Stanford | ENGINEERING
Electrical Engineering

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Dear Electrical Engineering Alumni, Friends, and Colleagues:

This past academic year was another exciting one for the department. Our field is in transition from an era of evolutionary advances to a future in which revolutionary technologies and systems are needed to meet the demands of a Big Data–driven world and societal challenges in areas such as healthcare and energy. As I outlined last year, we have been working on a strategic plan that promises to keep electrical engineering at Stanford poised to lead this transition.

We completed our strategic plan, **Electrical Engineering in the 21st Century** (EE21, in short), in the summer of 2014. The plan was well received by our new dean, Persis Drell, and the school's executive committee, composed of the associate deans and all nine department chairs. I am pleased to share this plan with you and the steps we have taken in the past year to implement it. I am also proud to share some of the exciting new research going on in the department and highlight significant recognition of faculty.

ELECTRICAL ENGINEERING IN THE 21ST CENTURY — EE21 PLAN

Electrical engineering's challenges

A key driver in the advance of information technology over the past 50 years has been the scaling of CMOS technology to develop ever faster, cheaper, and more energy-efficient computing and communications systems. As we approach the end of Moore's Law, the current rate of progress in information technology can no longer be sustained through technology scaling and evolutionary extensions of current computing architectures. At the same time, the demands for continued information technology scaling are greater than ever. Specifically, these demands include:

- The "Internet of Things" (or "Internet of Everything"), which is expected to connect a trillion devices in our homes, buildings, cars, and even bodies to monitor our health, our environment, and our resources, presents major challenges: Current devices and systems consume too much power; a trillion devices cannot all be battery-powered; how do we design and manufacture millions of different things; a trillion devices form a large "attack surface."
- The deluge of additional data generated by the Internet of Things—from sources including healthcare records, genomics, and social networks—presents major challenges to information storage and processing.
- Of the National Academy of Engineering's Grand Challenges for 21st-century engineering, those to be addressed in the areas of healthcare, energy, environment, and urbanization require unprecedented integration of information technology into "societal networks."

Electrical engineering's future

To meet these exciting and daunting challenges, the field of EE will need to:

- Develop radically new types of devices and integration technologies that consume orders of magnitude lower energy than the state-of-the-art today.

- Create new data/application-driven systems which will require the invention of radically new architectures that mimic the functionality of the human brain.
- Reinvigorate the "maker culture" in electrical engineering, in which students, researchers, and faculty gain insights and demonstrate their inventions through prototyping from nanostructures to implantable and wearable devices to entire systems of systems.
- Create deeper collaborations with other fields that stretch the definition of electrical engineering and engage experts in health, environment and energy, social sciences, and more.

Realizing this vision requires hiring new faculty, reinventing the undergraduate curriculum, establishing collaborations that span all areas of department and help create a myriad of new collaborations across Stanford, and creating modern facilities.

PROGRESS ON IMPLEMENTING EE21 PLAN

Faculty hiring

One key to realizing the EE21 vision is to add faculty with complementary vision and expertise to our already outstanding faculty. I am happy to report that last year three new faculty have joined our department:

- **John Duchi** – Appointed Assistant Professor of Statistics and of Electrical Engineering, effective September 2014, John's research focuses on machine learning and algorithms for Big Data. He received his PhD in EECS from UC Berkeley.
- **Hyongsok "Tom" Soh** – Appointed Professor of Radiology and of Electrical Engineering, effective July 2015, Tom's research focuses on developing novel materials and biosensors for human health; for example, early cancer detection. Tom was previously the Garland Endowed Chair in Mechanical Engineering and Materials Science at UC Santa Barbara.
- **Gordon Wetzstein** – Appointed Assistant Professor of Electrical Engineering, effective September 2014, Gordon's research focuses on computational imaging and displays and their applications in consumer electronics and biology, among other applications. He was previously a research scientist at the MIT Media Lab.

Reinventing the undergraduate curriculum

The goals of our new curriculum are to provide students with more flexibility to complete their co-term earlier, to double major, or to take courses outside EE; introduce application of the fundamentals of EE early in the curriculum; foster the maker culture in EE education; and teach all engineering students about basic EE tools. To achieve these goals, we have been revamping several core courses, introducing new core and capstone courses, and having our best teachers teach these courses.

There are early indications that the changes we have been making are achieving the aforementioned goals. Last year, our new course ENGR40M, *An Introduction to Making: What Is EE*, attracted close to 400 students. The enrollments in our three core courses (101A, 102A, 108) have almost doubled from 2013-14. The number of declared EE undergraduate students is now higher than any time in the last two decades.

Launching the SystemX Alliance

For over 30 years, the Center for Integrated Systems (CIS) was one of the most successful university-industry research programs in the world. Although its mission was "integrated systems," it became identified mostly with device technology and integrated circuit fabrication technology. Emphasizing

application-driven and system-oriented research, SystemX aims to return CIS to its original mission, with a 21st-century focus of fostering innovations at all levels of the technology stack. SystemX focus areas span a wide range from the Internet of Things to bio interfaces, to quantum technologies and heterogeneous integration.

Planning new shared laboratory facilities

Creating the new devices and systems and fostering the maker culture envisioned in the EE21 plan require new types of shared research laboratories. We are currently planning two new shared facilities, both of which will be used for research and for maker classes:

- **Experimental Fab (ExFab).** This facility aims to provide the tool set and expertise to prototype a wide variety of materials, from organic molecules and nanostructures to polymer and metal thin films to semiconductors, including the integration of electronic and optoelectronic chips with other materials.
- **System Prototyping Facility (SPF).** This facility aims to provide design services for prototyping complete systems comprising integrated circuits, printed circuit boards, and software.

Planning new instructional labs

Our new undergraduate curriculum aims to create a *culture of creators*, which entails continued innovation, networking, and collaboration. Having the laboratories and overall environment conducive to this new vision is critically important. Hence, we are planning a major of renovation in the Packard building to provide (i) a maker space that allows students to design and build things (outside their classroom work) that we cannot predict today; (ii) completely transparent space—students can see what tools are available, who is working with them, and what can be done with them—to foster open exchange of new ideas; and (iii) meeting spaces to allow students to collaborate on projects and to share their ideas.

In addition to these exciting developments that collectively aim to realize the EE21 vision, I would like to highlight the following developments:

- We have introduced a new joint **EE MS/MBA** program. This joint degree represents the growing emphasis on multidisciplinary learning at Stanford, builds on the culture of entrepreneurship and creativity in the schools of business and engineering, and will better equip our students to take new technologies from basic research to commercial products.
- For the first time in the department history, our undergraduates now have a department supported student group, **Fuse**, which aims to strengthen the EE undergraduate student community through study nights, social events, and peer networking.
- In addition to providing the latest EE news and event information on our homepage, we are now providing this information through **social media** channels including Facebook and LinkedIn. You will find links to these communities on our home page, ee.stanford.edu.

RESEARCH HIGHLIGHTS

As always, a tremendous amount of exciting research is going on in the department. I encourage you to visit the EE Department website, ee.stanford.edu, to learn about our ongoing research across the entire field.

Amin Arbabian and his collaborators used ultrasound to power tiny medical implant chips. The chips could potentially execute medical commands and report back.

Shanhui Fan and an interdisciplinary team from EE, ME, and Applied Physics reported an energy-saving breakthrough in the journal *Nature.* Using a thermal photonic approach, the material reflects sunlight and emits heat, demonstrating new possibilities for energy efficiency. Shanhui and graduate students **Yu Shi** and **Zongfu Yu** reported in a *Nature Photonics* article backward leakage of optical data transmission, which is important for the design of isolators on optical chips.

David Miller's research has made breakthroughs in the design and fabrication of optical structures that can combine and separate laser beams based on the shape of the wave they generate, potentially allowing more data to flow faster with less energy.

Ada Poon and collaborators in Bioengineering and Anesthesia are leveraging her minuscule wireless devices to study and eventually develop treatments for chronic pain.

Krishna Shenoy's research team observed the moment when a decision is made, or the mind is changed. This finding will help researchers fine-tune the algorithms for controlling neural prostheses.

Jelena Vuckovic and her team published an article in *Nature Photonics* on a process that could revolutionize computing by making it practical to use light instead of electricity to carry data inside computers.

Shan Wang's research team developed a hepatitis B blood test that can be analyzed in minutes using the microprocessor in a smartphone. Their invention has been recognized as a Distinguished Award Prize winner in the Nokia Sensing XCHALLENGE.

Tsachy Weissman's research has led to a way to store and process the vast amounts of genetic information needed to tailor medical care to individual needs.

H.-S. Philip Wong and graduate student **Ling Li** reported that graphene promises improved semiconductor performance. Philip is also collaborating with Stanford School of Medicine to test a wireless pressure sensor as a potential tool for patients with severe brain trauma.

FACULTY AWARDS, HONORS & RECOGNITIONS

Four faculty were elevated to IEEE Fellow: **Christos Kozyrakis**, for contributions to high-performance, energy-efficient, and secure memory systems; **Sanjay Lall**, for contributions to control of networked systems; **Tom Lee**, for contributions to the design of CMOS radio-frequency integrated circuits; and **Boris Murmann**, for contributions to the design of digitally assisted analog integrated circuits.

Amin Arbabian received an NSF Early Career Development Award to develop disruptive technologies to scale dimensions down to the sub-millimeter regime while maintaining the capacity to perform advanced multimodal closed-loop monitoring and stimulation for a variety of clinical applications.

Dan Boneh received the 2014 ACM-Infosys Foundation Award in the Computing Sciences for groundbreaking contributions to the development of pairing-based cryptography and its application in identity-based encryption.

Michael J. Flynn received the IEEE Computer Society Pioneer Award "for more than 50 years of leadership, which includes the creation of TCCA and SIGARCH, basic contributions to computer arithmetic, microarchitecture and multiprocessing, and quantitative analysis of microarchitectures."

Bernd Girod was elected to the National Academy of Engineering "for contributions to video compression, streaming, and multimedia systems."

Andrea Goldsmith received the 2014 IEEE Communications Society Edwin Howard Armstrong Achievement Award "for sustained and fundamental contributions to wireless communications."

Jim Harris received the Al Cho MBE Award for his seminal and sustained contributions to the science, technology, device applications, and commercialization of molecular beam epitaxy.

Thomas Kailath was awarded the National Medal of Science by President Obama. Quoting Kailath, "The president said scientists are intrinsically hopeful and believe in grand answers, and that if we work hard enough we can find some of them in our lifetime."

Christos Kozyrakis won the 2015 Maurice Wilkes Award "for outstanding contributions to transactional memory technologies."

Nicholas McKeown was elected to the 2015 class of the American Academy of Arts and Sciences.

Subhasish Mitra received the Semiconductor Research Committee Technical Excellence Award, and was elevated to Fellow of the ACM "for contributions to the design and testing of robust computing systems."

James Plummer received the IEEE Founders Medal "for leadership in the creation and support of innovative, interdisciplinary, and globally focused education and research programs."

Krishna Shenoy has been appointed as a Howard Hughes Medical Institute (HHMI) investigator. He is a leader in the emerging field of brain-machine interfaces to control the movement of computer cursors and prosthetic limbs.

Jennifer Widom was named the 2015-16 ACM Athena Lecturer by the Association for Computing Machinery's Council on Women in Computing. She introduced active database systems, a major area of research in the database field.

STANFORD ENGINEERING HERO — MARCIAN "TED" HOFF (PHD '62)

Because engineers often work behind the scenes, the Heroes program highlights the profound effect engineering has on our everyday lives and aims to inspire the next generation of engineers. **Ted Hoff** was named to the most recent class of Stanford Engineering Heroes. He is best known as the architect of the first microprocessor, Intel's 4004, released in 1971. The Intel 4004 paved the way for many subsequent breakthroughs in personal computing, communications, and the Internet.

STAYING CONNECTED

So much to be proud of, and yet there's much left to do. As EE alumni, you all are part of our storied success—past, present, and future. I'd love to hear your thoughts on our current efforts by emailing me at chair@ee.stanford.edu. Your ideas and support are essential to everything we do.

On behalf of my colleagues, thank you for being an integral member of the EE community. We're very excited about what's to come in 2015-16!

Best regards,

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