for example, through self-paced video lectures. As a result, the instructor can now dedicate their lecture time to guiding students toward higher levels of understanding through interactive exercises, group discussions, or hands-on work. Several key undergraduate courses have been transformed into this model, such as ECE35, ECE65, ECE15, ECE16 and ECE101.



Pedagogical Innovations

In addition to integrating established pedagogical techniques, ECE faculty are also researching new approaches to improve the learning process for our students. One of our studies looks at oral exams, where students meet one-on-one with the instructional team to verbally explain their thought process and the fundamental concepts underlying their solution strategies. These oral exams have been integrated into several courses such as ECE35, ECE65, ECE101 and ECE144 to complement traditional written exams. In another study, students are asked to design exam questions themselves. The aim of this idea, which has been pioneered in ECE101, is that students deepen their learning by thinking about how their questions assess the learning outcomes for the course.

Project-Based Learning

Complementing our strong theoretically driven coursework, hands-on courses in the ECE curriculum offer project-based learning (PBL) opportunities, where students build systems-level projects that require technical skills, teamwork, and resiliency. Many of these "learning-by-doing" courses are housed in the ECE Makerspace or in the Envision Arts and Engineering Maker Studio. For example, the required introductory course ECE5 exposes freshmen to basics of electrical engineering through a series of short projects, also giving them insight into what ECE has to offer. Subsequent courses such as ECE16, ECE111, ECE115, ECE140A/B, ECE144, ECE148 and ECE260C take a project-based approach to topics such as embedded systems, digital design, rapid prototyping, product engineering, LabVIEW programming, autonomous vehicles and advanced VLSI design. Additionally, in group design courses, such as ECE191 and ECE196, students focus on teamwork and hone their broader engineering skills.

ECE's Summer Internship Prep Program

Hands-on learning also forms the bedrock of the ECE Summer Internship Prep Program (SIPP) for incoming ECE freshmen and transfer students. This program, which has been running for three straight years, prepares students for the academic year, with a specific focus to help them in their quest to obtain meaningful internships in academia and industry afterwards. To this end, ECE tutors guide SIPP students through technical topics such as python, circuits, 3D modeling and PCB design, all leading up to final projects that boost their resume. The program also helps the students develop professionally through networking, improving resumes and portfolios, presentations and participating in mock interviews. Additionally, SIPP students are introduced to ECE student orgs, alumni, and campus resources covering the many needs and diverse pathways towards internships and job opportunities.

Teaching Innovations Committee

To continue to drive our pedagogical mission forward, the ECE department established a new Teaching Innovations Committee in Fall Quarter 2021. This committee has three main goals: 1) serve the department as a resource for educational innovation and improvement; 2) facilitate department-wide embrace of new instructional materials and modalities; and 3) contribute to the evolution of a tightly integrated undergraduate curriculum.

In support of the first two goals, a quarterly Teaching Innovations (Teach-In) Seminar Series for faculty was launched as a forum for faculty members to share their teaching experiences and insights. The inaugural series included the following interactive lectures:

- Alternative Assessment Methods, by Prof. Saharnaz Baghdadchi (Fall 2021)
- Why would you consider "flipping" your class and how to get started?, by Prof. Curt Schurgers (Winter 2022)
- Feedback Control for Teachers: How to use surveys to improve your teaching and your students' learning experience, by Prof. Karcher Morris (Spring 2022)

The committee is also developing an enhanced online ECE Course Curriculum Map, intended to help students visualize course content, course dependencies, and curricular pathways. In addition, this map development will guide our ongoing efforts in improving curriculum continuity and integration.

ECE AMP
Alumni Mentorship Program

Learn more about ECE AMP and get involved: ece-amp.ucsd.edu

ECE's Alumni Mentorship Program was another success in its second year. The six month program paired a current ECE student with an ECE Alumni who shares similar interests, both in academics and research as well as personal interests and hobbies. In addition to two recommended mentor-mentee meetings a month, the whole group of participants met for one or two additional group activities each month, including social events, discussions, or guest speaker sessions. For its second year, participation was sky-high. "We increased our student participation by over 35%," said Program Director, Hamna Khan '18. "We even opened up our application to masters students who were eager to get involved with AMP." 150 students and 100 alumni participated in 2022.

Khan, an Electrical Engineering alumna who now works for the Under Secretary of Defense for Research and Engineering as a Technology and National Security Fellow, was the president of the ECE Alumni Advisory Board from 2019-2021. Students and alumni filled out a long list of questions in the application process designed to ensure the mentors and mentees had enough interests in common to have meaningful conversations—from technical interests to personal hobbies, to larger topics such as climate change, social justice, intellectual property, or space, to areas where the students felt they needed support in and areas the alumni felt they could offer their support.

The theme for Fall quarter's meetings was preparing for job interviews—how to polish LinkedIn profiles, resumes, conducting mock interviews and helping students develop the confidence to apply for roles they're interested in. Themes for Winter and Spring quarters focused on bringing alumni together in panel-style discussions, covering topics like compensation, negotiating, and navigating work opportunities. The program ended with an all-group picnic at the Kate Sessions Park in May.

The overwhelming enthusiasm for ECE AMP ensures this program will return in the 2022-2023 school year in a hybrid format where alumni will have the option to serve as mentors either physically in San Diego County, or virtually. Returning mentors and mentees are welcome to reapply each year, being matched with a new partner, and new participants are always welcome. "It's been great to see how many alumni are participating in this that have never gotten involved before—so many new faces," said Khan. "A couple were also interested in the Alumni Advisory Board and I love that we're getting more people to understand that we're here to help everyone and build a stronger ECE community."

2022 ECE Distinguished Alumni Award

Dr. Hossein Eslambolchi is the Chairman and CEO of 2020 Venture Partners founded in 2006, and currently serves as full Venture Partner for Cloudscale Capital Partners in Silicon Valley, investing in cloud-based technologies and its ecosystem to new wireless systems operations. Additionally, Dr. Eslambolchi provides consulting services to Private Equity Firms and enterprise companies in the areas of telecommunications & software infrastructure, network intelligence- including Artificial Intelligence, Machine Learning, and Deep Learningsp- and is one of the top 100 LinkedIn influencers with articles and posts on innovative areas of interest in the entire industry. Dr. Eslambolchi is recognized in the scientific community as one of the most thought leaders and technological scientists of the 21st century and is often compared by a significant number of industry experts for his business and technical accomplishments and future vision to leaders for strong End-To-End transformational leadership skills. A quintessential communications visionary, Dr. Eslambolchi champions the creation and delivery of pragmatic state-of-the-art transformational business strategies for both wireless and wireline communications. As AT&T's Chief Transformation Officer, he developed and executed in the brief space of fewer than three years a comprehensive four-stage strategy that included Enterprise Customer Service, Network Transformation, Services, and Cultural Transformation; essentially, the major overhaul and re-engineering and modeling of the AT&T communications that SBC dubbed the 'new' AT&T after the merger in 2005. Dr. Eslambolchi is known in the scientific community as the foremost thought leader on IP based technology and wireless including design, architecture, system engineering and led the major responsibility to manage and operate the largest IP & wireless network in the world connected to edge network consisting of several technologies based on topology and customer & market requirements. His area of leadership includes wireless technology (3G, 4G, 5G, 6G), including the significant number of WIFI-based technologies, innovation, and patents for completion of edge-based distributed networks, especially for East-west traffic using cloud-based architecture. Dr. Eslambolchi's (Applied Physics) thesis on beam steering is now the foundation of new 5G wireless networks alongside a significant number of applications using ultrasound in the medical and healthcare business to detect human organ anomalies to prevent problematic solutions for patients worldwide.

Awards and Patents

- Ellis Island Medal of Honor – May 2017
- Appointed an AT&T Fellow, AT&T's highest technical honor, in 1999.
- Won AT&T science and technology medal in 1997
- Won ATT significant Patent award in 1997.
- Named "Inventor of the Year" by the R&D New Jersey Inventors Hall of Fame in 2002 and 2013. Only Thomas Alva Edison and Albert Einstein were so honored.
- "Top 25 Most Influential CTOs of 2005" (InfoWorld); honored by Cisco IQ Magazine as "One of its 10 Internet Business Leaders (2003);
- One of the Premier 100 IT Leaders for 2004 (Computerworld Magazine); "Number 1 'mover and shaker' in telecommunications, (2003) (Light Reading).
- Finalist for President's science and technology award in 2005.
- Published a book called, 2020 Vision, and made a significant number of 'Keynote' speeches to business, scientific and technology-focused audiences.
- Light Reading Number 1 and Mover/ Shaker in the world (2003)
- Business Week Pragmatic and visionary award, 2005
- New York Times Exceptional artist for transforming ATT from Legacy-based network to IP-based network and services (2005)

True Triton Award

Hamna Khan '18 graduated from UC San Diego (Warren College) with a bachelor's degree in Electrical Engineering. She currently works as a Technology and National Security Fellow for the Office of the Under Secretary of Defense for Research and Engineering in Washington D.C.

From 2019-2021, Hamna served as the President of the Electrical and Computer Engineering (ECE) Alumni Advisory Board, where she developed the ECE Alumni Mentorship Program. Since its launch, the ECE program has helped to connect current students with more than 200 alumni. Hamna's involvement with the Graduates of the Last Decade (GOLD) Steering Committee began at its inception in 2019, where she works as a volunteer to build a stronger alumni community with recent graduates. In addition, Hamna regularly gives her time to assist students and alumni alike, and plans to continue her service to the UC San Diego community for years to come.

Alumni Service Awards 2022

Mark Hayworth BS '81

Mark Hayworth received his BS in Engineering Physics with Specialization in Optics from UC San Diego in 1981. After going on to earn his Ph.D. in Optical Sciences from the University of Arizona in 1988, Mark joined R&D in The Procter & Gamble Company where he still works today. He is a Senior Scientist and Inventor in one of the world's 10 largest industrial corporations doing image analysis full time. He is still actively using the knowledge and skills he learned at UC San Diego. He specializes in imaging, image processing, and custom image analysis programming and algorithm development. He has experience designing custom light booths and other imaging systems. He has experience with color and monochrome imaging, video analysis, thermal, ultraviolet, hyperspectral, CT, MRI, radiography, profilometry, microscopy, NIR and Raman spectroscopy, etc. on a huge variety of subjects. His image analysis systems are crucial in the development of consumer products improving the lives of billions of consumers worldwide, such as Tide, Cascade, Pampers, Gillette, Bounty, Swiffer, Pantene, Dawn, etc.

Mark has been part of the Alumni Mentorship Program at UC San Diego for two years and mentors two ECE students (one undergrad and one grad student). He has become friends with his students and continues monthly meetings with them even after the school year ends.

Seyhan Karakulak MS '07, PhD '10

Seyhan Karakulak received her Ph.D. and M.S. degrees in Electrical Engineering in 2010 and 2007 from UC San Diego. She graduated from Istanbul Technical University in 2003 and 2004 with two bachelor's degrees in Electronics and Communications Engineering and in Mathematics. She has over 15 years of cumulative industry and research experience in the areas of system architecture for solid state storage devices, data science, machine learning, statistical learning, information theory, communication theory, error correction coding, and signal processing.

She served as ECE Alumni Advisory Board member between from 2015-2018. She has been mentoring in the ECE AMP program and mentored in the Jacobs Undergraduate Mentoring program in the past. She is passionate about supporting historically underrepresented students in STEM.

True Xiong MS '05

A 2019 UC San Diego Alumni Changemaker Award recipient, True was recognized for his continued work to ensure that younger generations thrive in science, technology, engineering, and mathematics (STEM) fields. True holds a Master's degree and is finishing a doctorate; he is a strong proponent of education and equality. He has proven himself a Changemaker by actively promoting STEM careers to under served students on campus and in his community. True established the STEMUplift Foundation to provide scholarship opportunities for underrepresented students. He serves as a volunteer, advisor, and partner with local, state, and national events and organizations such as the Greater San Diego Science and Engineering Fair, San Diego Festival of Science & Engineering, San Diego Women Hackathon, California Science & Engineering Fair, and Society for Science to advance STEM education and opportunities. He regularly gives back to UC San Diego, which has given him much through time and treasure as a speaker, volunteer, judge, mentor, advisor, and donor.

True is a Sony PlayStation engineering manager and a prolific inventor with over 100 patents. Some of his patented work have been demoed at the Las Vegas Consumer Electronics Show (CES) and Sony Tokyo Science Fair, and featured on "USA Today", "PC Magazine", "Ubergizmo", "The Verge", "DigitalTrends", "Mashable", "Gizmodo", "Trusted Reviews", "International Business Times", "Tech Spot", "Irish Examiner", "What A Future", etc. During his time at Sony, he has worked on an array of electronic products and services, including networked digital television, blu-ray, audio devices, VAIO laptop, cameras, PS4, and PS5. He enjoys hosting field trips at Sony for students from UC San Diego COSMOS on STEM careers.

In Memoriam

Professor Alexander Vardy
[1963-2022]

Professor Alexander Vardy, a pioneer in the theory and practice of channel coding, passed away on March 11, 2022, at the age of 58.

Professor Vardy's ground-breaking contributions ranged from unexpected solutions of long-standing theoretical conjectures to ingenious decoding algorithms that broke seemingly insurmountable barriers to code performance. Inspired not just by the mathematical beauty of coding theory but also by its engineering utility, Professor Vardy developed novel coding techniques that had a profound impact on modern information technology. At the same time, his innovations left their imprint on other scientific disciplines, such as information theory, computer science, and discrete mathematics.

Professor Vardy joined the faculty at UC San Diego in 1998. He held joint appointments in the Department of Electrical and Computer Engineering, the Department of Computer Science, and the Department of Mathematics. He was affiliated with three UC San Diego research centers: the Center for Memory and Recording Research (CMRR), the Center for Wireless Communications (CWC), and the Qualcomm Institute/California Institute for Telecommunications and Information Technology (QI/Calit2). In 2013, Professor Vardy was named the inaugural holder of the Jack Keil Wolf Endowed Chair in Electrical Engineering.

Professor Vardy received numerous awards for his scholarship. He was co-recipient with Ralf Koetter of the 2004 IEEE Information Theory Society Paper. He shared the Best Paper Award at the 2005 IEEE Symposium on Foundations of Computer Science (FOCS) with his student Farzad Parvaresh. In 2017, he was co-recipient with Ido Tal of the IEEE Communications Society & Information Theory Society Joint Paper Award for their 2015 paper "List Decoding of Polar Codes." This paper forms the basis for Tal and Professor Vardy's patented algorithm on list decoding of CRC-aided polar codes which plays a key role in the 5G New Radio standard. With his student Hanwen Yao and post-doc Arman Fazeli, Professor Vardy shared the 2021 IEEE Jack Keil Wolf ISIT Student Paper Award.

Professor Vardy was active in professional service. He was elected to the Board of Governors of the IEEE Information Theory Society five times. He was appointed to several positions on the editorial board of the IEEE Transactions on Information Theory, including Associate Editor for Coding Theory, Editor-in-Chief, and Executive Editorial Board member. He was Guest Editor of a special issue on "Codes and Complexity." He also served as an Editor for the SIAM Journal on Discrete Mathematics.

Professor Vardy was named a Fellow of the IEEE in 1999 for "contributions to the theory and practice of channel coding." He became a Fellow of the ACM in 2017 for "contributions to the theory and practice of error-correcting codes and their study in complexity theory."

UC San Diego

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