"Engineering to me is a blend of magic and science."

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Ali H. Sayed, dean of the School of Engineering at EPFL, talks about engineering today and how it impacts our daily life. He also explains the diversity of engineering and how the school works on today's World main challenges.

> *"EPFL is blessed with strong faculty members and a population of dynamic and creative students."*
>
> — Ali H. Sayed, Dean of the School of Engineering

What is engineering to you?

Engineering to me is a blend of magic and science. When you pick up your cell phone and talk to a friend who is miles away on another continent without any wire connecting you to them, isn't that magical? When you slide into an MRI machine and it scans the inside of the human body and even your brain without touching you, isn't that magical. Just imagine how much engineering ingenuity and creativity went into designing these systems and many others.

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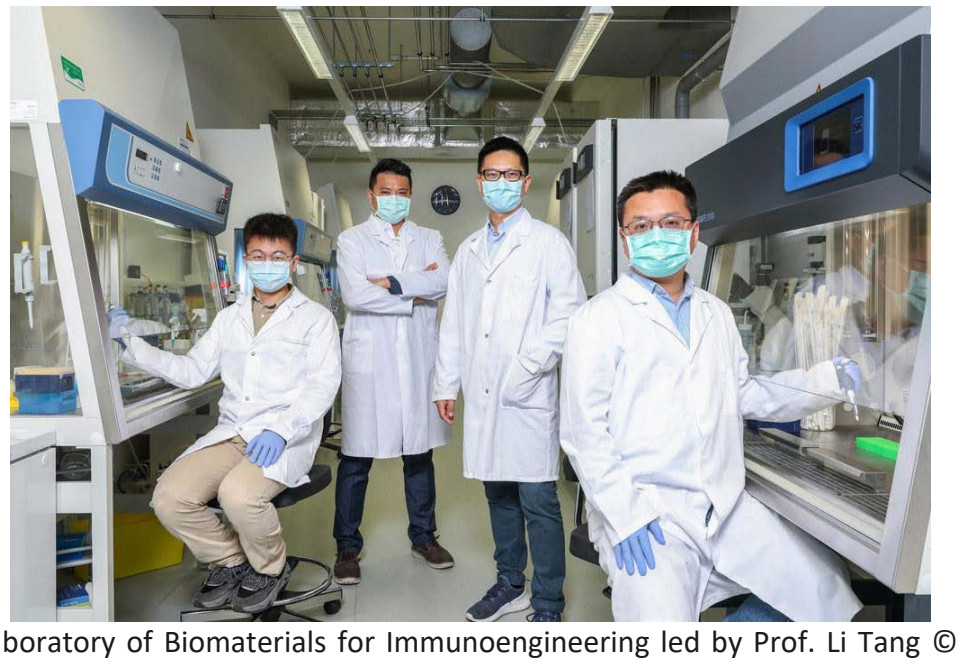
But we rarely think of these complexities?

Precisely. Engineers are so good at perfecting their designs that they become second nature to us. Each one of us carries a cell phone in their pocket, drives their car, or flies regularly between destinations, without giving minimal thought to the devices we use and how much engineering science went into their development.

I once participated in an event with close to 2000 parents and their children to welcome them to the engineering campus. I walked to the podium, turned off the microphone, and started talking. People obviously started complaining, at which point I turned the system back on and made my point. We take microphones, electricity, and other amenities for granted and often forget how much history, science, and engineering stand behind them. I explained that I was there to welcome their children to a place that will prepare them to that amazing cycle of creation and design.



Laboratory of Biomaterials for Immunoengineering led by Prof. Li Tang © EPFL - Alain Herzog

It sounds both exciting and challenging. What advice do you have to students interested in engineering?

If you love problem-solving then engineering is for you. Engineering is the art of exploring, aiming for the impossible, and coming up with pragmatic technological solutions. An engineer looks into the sky and starts planning with their fellow scientists how to launch a robot into the dark deep space and land it on a remote planet, to explore vastness never touched before. Along the way, many new discoveries and technologies are brought to life that benefit society at large.

If you care about the challenges our society faces today, then engineering is also for you. Our discipline is essential to tackle many existing societal problems, whether in planning more efficient transportation systems, designing machines and processes with minimal impact on the climate and environment, or developing technologies to counter neurological disorders. The range of opportunities is broad and appeals to a wide spectrum of students whatever their interests are. An engineering education will prepare them to stand up confidently, face many technological challenges of the future, and leave an impact on their World.

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Indeed, technology has fundamentally altered the way we communicate and even live our lives.

I once wrote in one of my editorials, just “imagine if we were to switch off electricity today, ground our planes, park our cars, disconnect our communications infrastructure, and disable all phones, radios, TVs, and the Internet. In the minds of many, we would be returning to the Stone Age.” Of course, in the wrong hands, even a well-intentioned technology can do harm and this trend has existed since time immemorial. But overall, technological advances have brought comfort to humanity. Can you imagine how much harder it would have been to live through the current COVID pandemic without video-conferencing and wireless communications technologies?

Even more importantly, engineering today is a discipline where real scientific discoveries happen, and not just inventions or innovations. Einstein postulated the existence of gravitational waves around 100 years ago, but it took until 2016 to detect them with the assistance of enabling technologies and engineering advances.

Moreover, many engineering innovations such as the radio, the transistor, the LED, fiber optics, and foundational work on information and communication technologies have been awarded Nobel Prizes.

In what other ways is the engineering discipline evolving?

Engineering is undergoing transformational changes that influence the way we run our research, educate our students, and interact with industry and society. For one, these changes will create new types of jobs for our students and necessitate that we continually adjust our curricular activities and research focus. I recognize at least four trends.

First, there is a much closer synergy evolving between the engineering and life sciences. This proximity will alter the way we probe and interact with living cells, and it is driven by modern advances in engineering technologies such as miniaturized circuitry, nano- actuators, implantable devices, soft materials, and even powerful imaging modalities. The combination of “miniaturization,” “invasive probing,” and “imaging’’ will lead to new science, new discoveries, and new treatment modalities.

How is the School of Engineering responding to this trend in the health sciences?

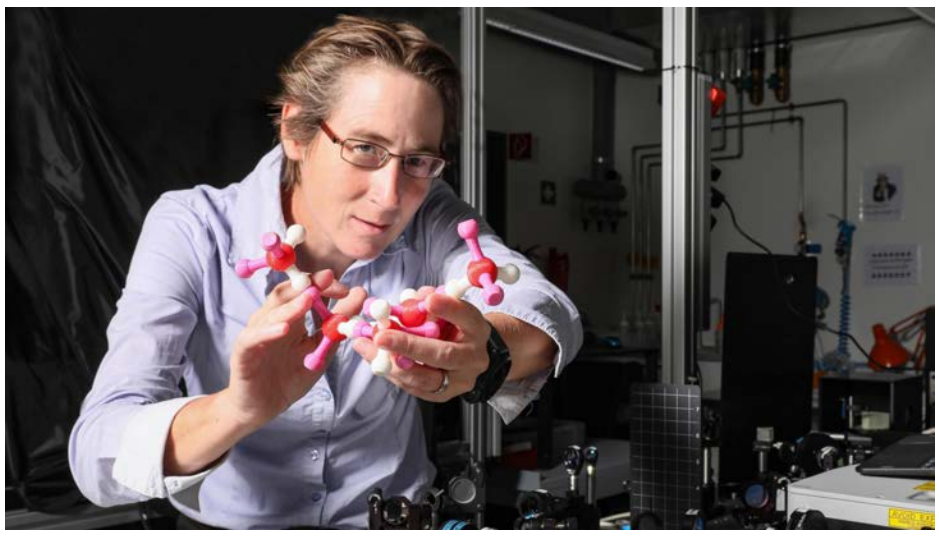
Underwater view of a metasurface consisting of gold nanorods © Aurélian John- Herpin / 2021 EPFL

We have formulated a couple of strategic initiatives at the School of Engineering, one of which is aimed at strengthening our contributions to the life and health sciences. Several recent and planned faculty searches in the School have been in support of this strategy including, for instance, hires in neuro-engineering, cancer engineering, brain-machine interfaces, bio- robotics, and integrated biosensors and bioelectronics.

The school has also been strongly supportive of several EPFL-wide initiatives that contribute to this same strategic theme, such as the newly launched EPFL Center for Imaging, the new joint EPFL/Ludwig/CHUV/UNIL Center on Onco-Immune Engineering, and the ongoing EPFL initiative on NeuroX, which aims at consolidating all activities related to neuroscience and neurotechnology. Some of these efforts involve curricular programs as well, in order to train our students for careers in these important fields.

Maartje Bastings © 2021 EPFL

Already today, the School of Engineering has formidable strength in bio-related disciplines, with several of its faculty members playing leading roles. For example, Stephanie Lacour leads the Center for Neuroprosthetics in the Geneva Biotech campus, Michael Unser leads the Center for Imaging in the Lausanne campus, Yves Perriard leads the Center for Artificial Muscles in the Neuchatel campus, Sylvie Roke co-leads the Institute of Bioengineering in the Lausanne campus, and Christoph Merten co-leads the Center on Onco-Immune Engineering. Several other faculty members run research programs in supporting fields such as medical imaging, brain imaging, and microscopy, implantable devices, prosthetics, bio-instrumentation, biomechanics, micro-robotics, and labs-on-a-chip, as well as biomaterials, nanomedicine, and immuno- engineering, including by Professors Jean-Phillipe Thiran, Dimitri Van De Ville, Phillipe Renaud, Carlotta Guiducci, Li Tang, Francesco Stellacci, Hatice Altug, Maartje Bastings, Masha Shoaran, Diego Ghezzi, Silvestro Micera, Selman Sakar, Aleksandra Radenovic, Dominique Pioletti, Georg Fantner, Sandro Carrara, and the list goes on. Students interested in these domains will find a gamma of research labs and educational courses available to them.



Sylvie Roke in her laboratory © 2020 Alain Herzog

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What other trends are happening in engineering?

A second important trend is the gradual merging of the “physical and virtual worlds,” through machine intelligence and the development of wearable technologies, augmented reality, robotic co-workers, autonomous and intelligent systems, and other similar technologies. Once fully developed, these intelligent interfaces will influence the way we live and work. This is because intelligent systems will be able to learn from experience and from humans. These systems will blend elements of robotics and artificial intelligence, and they will impact manufacturing, transportation, healthcare, privacy, and other domains. We need to be conscious of these implications and remain alert to the many ethical questions that will arise in this evolving environment. A new engineering science will need to emerge in order to design and control sophisticated systems that will now have a “mind” of their own.

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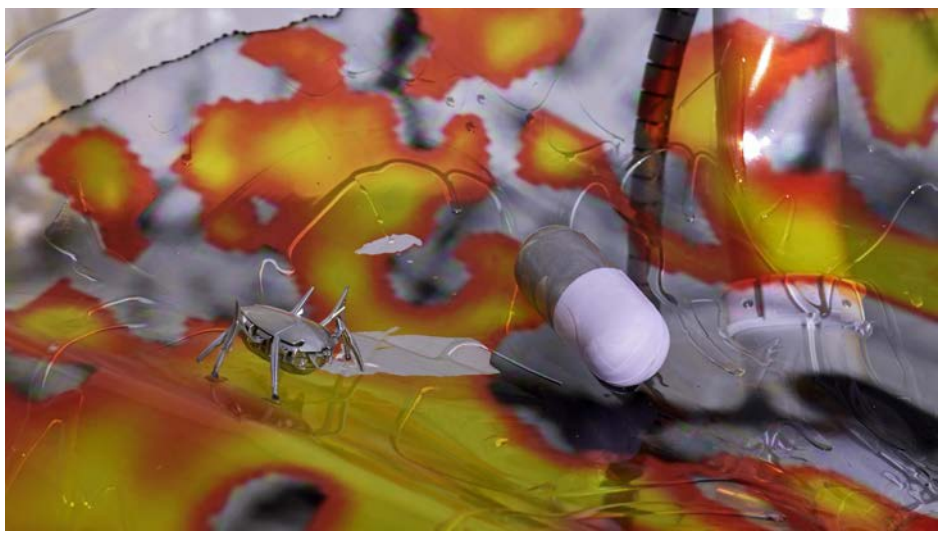
How is the school responding to this trend on intelligent and complex systems?

Dimitri Van De Ville and Anjali Tarun © Alain Herzog / 2021 EPFL

We have put in place a second strategic initiative aimed at expanding our presence in the domain of intelligent and complex systems. Several recent and planned faculty hires have been in support of this strategy, including hires related to intelligent robotics, advanced manufacturing, and machine learning for science and technology. The school has also been a strong promoter of the EPFL Center on Intelligent Systems with other sister schools on campus. Again, curricular programs are being adjusted or will be developed to train our students on the foundations of machine intelligence for complex systems engineering. There is also formidable expertise across campus that is relevant to the study and design of intelligent systems, and the School of Engineering is supporting the consolidation of these efforts.

Students interested in this domain will be able to find many research labs and faculty members already active in this domain. For example, Pierre Vandergheynst leads the Center on Intelligent Systems on the Lausanne campus, Pascal Frossard leads the ELLIS unit (European Lab for Learning and Intelligent Systems) also on campus, and Dario Floreano leads the NCCR on robotics. Several other faculty members run research programs in supporting fields such as optimization theory, statistical learning theory, adaptive systems, graph theory, network science, mechatronics, and robotics including Aude Billard, Volkan Cevher, Florent Krzakala, Jaime Paik, Auke Ijspeert, Josie Hughes, Herb Shea, my own lab, and others.



Robotics at EPFL © 2021 EPFL / Alain Herzog

You mentioned earlier four trends. What are the other two?

Right. The third trend relates to digitization and the prevalence of massive amounts of data. There is no question that we are living in a highly networked society, with data exchanges at rates unseen before. And this level of connectivity will continue to increase with the deployment of IoT, 5G, new sensing modalities, edge computing, and cloud technologies. The engineering discipline will need to adapt to this new reality. While in the past, it has been normal to center much of our engineering designs around pre-determined models, we will now be able to pursue designs that are almost entirely data-driven without the need for explicit models or even in situations where such models do not exist.

Applications will be abundant including in bioinformatics, personalized health, finance, discovery of new materials, digital twin technologies, and other areas. Safety, security, and reliability will be key, especially since these data-driven designs will need to remain alert to intrusion and manipulation. We are all aware today of the possibility of deep fake videos. Deep fake data is not far behind.

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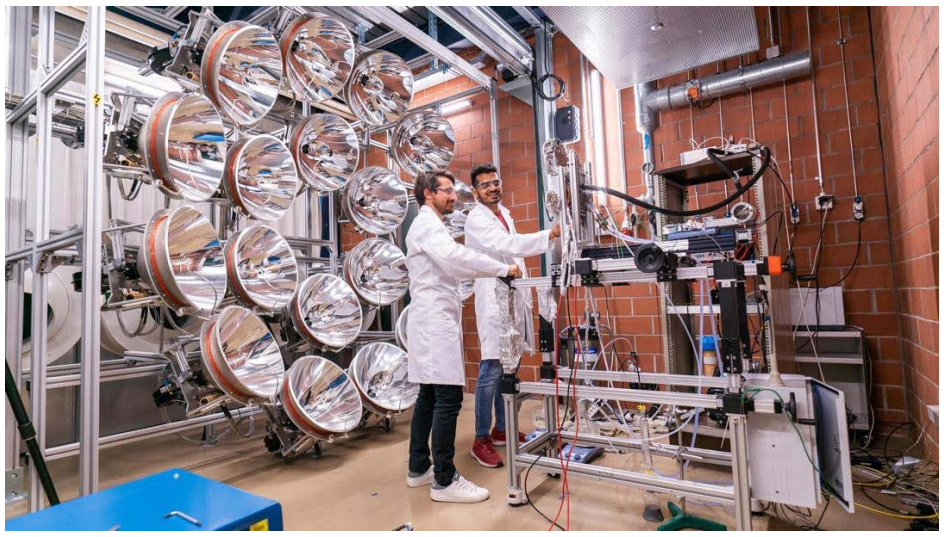


Laboratory of Renewable Energy Science and Engineering © 2021 STI

The fourth trend relates to the use of renewable resources and sustainable materials in engineering design. This is the result of a more alert society, one that is increasingly aware of the impact of technology on their welfare. Society at large is imposing, and rightfully so, more stringent requirements on the use of raw materials, energy resources, and the effect on climate and the environment. The situation is compounded if we consider that these constraints will need to be met alongside the ongoing proliferation of wireless technologies, data servers, electric cars, and autonomous systems, all of which will demand more energy and will need to rely on renewable and sustainable materials.

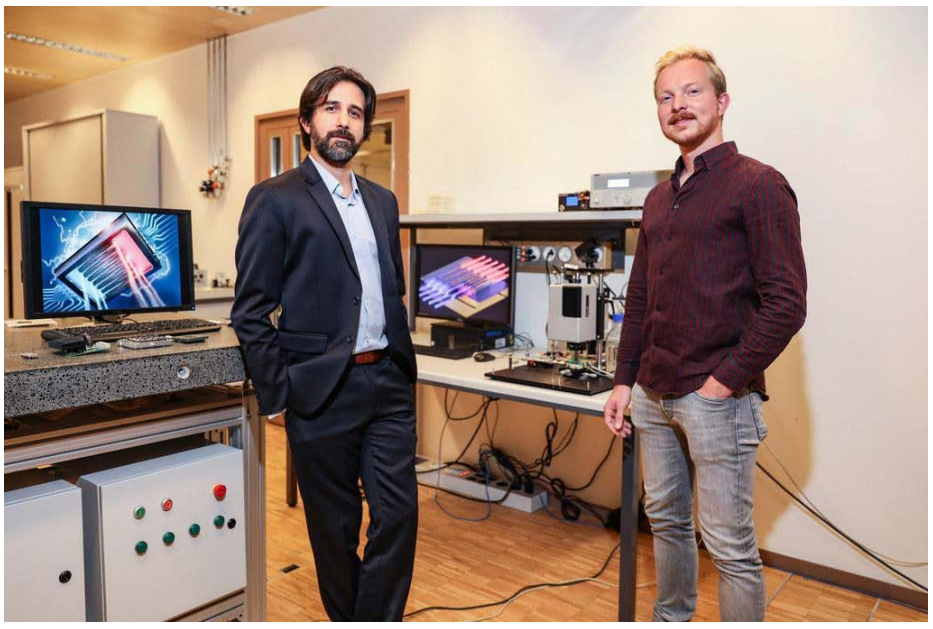
How is the School of Engineering responding to these two trends?

Digitization is a strategic initiative for EPFL, and also for Switzerland. Engineers need to be at the center of this revolution for one simple reason. If we flash back to the 1970s and 1980s, it was engineers who took great advantage of the software “revolution” at that time. They used it to develop impressive computer-aided design (CAD) tools, which we use today to design sophisticated aircrafts and even integrated circuits with billions of transistors inside our desktop computers. Engineers will play a similar role in the ongoing data “revolution.” They will be the ones who will be designing the intelligent machines of the future. And to do that, they will tap into the ongoing progress in machine learning and AI to create new “intelligent” CAD tools that will help them explore the design space more fully, discover new materials and processes, monitor climate and environmental conditions, and much more. We need to prepare our engineering students to contribute to this reality.

Faculty members and staff © 2018 EPFL

At the School of Engineering, we have formulated two other strategic initiatives that aim at advacing data- driven engineering, as well as contributing to a more secure and sustainable society. Again, several recent and planned faculty searches contribute to these efforts, including hires related to data-driven design, sustainable materials, sustainable manufacturing, energy storage, materials for batteries, and hydraulic machines. Several engineering faculty members are involved in the EPFL Energy Center and in the Swiss Data Science Center, as well as in the new Master Program on Energy and the new Minor on Sustainability. The School has also been a strong supporter of the newly launched EPFL Center on Quantum Science and Engineering. This field is strategic and, once successful, quantum technology will facilitate the processing of massive amounts of data.

For students interested in digitization and sustainability, we have many active research groups. For example, Mario Paolone leads the EPFL Energy Center, Christophe Ballif leads the CSEM PV Center in Neuchatel on solar energy and photovoltaics, and Nicola Marzari leads the NCCR on Computational Material Science. Several of our faculty members run research programs in supporting fields such as computational design, large-scale simulation, IoT, edge computing, and quantum technology, concrete technology, sustainable materials, sustainable manufacturing, advanced manufacturing, renewable energy, energy distribution and conversion, fuel and cell technology, solar cells, smart grids, and power electronics, including by Professors Michele Ceriotti, Drazen Dujic, Edoardo Charbon, Adrian Ionescu, Andras, Kis, Sophia Haussener, Karen Scrivener, Veronique Michaud, Holger Frauenrath, Pedro Reis, Giulia Tagliabue, Elison Matioli, Harm-Anton Klok, Dimitrios Kyritsis, Jurg Schiffmann, William Curtin, Tobias Kippenberg, Vivek Subramanian, Jan Van Herle, David Atienza, Francois Marechal, and others.



Elison Matioli & Remco Van Erp © 2020 EPFL

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Any concluding thoughts?

EPFL is blessed with strong faculty members and a population of dynamic and creative students. Given our faculty size, the engineering school needs to be focused in its approach without spreading thin in many directions. For this reason, we have been promoting these four strategic areas related to the life sciences, intelligent systems, data-driven design, and sustainability, along with an emphasis on strong foundations and on domains of great societal impact in coordination with sister schools on campus. This three- pronged approach consisting of a focused strategy plus strong foundations plus societal impact is the driver behind our activities in the School of Engineering.

Engineering students participating in an Embedded Systems competition run by Professor David Atienza © EPFL

Source: People

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