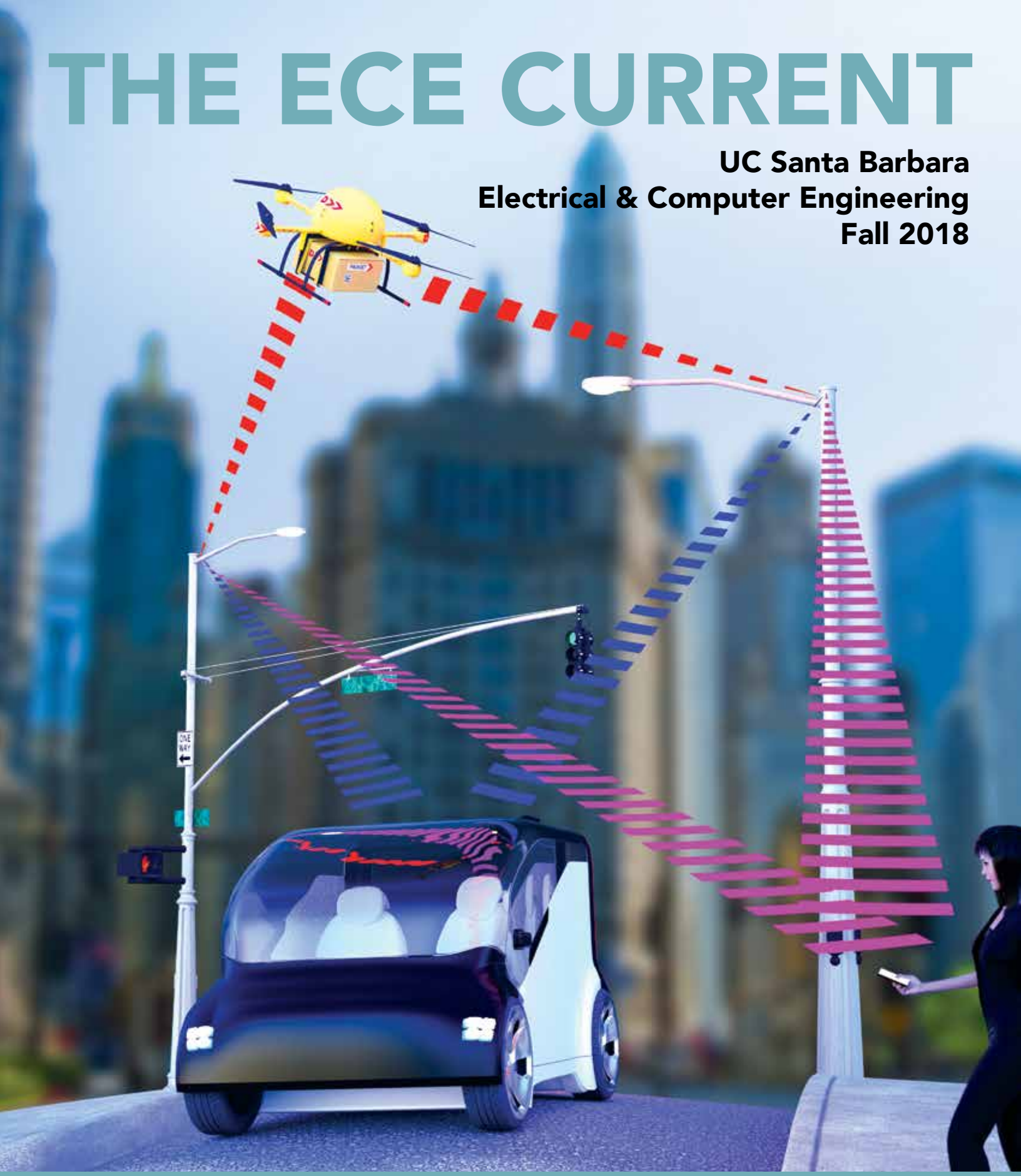
THE ECE CURRENT

UC Santa Barbara
Electrical & Computer Engineering
Fall 2018



ECE 5 FRESHMEN COURSE | PG. 2
INTRODUCTION TO ELECTRICAL AND COMPUTER ENGINEEERING

2018 CAPSTONE | PG. 3

UPAMANYU MADHOW | PG. 6
SHAPING NEXT-GENERATION INFORMATION INFRASTRUCTURES VIA MILLIMETER WAVES

A LETTER FROM THE CHAIR

This has been a very busy year full of excitement. After many years of no or very slow growth, we started to recruit for multiple positions. Overall, we interviewed a significant number of bright, driven, and very worthy candidates. Recently our searches started to bear fruit and we are expecting several new faculty members to join the department in the coming year.

We are continuously making improvements to our undergraduate curriculum. There is now a new beginning laboratory intensive course to provide freshmen with a broad overview of electrical engineering. The capstone program will also be required for all undergraduates beginning fall 2019. The department has dedicated space, equipment and design resources for a capstone laboratory that will allow a wide range of projects. The capstone course has been very successful so far. As a recent success example, read the story of our Hyperloop team who won the SpaceX Levitation competition this year.

Our faculty continue to gain major research grants and centers. One notable example is the Center for Converged TeraHertz Communications and Sensing (ComSenTer), which is part of the new $200 million, five-year Joint University Microelectronics Program (JUMP). Examples of additional center and joint research programs can be found on our website. These excellent funding opportunities are augmented with significant awards and honors our faculty received, which are described in this newsletter.

Overall the department continues to do very well. Our national and international rankings are high. U.S. News & World Report ranks ECE graduate program 12th among public universities. Applications to our graduate program have been over 1200 for many years. GPA of incoming freshman holds very high.

We are also very grateful for the gifts from alumni and friends of our department. These gifts enable us to make many improvements to our laboratories, student life and department in general. We are very thankful for your generosity.

Nadir Dagli

Nadir Dagli
ECE Department Chair

> Over the years, freshmen projects have included a robot car, a light system that responds to sounds, and even a small game console.

ECE 5 A HANDS ON APPROACH TO ENGINEERING

For several years, the ECE department had been looking for approaches to provide students with a broad and compelling overview of the field early in the undergraduate curriculum. The goal was to create a new laboratory-oriented class where students could experiment with real engineering designs of their own choice. It began in 2011 as a small independent study class, taught by Forrest Brewer, in close cooperation with the IEEE student chapter. Over the years, João Hespanha has transformed the course into ECE 5: Introduction to Electrical and Computer Engineering. This program has been a great success and is now a mandatory part of the Electrical and Computer Engineering curriculum.

This class gives students a sample of the fun projects they will be able to design four years down the road. Despite the challenging subject material, the course is approachable for students who have only completed high-school level physics. Over the years, freshmen projects have included a robot car, a light system that responds to sounds, and even a small game console. Students are encouraged to apply ECE fundamentals into designs they work on throughout the quarter, culminating in a presentation to their friends, families, and peers.

Because these projects are typically fairly sophisticated, personalized instruction is provided to each group. To ensure that this course remains accessible to upwards of ninety students per quarter, we enlisted the local IEEE student chapter to provide additional mentoring — both during the class and after hours. Every year, students create a unique set of projects and we help them find the design solutions necessary to realize their visions. Technical support is provided by the faculty, TAs, and qualified upperclassmen. Groups run into technical issues and their plans are reworked. The short deadline encourages teamwork and goal-directed planning. We always have tremendously creative projects and most students go above and beyond what is needed to get a good grade.

We encourage all to see our students' accomplishments at:

https://web.ece.ucsb.edu/~hespanha/ece5/

2018 CAPSTONE

The capstone program is a year-long project course sequence in which senior students have the opportunity to tackle challenging engineering problems posed by industry and research partners. Working in small groups of four to six, the teams draw on the strengths of each member, and projects are intended to be the culmination of the students' undergraduate education. Capstone offers a true team experience to complete a complex project.

This past academic year, the **electrical engineering capstone** saw five teams complete projects in topics ranging from electrified transportation to portable cloud-connected speakers to image recognition and artificial intelligence for medical device applications. The achievements of all five teams were quite extraordinary, and were in large part made possible by the students' extensive interactions with a variety of experts in academia as well as industry partners such as SONOS, Arthrex, Wright Electric, Laritech, Raytheon, and Northrop Grumman. Additionally, this year marked the grand opening of the Naples Design Lab, providing teams with some much-needed tools and work space as well as a conferencing area for remote meetings with mentors, sponsors, and amongst themselves.

The lab features a full soldering and rework station, several sets of industry grade electrical test equipment, and a computing station including a GPU-powered machine optimized for graphical processing and training of neural networks. There is plenty of writable wall space, several 75" screens equipped with webcams to facilitate problem solving, and a sound system generously donated by SONOS to create an enjoyable work atmosphere.

The **computer engineering capstone** projects are all about building custom computer hardware and then writing software for a specific application. Students experience all stages of developing an embedded system: identifying a problem, designing to required specifications, managing budgets and printed circuit board fabrication, and delivering their finished product on time. The students have to learn how to split responsibilities, work in parallel, self-organize, and communicate. Students also learn about industry standard tools such as GitHub and PCB design software.

Last year computer engineering students successfully completed seven projects. TiresiaScope is a completely student-defined project. GauchoHawk, SPOT, and HoverHand are industry sponsored projects. Wall-E and DeepVision are sponsored by research groups at UCSB. Two student groups, DeepVision and Hyperloop, also participated in competitions. Each project is unique and required students to use their imagination to come up with innovative solutions. Students applied a lot of rigor to develop working prototypes and in some cases fully functioning products. These projects were made possible by generous industry contributions from various donors such as AeroVironment, Arveng Technologies, NASA, Oakley Lab, DJI, LARITECH, SUNSTONE, NVIDIA, and SEAL Lab.

Of particular note, our team working on a levitating Hyperloop pod, which included over thirty undergraduates from Electrical Engineering, Computer Engineering, and Mechanical Engineering, entered the 2018 Hyperloop Levitation Competition at SpaceX during the summer and took first place!

We invite you to learn more about and become involved with our program and projects. For more information please visit our website at:

https://capstone.engineering.ucsb.edu/

WHAT DOES MENTORING MEAN TO YOU AND WHY IS IT IMPORTANT IN YOUR PROFESSION?

Mentoring is the number one role of a professor, but we're researchers and we're teachers. Students need to navigate both a complicated technical world as well as a broader society. I mentor undergraduates who are trying to understand the field for the first time, but also who want to understand the context for the material in the world we live in. It's important to me to be a role model for students, so they understand who engineers are and what they do.

FACULTY MENTORSHIP
PROFESSOR JIM BUCKWALTER

AS A STUDENT DID YOU HAVE FACULTY THAT YOU LOOKED UP TO?

Yes, absolutely! Dave Rutledge at Caltech. As an undergraduate, I enjoyed his classes and then decided during my junior year that I wanted to pursue summer research in his lab. I approached him about it and he was eager – well not eager, but willing – to have me mess around in his lab and test out power converter circuits. He gave me a problem and I spent the summer trying to solve it. That's what I originally expected I would do as an engineer. At the time that's what I wanted, someone who could get me into the laboratory and make it a fun, engaging experience.

HOW DO YOU MEASURE YOUR SUCCESS AS A TEACHER?

I really consider success when students stay in my class even if they are challenged by the material. Some students struggle with the material – everyone struggles at some point in their education – and I encourage them to maintain the course and work through the material. I want students to learn to persevere. There's a lot of things you're going to have to work out in life and I guarantee getting through one quarter of my class is not the hardest thing you'll encounter. I measure success by coaching struggling students to see it through to the end.

DO YOU KEEP IN TOUCH WITH ANY OF YOUR FORMER STUDENTS?

Yes, certainly! A lot of the time I have students who come back and they want a job and they ask me things like "Who's hiring?" "What's a good direction to go?" It's always nice to have someone you can reach out to – and I'm always there for them.

DO MOST STUDENTS COME TO YOU WITH A CLEARLY DEFINED PATH AND GOAL? IF NOT, HOW DO YOU HELP THEM GET THERE? AND IF THEY DO HOW DO YOU PUSH THEM TO GROW IN WAYS THEY HAD NOT CONSIDERED?

I think it's completely natural to lack a clearly defined path as a sophomore or even senior. Students should allow themselves to be a little ambiguous early on and explore a broad reach of specialties or classes. Do something in controls, do something in photonics, do something in materials. Otherwise, you might miss something you would have really enjoyed doing. A faculty advisor who can push you to look beyond the scope of what you thought you wanted to do is really important. The career paths in engineering are not always linear or clearly defined, and I'm here to help students navigate that and consider all of their options.

WHAT ASPECTS OF AN ACADEMIC CAREER DO YOU FIND MOST REWARDING?

Certainly mentoring; but it's great to be able to do fundamental research and to teach. In the end, the reward of an academic career is when a student succeeds in their career and tells you they appreciate the time you spent with them.

WHAT DO YOU HOPE YOUR STUDENTS TAKE AWAY FROM THEIR TIME IN YOUR LAB?

There are very few places where you get to play with state-of-the-art equipment, and see how it works, and try to push the hardware to do something no one has done before. I don't expect my students to solve every problem that they encounter in my lab, but I hope they can appreciate and learn from the experiences.

DO YOU THINK IT'S HELPFUL FOR UNDERGRADUATES TO FIND A MENTOR AT THAT LEVEL?

Yes, I would encourage undergraduates to bang on our doors. Getting a mentor can have a huge impact on your future, both as a student and a professional. We know a lot of people in the industry and we know exactly what they are looking for. The sooner you start networking, the better off you will be. This is not a world for shy people. You need to put yourself out there. Engineering is such a vast field, and professors are a doorway into that world.

WHAT IS THE GREATEST THING A STUDENT EVER TAUGHT YOU?

First and foremost, my students have taught me patience and perspective. My students remind me to come out of a place of intellectual comfort and re-evaluate things from a fresh angle. Another thing they have taught me is perseverance and dedication; I have students who travelled through war-torn countries to get to an embassy where they can get a visa all so they could come here and be my student. Once you understand the sacrifices some people make to take advantage of the education we provide here, it's absolutely humbling.

DO YOU HAVE ANY ADVICE FOR ECE STUDENTS?

ECE is a great major because it's so broad and there are lots of opportunities for ECE students. You don't have to be just a hardware person; you can be a mathematician, or do something at the atomic level as a materials scientist. We have a remarkable program here in that it covers such wide breadth. As a student, I can understand how it might seem overwhelming. If you're unsure of what you want to do, this is a great major because you will have a chance to think about where you would like to be later on, and experience so many different things.

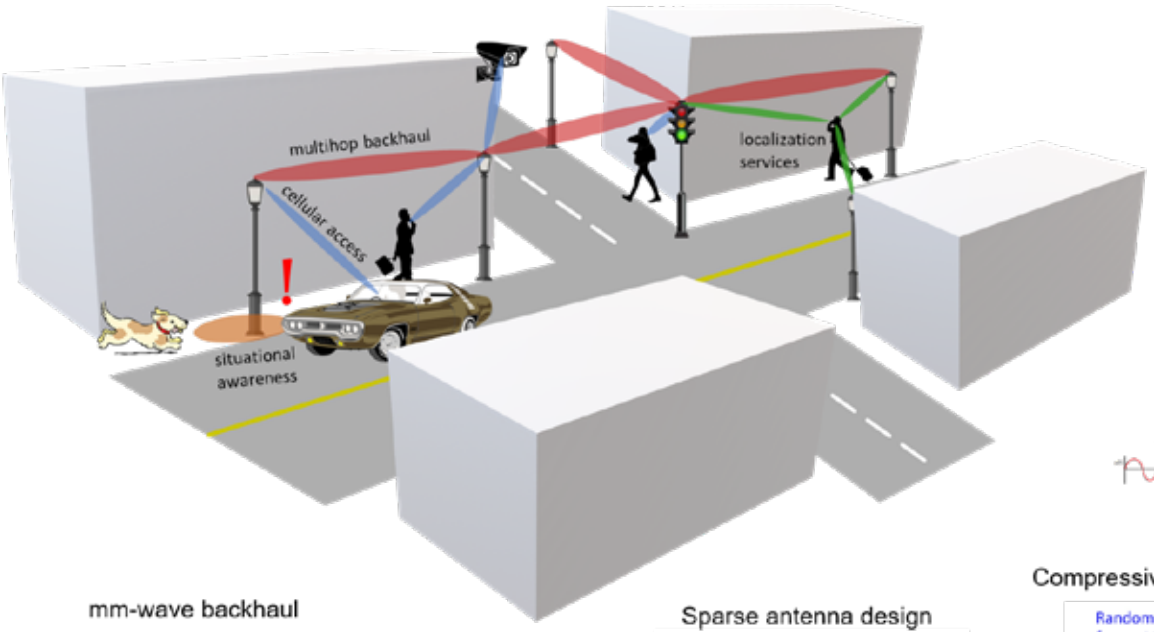
My best piece of advice is to take your time and don't rush. These are some of the best years of your life. No matter what you choose as a career, you will have all the experience you need to approach any other field.

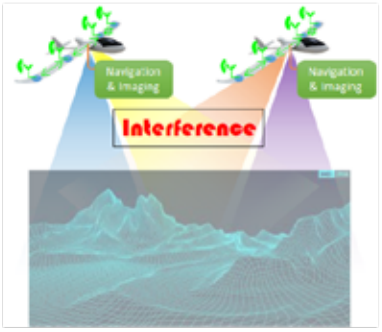
RESEARCH INITIATIVE
Professor Upamanyu Madhow

A key focus of the Wireless Communication and SensorNets Lab (WCSL) led by Professor Upamanyu Madhow is on identifying and addressing fundamental technical bottlenecks in the design and realization of next-generation information infrastructures. In particular, a major current thrust at WCSL is on millimeter wave (mmWave) systems, which use radio waves at carrier frequencies that are orders of magnitude higher than those used in today's cellular and WiFi systems. The bandwidth available in this band is also orders of magnitude higher, thus bypassing the scramble for spectrum at lower frequencies. The tiny carrier wavelength means that electronically steerable antenna arrays with a very large number of elements can be packaged into compact form factors, which can be used to realize "pencil" beams. These features, together with other geometric properties associated with small wavelengths, open up exciting new frontiers for next generation communication and sensing. However, there are significant technical challenges before this potential can be realized, and this is what drives much of the research at WCSL.

In order to put both opportunities and challenges in perspective, consider two intertwined applications. The first is next generation mobile data: Can we meet the explosion in demand for mobile data driven by smart devices, and deliver Gigabits/second data rates in densely populated urban environments? The second is next generation localization and situational awareness services: Can we provide an infrastructure that supports safe and robust vehicular autonomy? The answer to both might be a network of opportunistically deployed (e.g., on lamp posts or rooftops) mmWave picocellular base stations. The base stations need to track mobile users precisely in order to point pencil beams at them while communicating, so that a network of base stations can employ triangulation style techniques to provide fine-grained localization services to the mobiles. Indeed, a picocellular infrastructure can be used to provide localization services even without explicit communication between base stations and mobiles. The base stations' beacons can be used by a mobile receiver to localize itself, much in the way a GPS receiver localizes itself by listening to signals from multiple satellites. The objective would be to provide localization with sub-meter accuracy, which autonomous vehicles can then use to supplement their onboard location and perception systems. The figure illustrates some of these concepts and the techniques being developed to realize them.

INFRASTRUCTURES VIA MILLIMETER WAVES

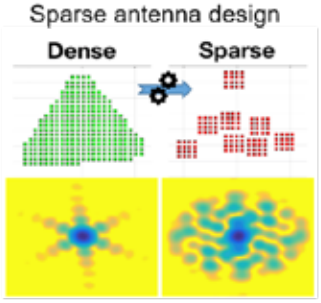




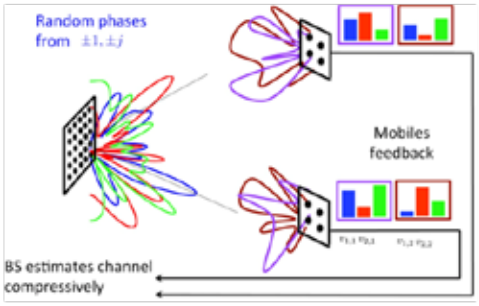
mm-wave sensing and perception

mm-wave backhaul

Sparse antenna design



Compressive channel estimation



System Concepts and Techniques for Millimeter Wave Communication and Sensing

Such system concepts build on work on fundamentals of millimeter wave systems in Professor Madhow's lab for the past decade. For example, mmWave transmissions are easily blocked, hence it is essential to devise agile techniques for discovering viable paths along which beams can be formed. "Compressive" techniques devised in Professor Madhow's lab potentially provide the basis for a low-overhead architecture that enables rapid path switching and handoff for picocells. As another example, dense deployment of picocells (e.g., on lamp posts) makes providing backhaul (i.e., connecting base stations to the wired network) a challenge, since digging trenches to lay optical fiber to every lamp post is an unattractive proposition. mmWave wireless backhaul provides an attractive alternative, but wireless network protocols and resource allocation strategies, originally devised for omnidirectional links at lower carrier frequencies, must be completely rethought.

Physics and hardware constraints play a crucial role in mmWave systems research, in contrast to wireless system design at lower carrier frequencies and lower data rates, where signal processing algorithms and network protocols can be abstracted away from hardware design choices. Thus, a critical enabler for the mmWave research in Professor Madhow's lab has been his long-term collaboration, over more than a decade, with Professor Mark Rodwell, who is renowned for pushing the envelope in ultra-high-speed hardware. This collaboration, for example, led to the development of theory and prototypes for spatial multiplexing in line-of-sight environments (recognized by the Marconi prize paper award in 2012), and continues space under ComSenTer, a large center led by Professor Rodwell, launched in 2018 with the goal of truly revolutionizing next-generation infrastructures by pushing the limits of hardware, communications, and sensing in harnessing mmWave and THz frequencies.

2017-18 FACULTY AWARDS & HONORS

ELECTRICAL & COMPUTER ENGINEERING

Umesh Mishra
UCSB Faculty Research Lecturer Award

Professor Umesh Mishra has been named Faculty Research Lecturer for 2018. The award is the highest bestowed by the University on one of its faculty, and Professor Mishra is being recognized for his "considerable contributions in the research and development of energy-efficient microwave and energy conversion power electronics, which have resulted in a market valued in hundreds of millions of dollars as well as added to a thriving green industry."

Professor Mishra said: "This enables us to be lucky to witness our Sputnik moment: The challenge of widespread deployment of energy-efficient electronics impacting a broad range of applications, from efficient microwave transmission to long-range electric cars. I feel very fortunate to be able to contribute to this endeavor in a meaningful manner and, most importantly, have fun doing it with outstanding colleagues at UCSB."

Rod Alferness
2018 Recipient of the Optical Society Frederic Ives Medal/Jarus W. Quinn Prize

Dan Blumenthal
2017 National Academy of Inventors (NAI) Fellow

John Bowers
Pioneer Award from the South Coast Business and Technology Awards

Forrest Brewer
Computer Engineering
COE Outstanding Faculty Award

Jonathan Klamkin
DARPA Young Faculty Award
NASA Early Stage Innovations Award

Hua Lee
Electrical Engineering
COE Outstanding Faculty Award

Sanjit Mitra
2017 IEEE Educational Activities Board Vice President's Recognition Award

Chris Palmstrøm
American Physical Society – 2018 David Adler Lectureship Award in the Field of Materials Physics

Clint Schow
2018 Fellow of the Institute of Electrical and Electronics Engineers (IEEE)

Yon Visell
2018 NSF Faculty Early Career Award For Haptics Research

Li-C Wang
Elected 2018 Fellow of the Institute of Electrical and Electronics Engineers (IEEE)
IEEE Test Technology Technical Council (TTTC) Bob Madge Innovation Award

STUDENT AWARDS & FELLOWSHIPS

Barpal Fellowship:

The Barpal Fellowship Fund was established through generous gifts from Isaac & Margaret Barpal to provide fellowship awards to outstanding graduate students. The 2017-2018 fellowships were awarded to:

Jason Rivera
Cameron Sheth

Kroemer Fellowship:

Funded by Henry Chien in honor of Professor Herbert Kroemer to support a dissertation fellowship enabling PhD students to devote their full attention towards research in the final period of their PhD, the 2017-18 Kroemer fellowship was awarded to:

Faruk Gencel

Roger Wood Scholarship:

In recognition of their strong academic records and exceptional commitment toward their undergraduate education at UCSB, the 2017-18 Roger Wood scholarship was presented to:

Brandon Luu (EE)
Sang-Min Oh (CE)
Aditya Wadaskar (CE)

Ed Hass Scholarship:

Funded by Andrew & Annette Hass, this scholarship is awarded annually to outstanding juniors in the CE program. The awarded recipients for 2017-2018 were:

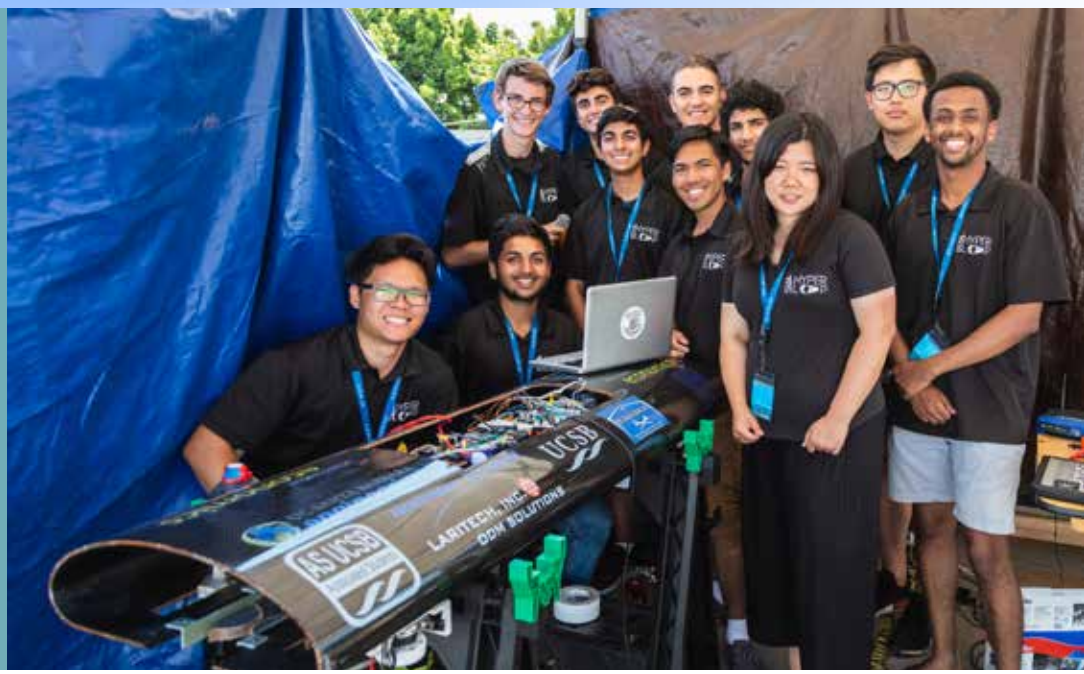
Sang-Min Oh
Aditya Wadaskar

Outstanding Teaching Assistant:

The following graduate students received: "Outstanding Teaching Assistant (TA)" recognitions from the graduating seniors in their program:

Caio Motta (CE)
Vincent Radzicki (EE)

SpaceX has built a mile-long enclosed test track as well as an open-air track at their facilities in Hawthorne, CA, and has been hosting an annual competition where university teams build prototype Hyperloop pods to race on these tracks.This year, a team of over thirty UCSB engineering undergraduate students competed and took home first place in the levitation competition!



Invest in the Department of Electrical and Computer Engineering

The goal of the Department of Electrical and Computer Engineering at UC Santa Barbara has always been to provide our students with the best possible opportunities to learn and develop. The faculty, students, and administration have created an atmosphere of interdisciplinary and collaborative research that is renowned throughout the nation and is the cornerstone of our success. Your investment in the Department of Electrical and Computer Engineering plays a critical role in our ability to fulfill our mission and provides essential support of ECE's teaching program and research enterprise.

Department funding opportunities include:

• **Unrestricted support** allocated to the highest priority needs of the Department.

• **Roger Wood Endowment,** established in honor of esteemed faculty member Roger C. Wood, supports undergraduate and graduate fellowships, faculty, and state-of-the-art teaching facilities.

• **Undergraduate laboratory renovations** maintain and upgrade the quality of essential facilities for teaching and research. Priority renovations and naming opportunities include: Digital Lab, Controls Lab, Computer Engineering Lab, High Speed Communications Lab, Microwave Lab, Digital Signal Processing Lab, and the Instructional Clean Room.

• **Endowed chair establishment** honors, encourages, and supports the professors whose brilliant minds and commitment to education and research promote the University's mission.

• **Petar V. Kokotovic Distinguished Visiting Professorship** was established by Dr. Kokotovic's former students and colleagues as a vehicle for honoring and recognizing his contributions to UCSB students, the UCSB campus, and the academic community. The fund supports an annual named distinguished visiting professorship.

• **Capstone Senior Project** gives Electrical and Computer Engineering students the opportunity to put their education into practice.

Photo by Matt Perko

To give to ECE, please visit
giving.ucsb.edu/funds

Thank you for your generous gift.

ELECTRICAL & COMPUTER ENGINEERING 2017-2018

Cisco Systems, Inc.
Intel Corporation
International Foundation for Telemetering
Microsoft Corporation
Montecito Bank & Trust
Pixar Animation Studios
Pure Engineering LLC
Qualcomm, Inc.
Roche Molecular Systems
Samsung Electronics Company, Ltd.
Sonos, Inc.
Ms. Evangeline Alfonso
Ms. Penny Alfonso
Ms. Antonia Alstad
Ms. Kathleen Altz
Ms. Mylene Angeles Corona
Dr. and Mrs. Christopher D. Arcenas-Utley
Mr. Mike Axelrod
Ms. Rosanna Bati
Mr. Eric D. Battenberg and Ms. Ekaterina Gonina
Mr. Douglas A. Beaubien
Dr. and Mrs. Jeoffrey P. Benson
Mr. Cameron S. Bijan
Mr. and Mrs. James P. Brady
Ms. Gracelynn Bravo
Mr. Joseph Burke
Mr. and Mrs. Paul F. Burrous
Ms. Carly Button
Mr. Jack J. Button
Mr. and Mrs. Mark Button
Mr. Dave Capper
Mr. Peter Carter
Mr. Yen Chen Chiang
Mr. Cyrus Choobineh
Ms. Nancy Choobineh
Mr. Terrence P. Codington, D.D.S.
Ms. Terri Coleman
Mr. Daniel A. Darakjian
Ms. Grace De Jesus
Mr. Song Detoc
Mr. and Mrs. Farid Dibachi
Ms. Jo Ann Dittmar
Mr. and Mrs. Stephen C. Douglas
Mr. and Mrs. Robert K. Douglas
Mr. Bill Duke
Ms. Marita Beth Earle
Mr. William W. Farthing
Dr. and Mrs. B. Richard Ferm
Dr. and Mrs. Douglas J. Fouts
Mr. Harrison M. Friedman
Mr. Sanjiv A. Ghate
Mr. D'Aun Goble
Mr. and Mrs. Kenneth Goldsholl
Mr. Barry Golombik
Mr. Antonio Graciano
Mr. and Mrs. Thomas D. Guckert
Mr. and Mrs. Richard Haraguchi
Ms. Lauren K. Higa
Mr. and Mrs. Jerry Hoffman
Ms. Jan Holtze
Mr. Zhijiong Huang
Dr. and Ms. John T. Jacobs
Mr. Varun Jain
Mr. and Mrs. Robert H. Jupille
Mr. and Mrs. Henry Kahrs
Dr. and Mrs. George P. Kerns
Dr. and Mrs. Steven J. Koester
Mr. Jeffrey G. Kramer
Mr. Laurence H. Laitinen
Dr. and Mr. Robert J. Lamoreaux
Mr. and Mrs. Luen-Yuan Lin
Ms. Heather Lofton
Dr. and Mrs. Stephen I. Long
Mr. and Mrs. Matthew J. Lum
Mr. Mingrui Lyu
Dr. Vikas Manan and Dr. Jingshi Yao
Mr. Andrew May and Ms. Wendy Lin
Mr. Michael Mayon
Ms. Maryellen McCone
Mr. and Mrs. James I. McGowan
Dr. and Mrs. James A. Means
Mr. Gene I. Miller
Mr. Tom Mitchell
Dr. Raghuraman C. Mudumbai
Mr. Balasubramaniam Muthuvelu
Mr. Amit Nagar and Ms. Padma Nagaraja
Mr. Shyam Natarajan
Mr. Ron V. Ocampo
Mr. Carlos Omphroy
Mr. Matthew A. Ortega
Ms. Theresa Parisher
Ms. Gieun Park
Mr. Kevin Priest
Mr. and Mrs. Frederick M. Przekop
Ms. Gael Sylvia Pullen
Mr. Charles A. Quan
Mr. Michael Quan
Mr. Kiyan Rajabi
Dr. Y. Srinivas Ramakrishna and Ms. Neeraja Sivaramayya
Mr. Yang Ren
Mr. Andres Reyes
Mr. Beck Reyes
Mr. and Mrs. Archie Reyes
Ms. Rachel M. Reyes
Ms. Twila Richvalsky
Mr. Kevin A. Robertson and Ms. Vana Han
Mr. Nathan S.Rudolph
Dr. and Mrs. Michael D. Santos
Ms. Samantha Saraniti
Dr. and Mrs. Edward B. Savage
Mr. and Mrs. Jeffrey M. Schlageter
Mr. Michael Schneider
Mr. Jack A. Schwartz and Mrs. Kyong Yim
Mr. Daniel Shu
Dr. and Mrs. Allen Shum
Mr. and Mrs. Steve Silva
Ms. Rosemary Steiss
Mr. Scott Stillinger
Mr. and Mrs. Thomas R. Stockton
Ms. Holly Stroth
Ms. Lisa Sugg
Mr. David K. Tengan
Mr. Gerald Teramae
Mr. and Mrs. Tuan A. To
Ms. Joan Tournoux
Mr. David Trissel
Mr. William Valaika
Mr. and Mrs. Ashok Vanmali
Mr. Kevin Vergel de Dios
Mr. Vikram Verma
Mr. Cong Wang
Mr. Timothy C. Wang
Mr. Jiafu Wu
Mr. and Mrs. James C. Yu
Mr. Shukun Zhao

We are grateful to all of our individual and corporate donors who made gifts in support of the Electrical and Computer Engineering Department. The above listed supporters made gifts between July 1, 2017 and June 30, 2018.

University of California, Santa Barbara
Electrical & Computer Engineering
Santa Barbara, CA 93106-9560

Non Profit
US Postage Paid
Santa Barbara, CA
Permit #104

ECE 5 FRESHMAN COURSE

Xiangyue Cao, Shi Bai, and Peizheng Tong demonstrate the sensing glove they developed for remotely playing a ukulele (not shown) at ECE 5's Science Fair.

For more information, visit:

https://www.ece.ucsb.edu/~hespanha/ece5/