2023-2024
ELECTRICAL AND COMPUTING ENGINEERING

UC San Diego

JACOBS SCHOOL OF ENGINEERING
Electrical and Computer Engineering

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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

#12

The UC San Diego Jacobs School of Engineering has ranked #12 in the nation in the influential U.S. News & World Report Rankings of Best Engineering Schools

ECE BY THE NUMBERS

65 Faculty	**1,350** Undergraduate Students
945 Graduate Students 624 | MS Students 321 | PhD Students	**355** Incoming Graduate Students 293 | MS Students 62 | PhD Students
17,000+ Alumni	**$38.3M** Research Expenditures
#10 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

Nikolay Atanasov

Early Academic Career Award in Robotics and Automation

The award from the IEEE Robotics and Automation Society recognizes outstanding academics who have made identifiable contributions that have had a major impact on the robotics and/or automation fields. Prof. Atanasov's award is in recognition for his contributions to the advancement of autonomous navigation, simultaneous localization and mapping, and active robot perception.

Shaya Fainman

Nick Holonyak Jr. Award Winner by Optica

The award from Optica recognizes significant contributions to optics based on semiconductor-based optical devices and materials, including basic science and technological applications. Prof. Fainman's award is in honor of his pioneering work on nanoscale science and engineering of ultra-small, sub-micrometer semiconductor light emitters and nano-lasers for information processing systems applications.

Tara Javidi

Schmidt AI in Science Postdoctoral Fellowship Program Award

Schmidt Futures Announces UC San Diego as Partner of $148M Initiative Accelerating AI Use in Science, led by Tara Javidi as the Principal Investigator, UC San Diego joins nine leading universities across the U.S., Canada, the United Kingdom and Singapore to launch the next frontier of scientific discovery through AI use in postdoctoral research.

Mingu Kang

Intel Rising Star Award

This award is in recognition of Prof. Kang's research in energy- and latency-efficient integrated circuits, architectures, and systems for machine learning and various signal processing algorithms by leveraging non-von Neumann approaches, including in-memory computing, in-sensor computing, and neuromorphic computing with both CMOS and emerging devices.

Farinaz Koushanfar

ACM Fellow

For Prof. Koushanfar's highly influential contributions in the areas of secure computing and privacy-preserving machine learning. The ACM Fellows program recognizes the top 1% of ACM Members for their outstanding accomplishments in computing and information technology and outstanding service to ACM and the larger computing community.

Yu-Hwa Lo

National Academy of Inventors

Prof. Lo has been elected into the National Academy of Inventors for his work as a leading researcher in the fields of biomedical electronic and optical devices, and nanoscale semiconductor devices. His research has led to the invention of the first bench-top microfluidic fluorescence-activated-cell-sorter, the invention of direct water fusion, and the invention of semiconductor single-photon detectors.

Florian Meyer

DARPA Young Faculty Award

"Active Planning for Geoacoustic Inversion"

The award aims to identify and engage rising stars in junior research positions, emphasizing those without prior DARPA funding, and expose them to DoD needs and DARPA's program development process. Prof. Meyer's research aims to characterize the undersea environment in shallow water based on inexpensive autonomous acoustic sensing systems.

Tina Ng

IEEE Sensors Council Distinguished Lecturer

Prof. Ng has been appointed as a Distinguished Lecturer (DL) of the IEEE Sensors Council DL Program for the period 2023-2025, based on her stellar reputation and experience in the sensors community. The goal of the program is to promote the field of sensors to the broad engineering and scientific community, and the public at large, by providing lecturers who are accomplished and eminent scholars in the field.

Jorge Poveda

Donald P. Eckman Award

The award from the American Automatic Control Council recognizes outstanding young engineers under 35 years old in the field of automatic control. Prof. Poveda's award is in recognition for his outstanding contributions to control and real-time optimization of hybrid dynamical systems, including model-free and extremum seeking control, adaptive feedback optimization, and networked decision-making.

Curt Schurgers

Academic Senate Distinguished Teaching Award

The Distinguished Teaching Award was created because UC San Diego faculty recognize the important role excellent teaching plays at the University. This Award is a tangible expression of UC San Diego's commitment to excellence in teaching and to ensuring that this commitment is maintained. Prof. Schurger's award is in recognition of the impact that he has made on the lives of our students and the culture of our campus.

Yang Zheng

Best Paper Award, IEEE Transactions on Control of Network Systems

"Sparsity Invariance for Convex Design of Distributed Controllers"

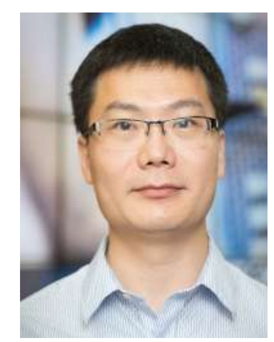
The award recognizes outstanding papers published in the IEEE Transactions on Control of Network Systems. Prof. Zheng's paper addresses the important control problem of designing optimal linear time-invariant (LTI) sparse controllers, which corresponds to minimizing a norm of a closed-loop system subjected to sparsity constraints.

Xiaolong Wang

NSF CAREER Award

"4D Human-Object Interaction Understanding in the Wild"

The research aims to build an artificial perception system that goes beyond 2D visual understanding and focuses on parsing the dynamics and 3D structure of the human-object interaction videos. To allow real-world applications, the system for understanding 4D (3D + time) human-object interaction is designed to generalize to unconstrained environments in normal daily lives, and in the wild.



Xinyu Zhang

ACM SIGMOBILE Rockstar Award

This early career award recognizes an individual who has made outstanding contributions to the field of mobile computing during the early part of that person's career. Prof. Zhang's award is in recognition for his significant contributions to wireless networking and wireless sensing, especially millimeter-wave network systems and new sensing modalities, driven by novel computational models and hardware platforms.

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.

$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."

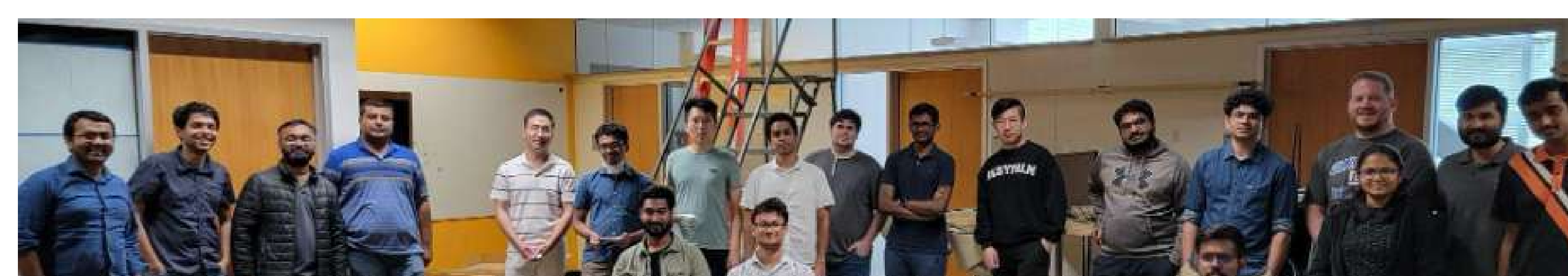
The goal of the project is to develop smart radio systems to detect and characterize suspicious radiofrequency signals, or RF anomalies, in complex RF environments. These RF anomalies include:

- 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.

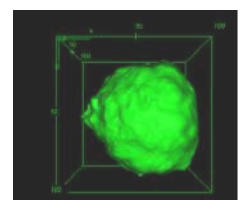


BIOLOGICAL CELL ANALYSIS

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.

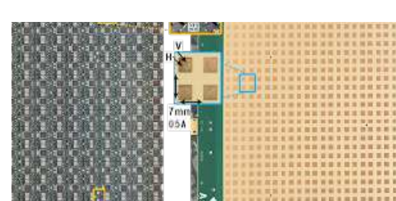
The biomedical device and system group, led by Professor Yuhwa Lo, has pioneered the research, development, and technology transition in next generation biological cell analysis and processing tools that are critical to medicine. Supported by several NIH grants and through close collaborations with the 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.



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.

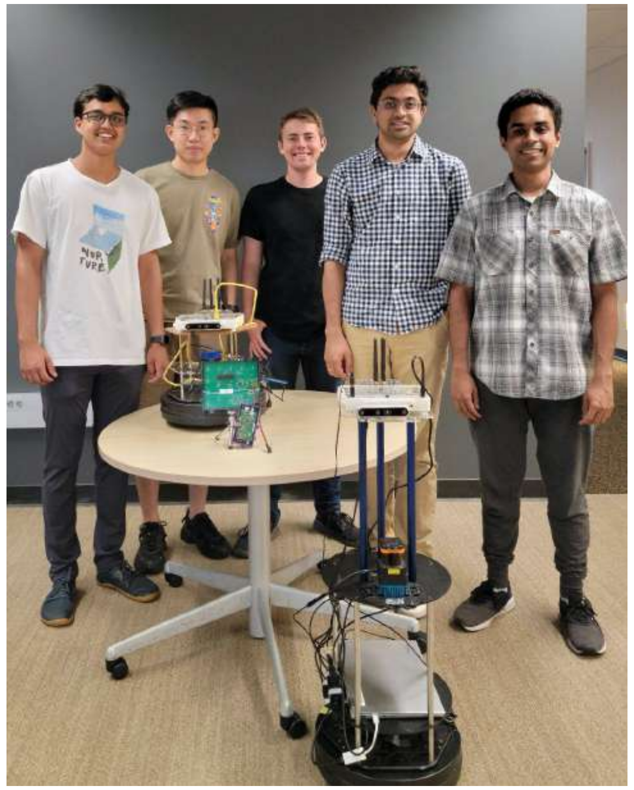
USING EVERYDAY WIFI TO HELP ROBOTS SEE AND NAVIGATE BETTER INDOORS

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.

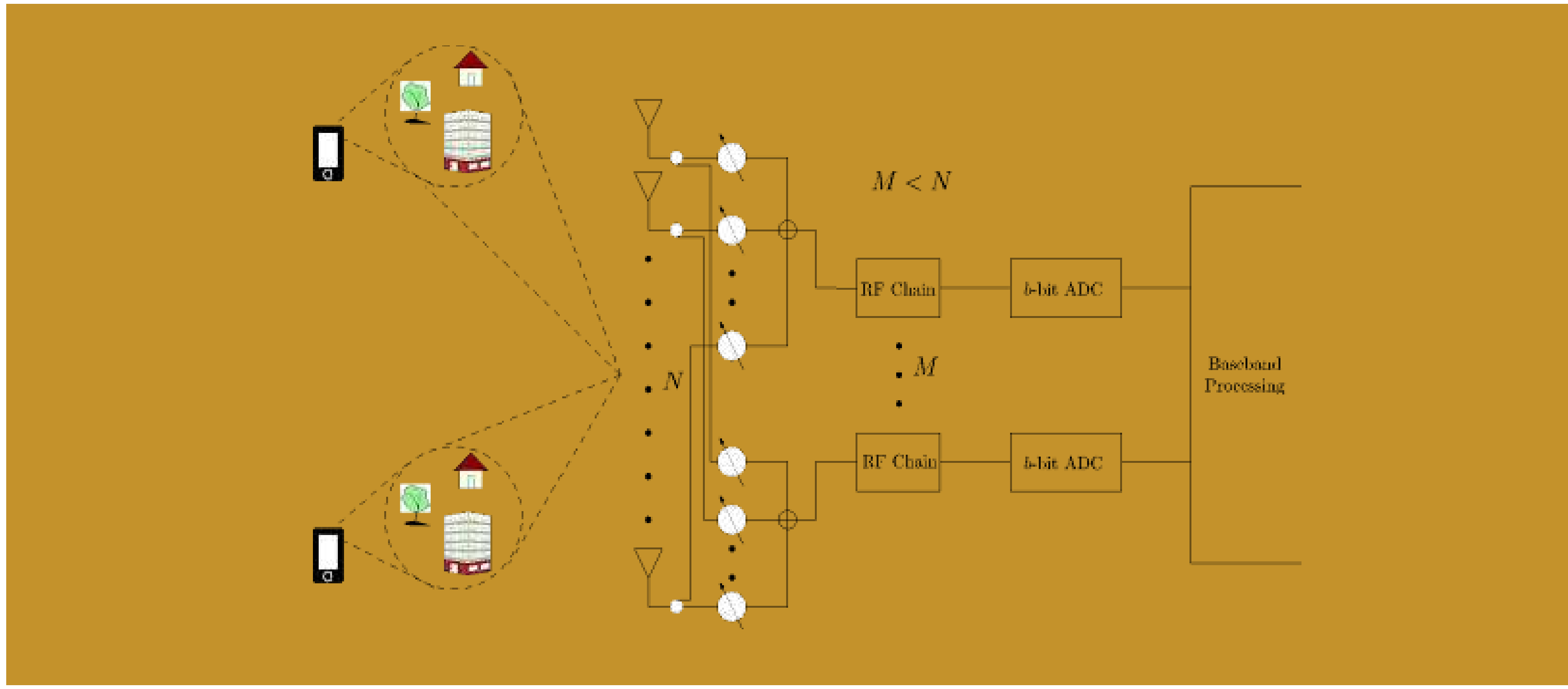
A team of researchers from the Wireless Communication Sensing and Networking Group, led by UC San Diego Electrical and Computer Engineering Professor Dinesh Bharadia, presented their work at the 2022 International Conference on Robotics and Automation (ICRA), a top-tier robotics conference. The team 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.



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).



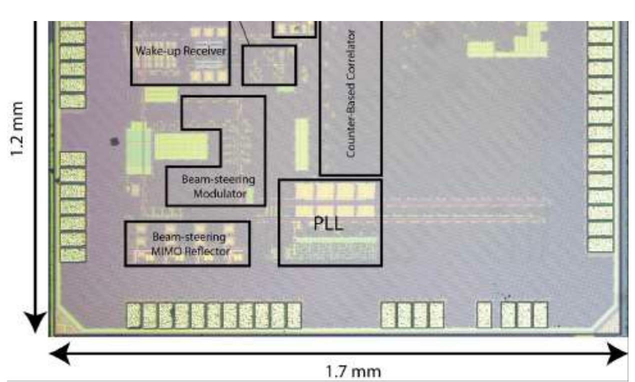
BEAM-STEERING AMBIENT WIFI AND BLUETOOTH SIGNALS FOR ULTRA-LOW-POWER IOT DEVICES

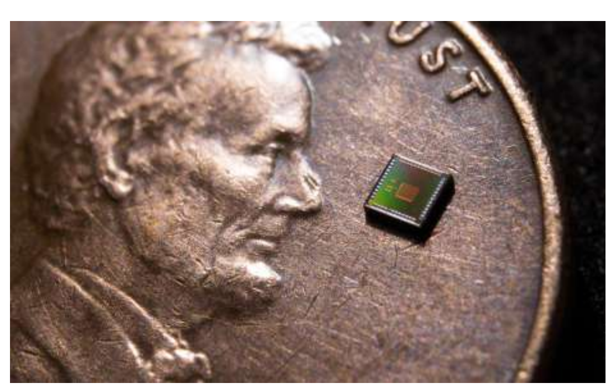
Wireless security cameras, wearable devices, pet health tracking systems, wireless earbuds, augmented reality glasses, and more, are all starting to take hold in today's marketplace. However, there is a major problem faced by many of these Internet of Things (IoT) applications: power consumption. Most 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.





COGNITIVE TESTING FOR ALZHEIMER'S DISEASE USING MOBILE SMARTPHONE PUPILLOMETRY

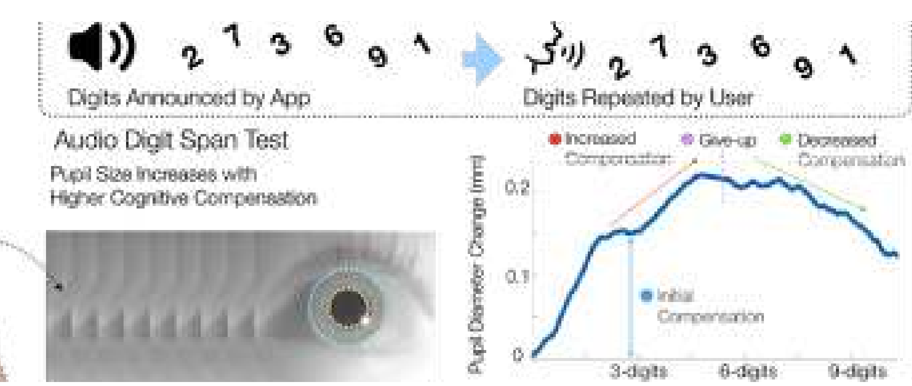
Researchers at the UC San Diego Digital Health Technologies (DigiHealth) Lab, led by Professor Edward Jay Wang, have developed a smartphone app that could allow people to screen for Alzheimer's disease, ADHD and other neurological diseases and disorders—by recording closeups of their eye. The app uses 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 Institute 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.

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



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.

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'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. 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 and 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 was awarded the ECE Best Undergraduate Research Award 2022 for his work. The manuscript describing this work published in the Bioinformatics journal. A public version of the aforementioned SARS-CoV-2 phylogenetically tree has been made publically available. More recently, Ye and Kyle Smith, another undergraduate researcher at Turakhia's lab, also contributed to a large-scale study on SARS-CoV-2 recombination that was published in the Nature journal.

SELF-POWERED SMART PILLS FOR REAL-TIME MONITORING OF GASTROINTESTINAL METABOLITES

ECE and Nanoengineering researchers led by ECE Professor Patrick Mercier have developed a battery-free, pill-shaped ingestible biosensing system designed to provide continuous monitoring in the gastrointestinal (GI) environment. The ingestible, biofuel-driven sensor facilitates in-situ access to the small intestine, making metabolite monitoring easier while generating continuous results. These measurements provide a critical component of tracking overall gastrointestinal health, a major factor in studying nutrition, diagnosing and treating various diseases, preventing obesity, and more.

Conventional access to the gastrointestinal system is extremely limited – in-vivo measurements typically require an endoscopy, which is an invasive procedure that involves placing a tube down the throat of a subject under general anesthesia. Importantly, endoscopies can only take spot measurements at one instance in time, limiting their utility to study, understand, and diagnos dynamic conditions in the gut. In contrast, the developed smart pill is swallowable, and travels through the GI tract over a period of many hours, giving the opportunity to deliver, for the first time, continuous, real-time metabolic data. Instead of a battery, this smart pill is powered by a non-toxic biofuel cell that runs on glucose naturally present in the GI tract. Power from the biofuel cell is used to operate a custom millimeter-sized integrated circuit, and the actual power extracted is measured and digitized as a way to sense glucose concentration information. This so-called "self-powered sensing" concept is compact and efficient – perfect for smart-pill applications. To avoid the use of bulky passives for DC-DC power conversion, the integrated circuit is optimized to run directly at the ~0.3-0.4V biofuel cell voltage, including an on-chip magnetic human body wireless communication transmitter that can deliver sensed information across the body at ultra-low-power levels.

The research team performed in-vivo experiments in farm pig subjects, demonstrating real-time metabolic monitoring in the GI tract. The team aims to augment capabilities to provide additional sensors and smaller overall size in future work towards unlocking new knowledge in the amazing microbiome of the human body. This work was published in Nature Communications, and was supported by the UCSD Center for Wearable Sensors.

ELECTRO-OPTIC MODULATORS

ECE Professor Shayan Mookherjea and Integrated Photonics lab researchers have recently published reports on electro-optic modulators with very high bandwidth and low driving voltage. The 3-dB modulation bandwidths are greater than 100 GHz with half-wave voltages as low as 2-3 Volts at 1310 nm and 1550 nm, and 1 Volt at around 800 nm, and far outperform what is possible using conventional silicon photonics, including optical power handling capability, which can exceed 100 mW. Potential applications include high-bandwidth optical communications, RF photonics and analog signal processing, as well as distributed quantum sensing and computing networks.

These high-performance modulators were integrated as part of a larger silicon photonic integrated circuit (PIC) which includes other photonic components such as bends, splitters, resonators, filters, and nonlinear optical devices. These devices consist of passive silicon or silicon nitride waveguides and a bonded film of thin-film lithium niobate (TFLN). In contrast to other approaches, the TFLN film is not etched, diced or damaged, and is incorporated by room-temperature bonding and low-temperature annealing, using steps that were creatively developed and improved at UCSD's Nano3 cleanroom by the team, especially Dr. Viphretuo Mere, a post-doctoral scholar. The team gratefully acknowledges numerous collaborations with industrial companies and government labs over the past decade, including SRICO, Sandia National Labs, JPL, Keysight, and others. This work was funded by NSF, DARPA, NASA, Sandia, the U.S. Government, and industry.

SUPER LOW-COST SMARTPHONE ATTACHMENT BRINGS BLOOD PRESSURE MONITORING TO YOUR FINGERTIPS

The Digihealth Lab led by Professor Edward Wang developed a simple, low-cost clip that uses a smartphone's camera and flash to monitor blood pressure at the user's fingertip. The clip works with a custom smartphone app and currently costs about 80 cents to make. The researchers estimate that the cost could be as low as 10 cents apiece when manufactured at scale. The technology was published May 29 in Scientific Reports.

The team say it could help make regular blood pressure monitoring easy, affordable and accessible to people in resource-poor communities. It could benefit older adults and pregnant women, for example, in managing conditions such as hypertension. "We've created an inexpensive solution to lower the barrier to blood pressure monitoring," said study first author Yinan (Tom) Xuan, an electrical and computer engineering Ph.D. student at UC San Diego.

"Because of their low cost, these clips could be handed out to anyone who needs them but cannot go to a clinic regularly," said Professor Wang. "A blood pressure monitoring clip could be given to you at your checkup, much like how you get a pack of floss and toothbrush at your dental visit."

Another key advantage of the clip is that it does not need to be calibrated to a cuff. "This is what distinguishes our device from other blood pressure monitors," said Wang. Other cuffless systems being developed for smartwatches and smartphones, he explained, require obtaining a separate set of measurements with a cuff so that their models can be tuned to fit these measurements.

"Our is a calibration-free system, meaning you can just use our device without touching another blood pressure monitor to get a trustworthy blood pressure reading."

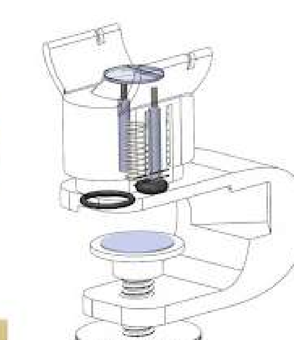
To measure blood pressure, the user simply presses on the clip with a fingertip. A custom smartphone app guides the user on how hard and long to press during the measurement. The clip is a 3D-printed plastic attachment that fits over a smartphone's camera and flash. It features an optical design similar to that of a pinhole camera. When the user presses on the clip, the smartphone's flash lights up the fingertip. That light is then projected through a pinhole-sized channel to the camera as an image of a red circle. A spring inside the clip allows the user to press with different levels of force. The harder the user presses, the bigger the red circle appears on the camera.

The smartphone app extracts two main pieces of information from the red circle. By looking at the size of the circle, the app can measure the amount of pressure that the user's fingertip applies. And by looking at the brightness of the circle, the app can measure the volume of blood going in and out of the fingertip. An algorithm converts this information into systolic and diastolic blood pressure readings.

The researchers tested the clip on 24 volunteers from the UC San Diego Medical Center. Results were comparable to those taken by a blood pressure cuff.

"Using a standard blood pressure cuff can be awkward to put on correctly, and this solution has the potential to make it easier for older adults to self-monitor blood pressure," said study co-author and medical collaborator Alison Moore, chief of the Division of Geriatrics in the Department of Medicine at UC San Diego School of Medicine.

Next steps include making the technology more user friendly, especially for older adults; testing its accuracy across different skin tones; and creating a more universal design. Additionally, Wang and his lab members have been invited to discuss the design process for the project at the IEEE Biomedical and Health Informatics (BHI) conference.



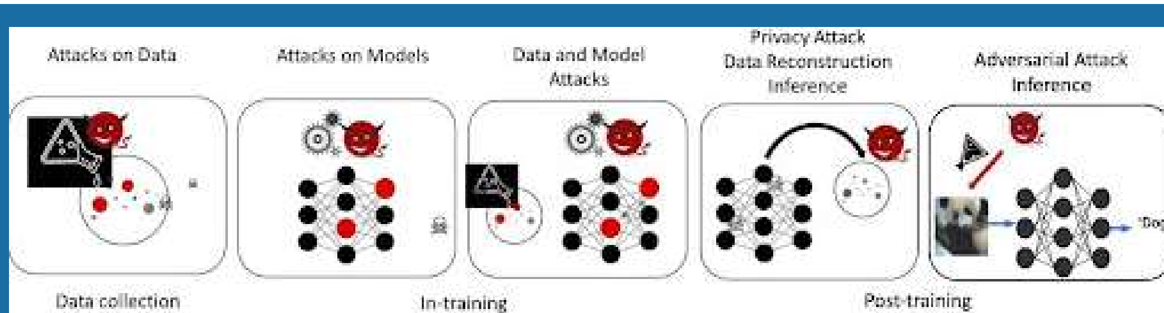
ROBUST PRIVATE COMPUTING FOR DISTRIBUTED AND COLLABORATIVE AI SYSTEMS

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.



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.

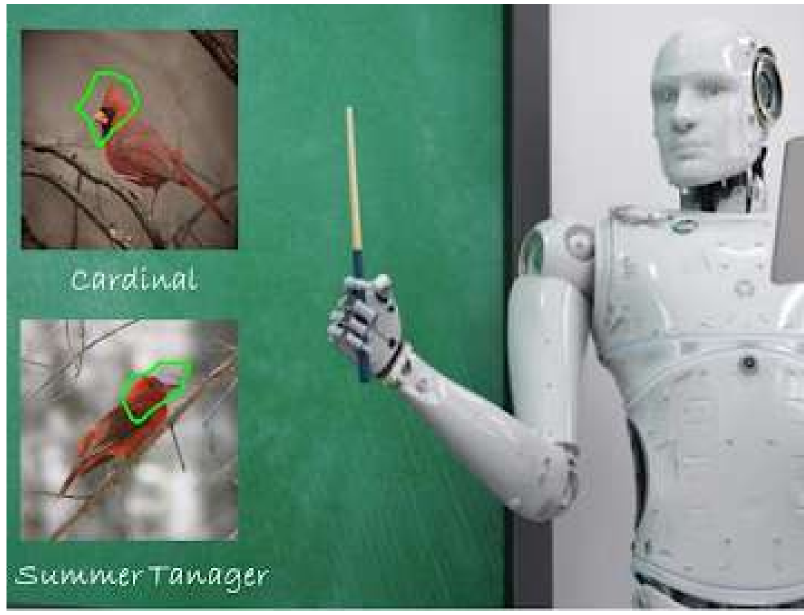
COLLABORATIVE ROBOT PERCEPTION AND MOTION

Mobile robots operating autonomously outside the factory floor need to understand the geometry and semantics of their surroundings to perform effectively in complex applications. Multiple robots collaborating by exchanging perceptual information through wireless communication can arrive at a more precise and complete environment model more efficiently than a single robot. The Existential Robotics Lab, directed by Prof. Nikolay Atanasov, develops algorithms for distributed optimization and applies them to perception and planning problems for robot teams including unmanned ground vehicles (UGVs) and unmanned aerial vehicles (UAVs). Each robot receives measurements from its onboard RGBD cameras or LiDAR sensors and uses Bayesian estimation techniques to maintain a probabilistic map of the occupied space and object categories around. Robots within communication range of each other exchange and fuse their map distributions to achieve a common understanding of the environment. A team of Clearpath Jackal robots constructing an outdoor 3D metric-semantic map of buildings, roads, grass, and vegetation using distance measurements and semantic segmentation information is shown in the diagram. To enable autonomous exploration, Atanasov's lab designs distributed robot trajectory optimization algorithms that enable the robots to evaluate the map uncertainty using information theory metrics and plan their motion to explore unknown areas and minimize inaccuracies in mapped regions. Similar to mapping, during planning the robots collaborate by exchanging motion plans with their communication neighbors to ensure that the team spreads out to cover uncertain areas intelligently and efficiently. The robots explore and map the environment in real time and, hence, can adapt to changes and achieve semantically meaningful objectives, such as locating objects of interest or avoiding navigation through tall grass and rough terrain.

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.

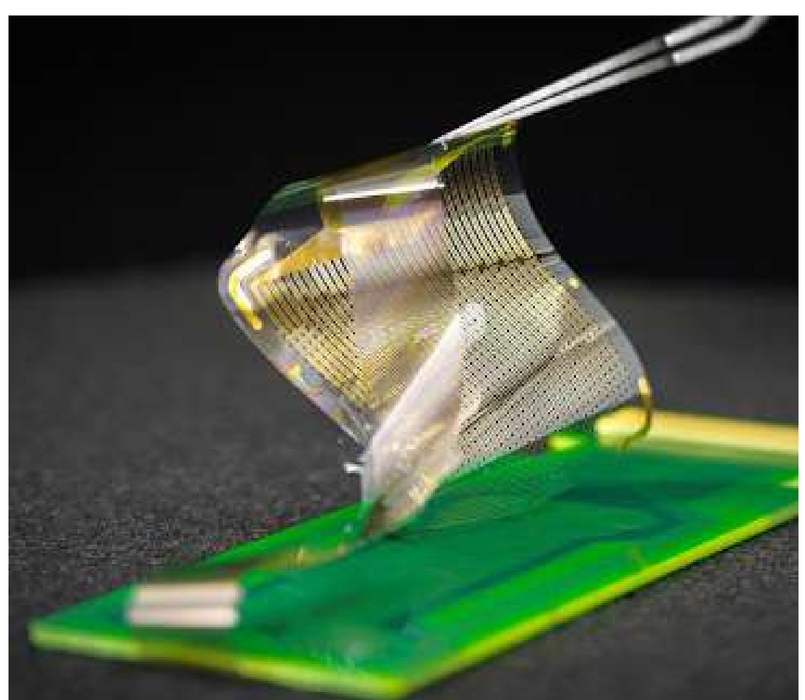
Being able to record brain signals at such high resolution could improve surgeons' ability to remove as much of a brain tumor as possible while minimizing damage to healthy brain tissue. In the case of epilepsy, higher resolution brain-signal recording capacity could improve a surgeon's ability to precisely 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.

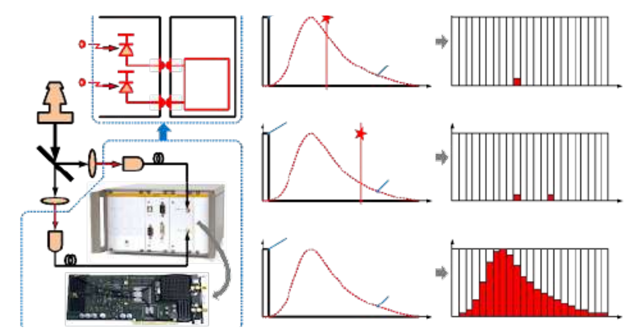
One of the challenges of removing brain tumors is that the presence of the tumor triggers changes in the brain, including changing what areas of the brain are involved in what functions. These changes make it critical for the surgical team to make a personalized map of the patient's brain – "functional 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.

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.

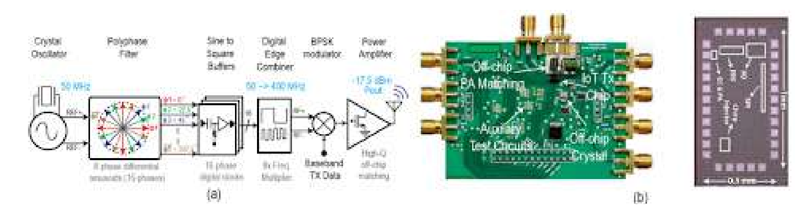
Using M-Cube, Professor Zhang's team has also been constructing a mmWave vehicle-to-everything (V2X) testbed on the UC San Diego campus (Fig. 2). The feasibility of mmWave V2X connectivity has long been questioned. One major doubt lies in how the highly directional mmWave links can sustain under high 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.

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!



STRUCTURAL SUPERCAPACITORS

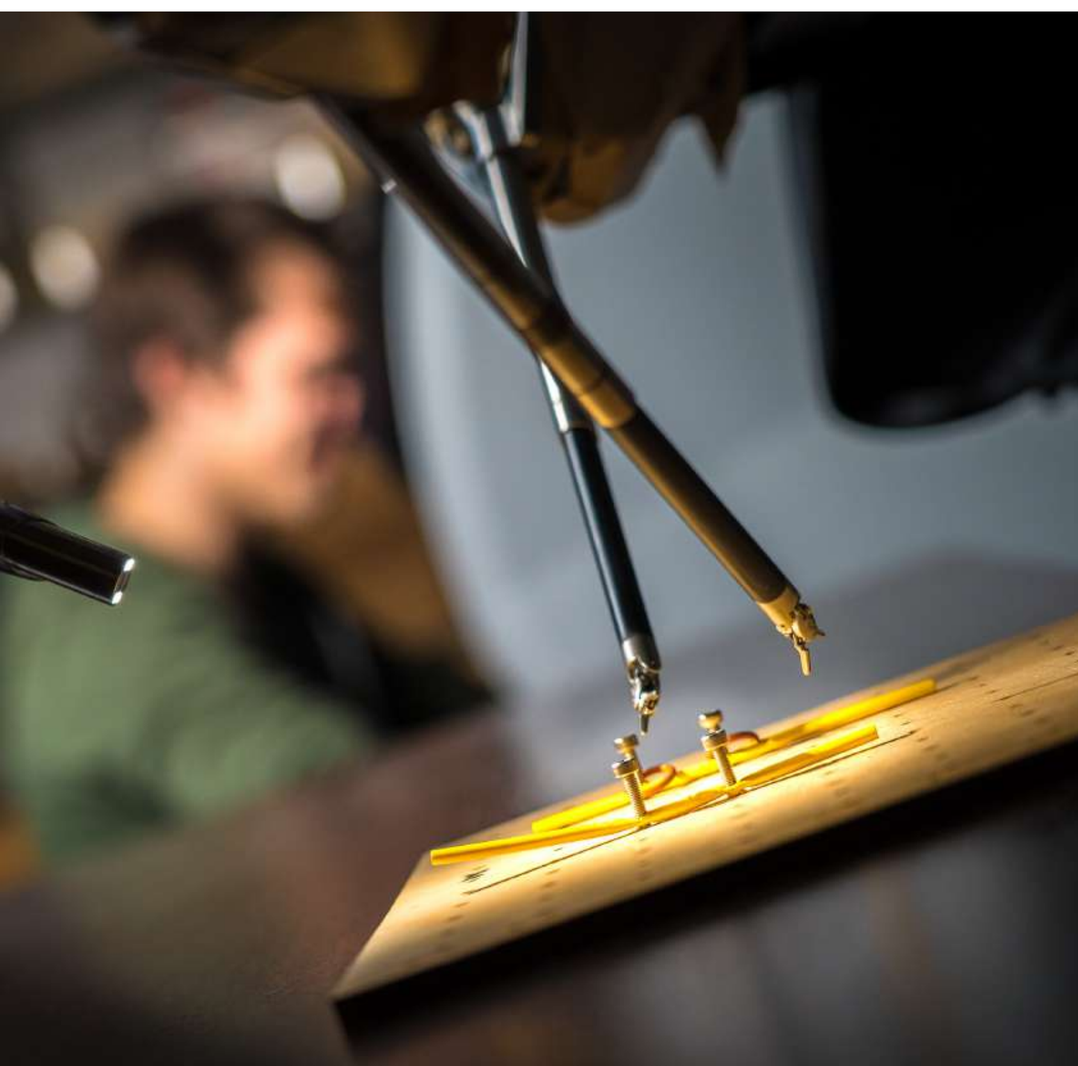
Our latest work on structural supercapacitors (Science Advances (2023) 9 eadh0069 https://www.science.org/doi/10.1126/sciadv.adh0069) aims to expand the energy capacity of a system by integrating load-bearing and energy-storage functions in a multi-functional structure, resulting in weight savings and safety improvements. As a collaboration between the students supervised by Prof. Tina Ng and Prof. Xinyu Zhang, we develop strategies based on interfacial engineering to advance multi-functional efficiency. The structural electrodes were reinforced by coating carbon-fiber weaves with a uniquely stable conjugated redox polymer and reduced graphene oxide that raised pseudocapacitive capacitance and tensile strength. The solid polymer electrolyte was tuned to a gradient configuration, where it facilitated high ionic conductivity at the electrode-electrolyte interfaces and transitioned to a composition with high mechanical strength in the bulk for load support. The gradient design enabled the multilayer structural supercapacitors to reach state-of-the-art performance matching the level of mono-functional supercapacitors. The structural supercapacitor was made into the hull of a model boat to demonstrate its multifunctionality.

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.

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.



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.

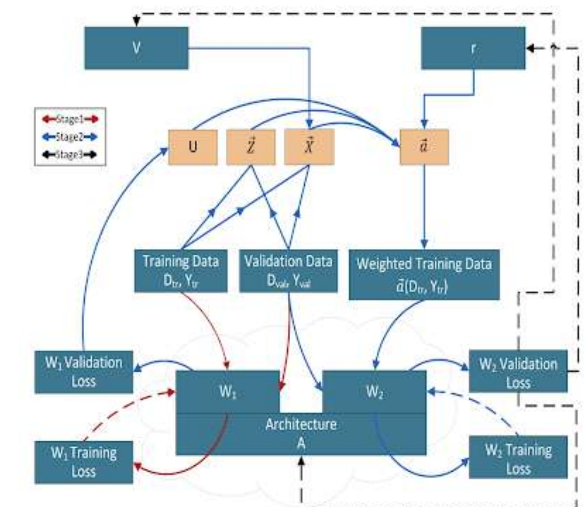
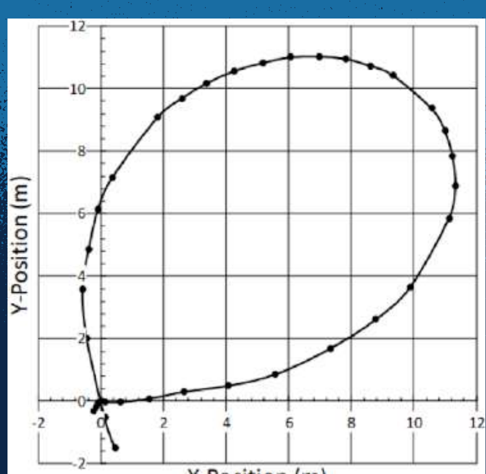


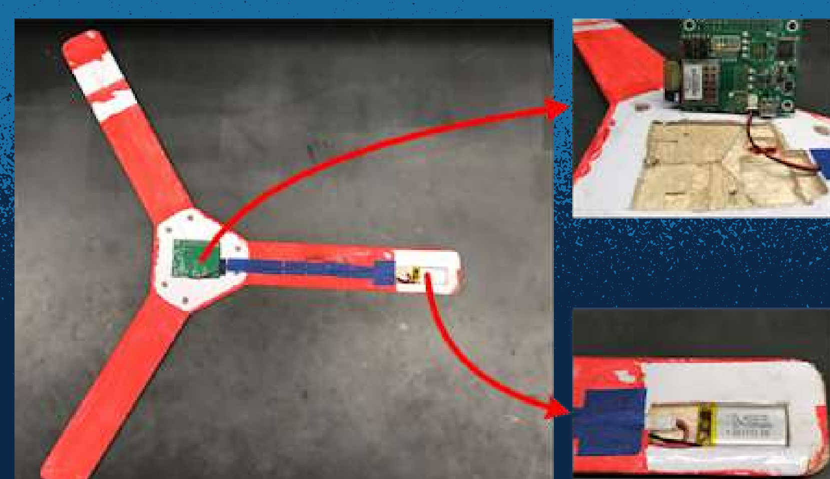
Figure 1: The overall process flow of our method when applying to NAS. The red arrows indicate stage 1 processes, blue arrows indicate stage 2 processes, and black arrows indicate stage 3 processes.

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.





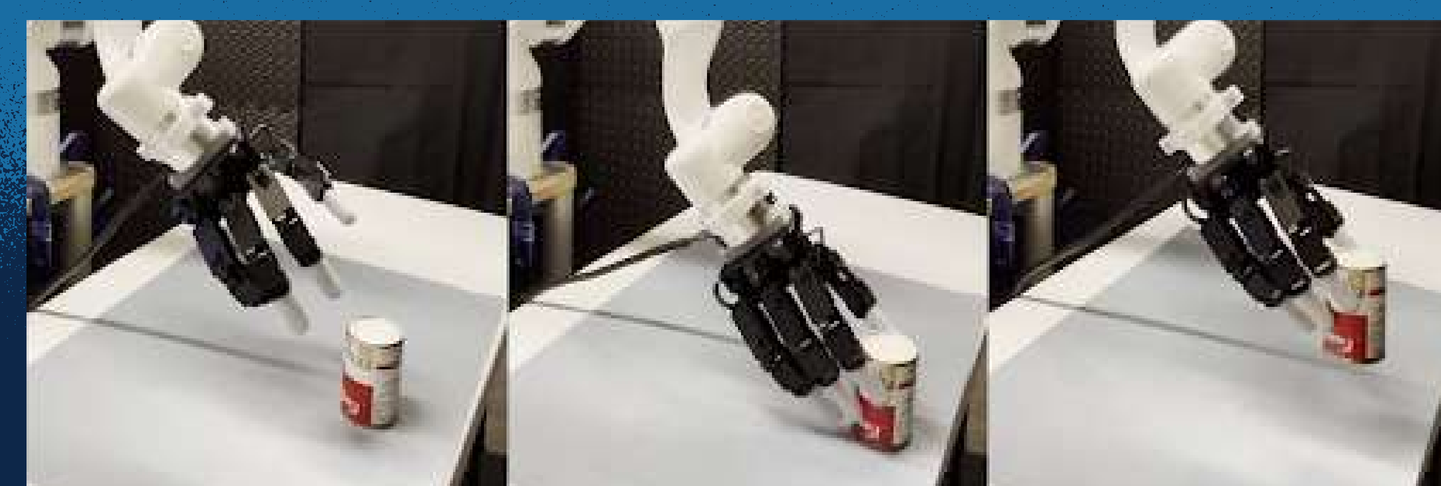
LEARNING CONTINUOUS GRASPING FUNCTION WITH A DEXTEROUS HAND FROM HUMAN DEMONSTRATIONS

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.



ECE Undergraduate Student Council (ECE USC)

The ECE Undergraduate Student Council (ECE USC) is the voice of Electrical and Computer Engineering (ECE) students at UC San Diego. Through community building, networking, and leadership, the council strives to effect change within the department and campus at large through various events and programs. During the 2022-2023 academic year, ECE Undergraduate Student Council initiated a podcast series to provide graduating seniors a platform to share their suggestions and experiences of their ECE experience at UC San Diego. On top of that, we restarted the career panel tradition that we had in the past and managed to invite more than 15 engineers in total to come speak about their experience in industry. With all these past accomplishments, we are looking forward to growing more and benefiting more students in this upcoming year!

Institute of Electrical and Electronics Engineers (IEEE)

IEEE at UCSD has witnessed noticeable growth in member participation this year. We successfully revived Robocup Soccer, our annual robotics competition against other universities, after a pandemic hiatus. Through a merger with the San Diego Supercomputing Center, we've additionally introduced a variety of supercomputing projects. Quarterly projects flourished with a participant count of 351, surpassing last year's participation by 150+. We also reinvigorated the largest 24-hour hardware hackathon, HARD HACK, with HKN. Lastly, after 2 years, we attended the IEEE Rising Stars Conference 2023 with 16 volunteers, having gained many insights into emerging technologies and career paths. Our student org is looking forward to more growth and innovation in the upcoming year!

ECE Graduate Student Council (ECE GSC)

The ECE Graduate Student Council (GSC) provides social, professional, and outreach opportunities to 1000+ graduate students throughout the school year. The group also serves as a resource for graduate students navigating research, school, and life. The GSC hosts biweekly coffee hours, quarterly socials, trivia nights, career panels, and more! The GSC also runs ECE 290, a seminar connecting students to professors and industry professionals, which has grown to run all year round, providing even more opportunities for students. With the ECE department growing and more students returning to campus each year, we are looking forward to expanding our future events and partnerships!

Project in a Box (PiB)

Project in a Box(PiB) aims to make projects more accessible to students and promote a hands-on approach to engineering education wherein students learn to place theory into practical, creative applications. Throughout 2022-2023, PiB has introduced a series of hands-on STEM technical workshops throughout San Diego county totaling an impact of 2100+ students both of K-14 from partnerships with local educational institutions and on-campus at UC San Diego. PiB's annual end-of-the-year project showcase concluded with fun interactive, student-engineered Arcade games and a display of PiB's kits from technical workshops to celebrate the year's progress!

Eta Kappa Nu (HKN)

HKN had a tremendous year full of immense growth, impact on our community, and tons of fun. Our Outreach program held its first on-campus event, where they brought K-12 students to UCSD. The students had a chance to tour research labs, meet college students, and get their first taste of what college is all about. Our events team organized more than 50 events throughout the year, including resume reviews, health sensor workshops, and fun social gatherings. With the support of IEEE and TNT, we successfully hosted the first in-person Hard Hack since 2020, San Diego's Largest Hardware Hackathon. As an organization, we expanded our board from 30 to 48 people. We are looking forward to showing UCSD what HKN is all about next year!

Association for Computing Machinery (ACM)

Welcome to ACM at UCSD, a members-first community! Together, we achieved remarkable milestones during the 22-23 academic year. With 3000+ students and a strong alumni network, we hosted 200+ engaging events, including the record-breaking Fall Kickoff with over 800 participants, our very first Career Fair, SPACE, and first outreach event! With our bit-byte program, we've brought together 100+ students and formed lifelong friendships. We showcased our passion for innovation with 27 diverse projects, spanning hackathons, design challenges, and AI initiatives. By fostering a collaborative and learning-centric environment, we aim to create a thriving community for UCSD students and professors.

Triton Neurotech (TNT)

At the heart of our organization, NeurotechX, we are driven by a deep passion for advancing the very technologies that grant us unparalleled insight into our own minds. Through hands-on soldiering workshops, captivating projects—such as our prosthetic hand—and meaningful networking opportunities such as HardHack, we immersed ourselves in the exploration of brain interfaces and cognitive enhancement this past year. Together, we form a dynamic community that embraces collaboration, creativity, and intellectual curiosity. As we enter the new school year, TNT will continue providing a supportive and inclusive space for all levels of experience to develop new skills and build long-lasting connections.

Women in ECE (WeCe)

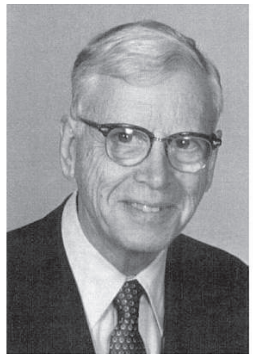
During the 2022-2023 academic year, Women in ECE (WeCe) continued to build a community among the graduate female student and faculty population. Hosting at least one event for each quarter, some of the most highlighted events were Lunch with Professors, Mini Lab Expo and the "How to Define Excellent Scientists" Seminar. Students gathered together, communicating and sharing their exciting research. The most unique part of WeCe events this year was bridging the gap between students and faculty members outside of the academia setting. Graduate students learned about personal experiences of being a professor, and also the academia environment.

International Society for Optics and Photonics (SPIE)

SPIE is an organization with the mission of promoting knowledge and interest in optics and photonics among people of all ages, from kids to professional researchers. We have introduced a diverse range of professional workshops for undergraduate students as part of their lab sessions. These workshops cover topics such as optical tweezers, Fourier optics, quantum cryptography, and optical communication. Additionally, we actively organize various workshops for professional optical researchers, including sessions on the IEEE publishing process, industry talks, and lectures by esteemed professors. Furthermore, we cohost an optical themed coffee hour with GSC to both graduate and undergraduate students across different academic tracks. Our outreach efforts extend beyond higher education, as we have acquired an optical suitcase specifically designed for elementary and middle school students. This optical demo suitcase has been a highlight at different outreach events, ranging from summer camps to campus tours.

ECE Day 2023

ECE Day is an annual celebration of the students and faculty members of the ECE Department at UCSD, co-hosted by HKN, IEEE, Project in a Box, ACM, and the ECE Undergraduate Student Council. Attendees have the opportunity to attend a number of fun technical workshops and socials, as well as a tabling event to showcase the wide range of engineering organizations on campus.



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.

Akshit Agarwal
Arturo Amaya
Masanori Ando
Yuhan Bao
Charles-Pierre
Marcel L Beurtheret
Jicang Cai
Jean Gorby Villaruel
Calicdan
Jonathan Koby Cayaban
Hua Chai
James P Chen
Zekai Chen
Yuxiang Chen
Shifeng Cheng
Brent Douglas Delano
Quoc-Zuy Vu Do
Aidan Akira Dougherty
Joydeep Dutta
Aasem Fituri
Akshay Gopalkrishnan
Kaiwen He
Yilang He
Brandon Ho
Katie Jin-Shin Hsieh
Qingyang Hu
Yucheng Huang
Hannah Hui
Ho Tin Hung
William Stephen Hunter
Cory Huynh
Robert Jiaming Jiang
Jubal Josiah John Peter
Karl Andrew Johnson
Andrew Scott Kahr
Divneet Kaur
Mihir Sanjay Kekkar
Do W Kim
Shubham Kumar
Hao Le
Charles Chi Lee
Anne Sui An Lin
Siyue Liu
George Hongji Liu
Jiahong Long
Jerry Chao Lu
Sai Fu Lui
Junzhe Luo
Jonathan Mi
Farnia Nafarifard
Rajdeep Nag
Loc Nguyen
Owen Pan
Torin Perreyclear
Wei Qin
Etienne Paul Robin
Aksharan Saravanan
Arsalan Sepahpour
Anish Sharma
Salwan Shathar
Micah Aram Smyth
Jonah Soong
Ke-Chieh Sun
Shulun Sun
Michael Yuxiang Tang
Noah Todd
Meghaj Rao Vadlaputi
Justin Volheim
Samuel Dean Winton Woo
You Wu
Shixuan Wu
Caiwei Xiao
Wangdong Xu
Wenrui Yang
Yichen Yang
Manshi Yang
Xunhao Yang
Chengjing Yuan
Alden Z Yue
Haofan Zeng
Minzhe Zhan
Yuchen Zhang
Yiteng Zhao
Han Zhao

DR. WILLIAM S.C. CHANG BEST DISSERTATION AWARD

Xiaoxi (Josh) Wang
"Expanding Silicon Photonics Through Novel Components and Applications"

Sangheon Oh
"Energy Efficient Hardware Implementation of Neural Networks Using Emerging Non-Volatile Memory Devices"

HARRY WIEDER ELECTRONICS MATERIALS EXCELLENCE AWARD

Ritwik Vatsyayan

BEST TA AWARDS

Shubham Jain
Spencer Congero

BEST TUTOR AWARDS

Jean Calicdan
Emin Kirimlioglu
Dehao Dai

BEST UNDERGRAD RESEARCH AWARD

Kai-wen Cheng
Yuanyuan Shi

ECE UNDERGRADUATE STUDENT AWARD FOR EXCELLENCE (IDEA CENTER AWARD)

Meghaj Vadlaputi

UNDERGRADUATE STUDENT SERVICE AWARD

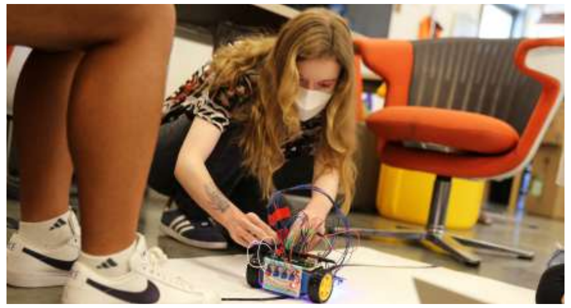
Katie Hsieh
Alexis Chin
Nishant Balaji
Marc Reta
Anthony Chan
Brandon Ho
Meghaj Vadlaputi
Frederick Yang

GRADUATE STUDENT SERVICE AWARD

Luisa Watkins
Poorva Bedmutha
Deepak Sridhar
Divya Seshadri Murali
Luke Herman
Xiang Dai

ALUMNI SERVICE AWARDS

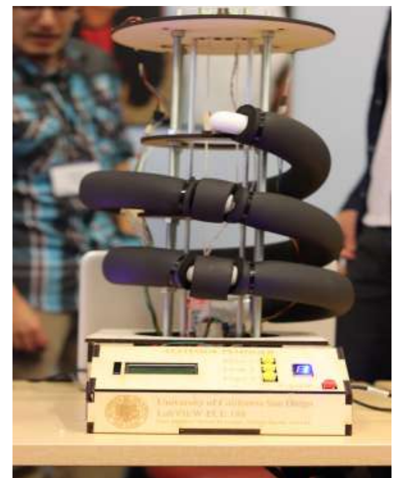
Ramsin Khoshabeh MS'07, Ph.D. '12
Simon Hu BS '19, MS '20

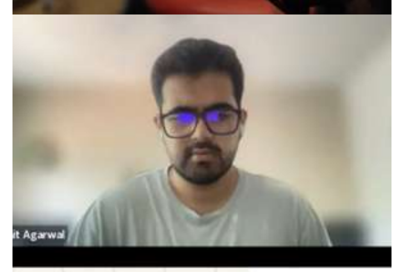


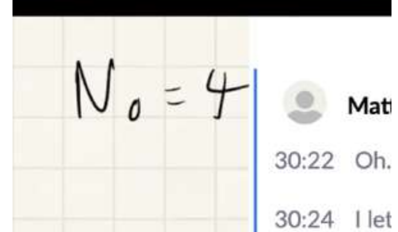
To support students in their learning, instructors throughout the ECE department have continued to integrate innovative approaches into their classes. A key component of these approaches is the idea of active learning, a topic that is well-studied in the Scholarship of Teaching and Learning (SoTL). It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

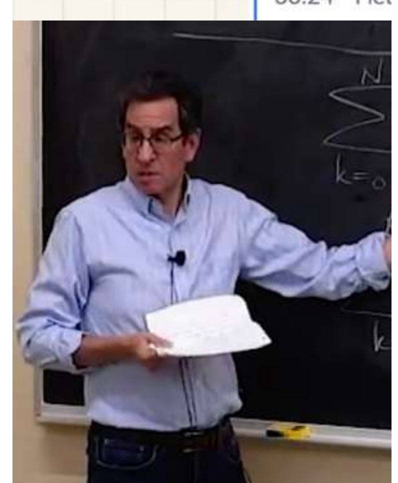
FLIPPED CLASSROOM

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

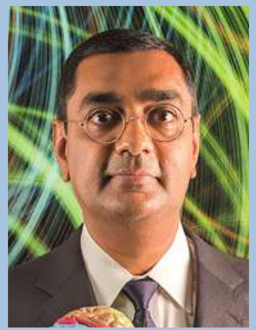
Learn more about ECE AMP and get involved: ece-amp.ucsd.edu

The ECE Alumni Mentorship Program (ECE AMP) was another success in its third year. The six-month program pairs current ECE students with ECE alumni who share similar academic and personal interests. The program aims to continue fostering a strong ECE community by engaging alumni with students to provide them with guidance on their professional, academic, and personal goals. Mentors and mentees meet twice a month and participate in social events, discussions, and guest speaker sessions. For the third year, we opened the application to ECE graduate students, and provided a hybrid option for alumni that are not in the greater San Diego area. 100+ students and 60+ alumni participated in 2023.

2023 ECE DISTINGUISHED ALUMNI AWARD

Slava Rokitski
Lead Technologist
Cymer, an ASML Company
Ph.D. EE (UCSD, 2006)

An Chen
Vice President of Engineering
Qualcomm Technology Licensing
Qualcomm, Inc.
Ph.D. EE (UCSD)



Dharmendra Modha
IBM Chief Scientist
Brain-Inspired Computing
IBM Corp.
Ph.D. EE (UCSD, 1995)

UC San Diego

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Electrical and Computer Engineering

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