ETH Zürich Foundation

# Uplift

The impact of giving

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## Robotics

ETH Foundation

# Switzerland is a robotics hotspot

ETH Zurich / Markus Bertschi

Christian Wolfrum
Vice President for Research at ETH Zurich



The greater Zurich area has come to be known as the Silicon Valley of robotics. Key contributors to the robotics success story are talented individuals at ETH Zurich whose innovations include exoskeletons to support rehab patients, indoor drones for inventory-checking in large furnishing stores, and weeding robots that improve environmental standards in agriculture.

Switzerland has the potential to capture a significant share of the globally competitive robotics market, but for ETH to remain a leader in research and continue to supply the market with world-class start-ups, it must be able to attract and advance the most inventive minds. Read on to meet some of the leading lights in ETH robotics, learn more about our partnerships – and be amazed at how smoothly robots will move in future.



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# At robot training camp

Robots that function reliably and independently: with her AI-based research, doctoral student Jelena Trisovic wants to help ensure that autonomous systems in the future provide us with the most effective support possible.

Getting self-driving toy cars to successfully navigate a mini-race track at high speed, or a robotic hand to transport an object from one place to another: behind the projects Jelena Trisovic is participating in are a variety of interlinked research questions. “I want to improve the interplay between perception and control in autonomous systems. Only then can the systems perform complex tasks in a challenging environment with the required autonomy and reliability,” the young researcher explains. Currently, most robots have two separate modules responsible for this: the perception module and the control module. The output of the perception module's readings, such as a map, is forwarded to the control module, which tells the robot where to go and what to do. If the data it receives is incorrect, the robot is unable to perform its task as intended, because it cannot compare data between the modules. This is of particular importance when it comes to search and rescue robots, for example. When deployed in disaster areas – and therefore in unfamiliar terrain – these robots must be able to process the sensor data and images they’re collecting and simultaneously use it to plan and execute their movements. In other words, the perception module and the control module must be able to coordinate consistently with each other. Jelena Trisovic is developing methods she plans to use on a mini-race track: here, self-driving toy cars have to race along an unknown route, while autonomously detecting and avoiding obstacles such as other cars.

**Inspiration from interdisciplinary influences**

The doctoral student is pursuing her research through a fellowship at the ETH AI Center, a hub which brings together more than 110 professors working on the foundations, applications and implications of artificial intelligence. Originally from Serbia, Jelena Trisovic came to ETH Zurich for her Master’s in electrical engineering and information technology and received support from an Excellence Scholarship. “Thanks to the scholarship, I was able to fully concentrate on my studies and benefit from an exciting community,” recalls the young scientist who, in addition to her exceptional

**“I want to play my part in safely harnessing the potential of autonomous robots for society.”**
Jelena Trisovic, ETH AI Fellow

*AI Fellowships are funded by the Dieter Schwarz Foundation, Google, Meta, the Asuera Stiftung and the Hasler Stiftung.*

At the Intelligent Control Systems group's racetrack, Jelena Trisovic tests models to improve the connection between computer vision and system control.

skills in mathematics, is also passionate about learning languages – and holds a black belt in karate.

Towards the end of her Master's programme, she applied for one of the coveted AI fellowships. She was among the two percent of all applicants to receive one of the spots. "I divide my time between the AI Center, Professor Melanie Zeilinger's Intelligent Control Systems group, and Professor Fisher Yu's Visual Intelligence and Systems group," Jelena Trisovic explains. While Melanie Zeilinger's lab focuses on the control of autonomous systems, Fisher Yu's research group is concerned with perception systems. The interdisciplinary setting allows the doctoral candidate to approach her research questions from different perspectives and draw on comprehensive expertise.

**Tapping into the full potential**

With her research, Jelena Trisovic not only wants to help robots become better at mastering their tasks, but also ensure their safe deployment in unknown environments. To achieve this, being able to explain and thereby understand the approaches used, including deep neural networks, is crucial. "Because that's the only way we can ensure that robots perform tasks as planned and cause no harm", the researcher explains. Jelena Trisovic sees important potential applications for autonomous systems primarily in situations that are risky for humans: "When robots like Mars rovers take readings in space or when they locate – or even help recover – survivors after an earthquake, the benefit they bring to society is huge."

Some of these applications are already a reality, but there's still a huge amount of potential to be tapped. Her explicit goal is to help develop a system that can perform its task reliably in an unknown environment without human supervision, i.e. that works "in the wild". But this is likely to take a while. After all, things that humans take for granted, such as reacting flexibly in unpredictable situations, or the ability to identify something by touch, require the interplay of countless components in robots. However, with rapid technological developments and new findings in the AI field, these scenarios are drawing ever closer – thanks in part to research of the calibre conducted by Jelena Trisovic.

Find out more:
ethz-foundation.ch/en/esop
ethz-foundation.ch/en/eth-ai-center

# "A huge amount of young potential"

ETH professor and serial entrepreneur Marco Hutter knows where the greatest opportunities in robotics lie. We pay a visit to his lab.

*The greater Zurich area, which includes ETH, is often termed the Silicon Valley of robotics. Justifiably so?*
**MARCO HUTTER –** We have indeed made a good name for ourselves. Besides our research, which counts among the world's finest, many robotics start-ups are located here, and also large companies – especially in the IT sector – that have entered into the robotics field. Switzerland has always been a leader in mechanical engineering and automation, and robotics is nothing other than a continuation along the journey to autonomation.

*ETH has set up the RobotX Center to bolster its position in the field of robotics in the coming years. How exactly?*
Firstly, by continuing to expand the scope of its research, specifically across disciplines. Secondly, with the support of industry, as many major industries are increasingly realising that robotics can provide the answer to many of today's problems – from the shortage of skilled workers to sustainability to the scarcity of resources. ABB Schweiz, Hilti and Credit Suisse are already partners and are jointly funding new professorships and projects. Thirdly, by designing programmes in which students not only learn theory but also work hands-on on systems, we want to promote education and training in the field.

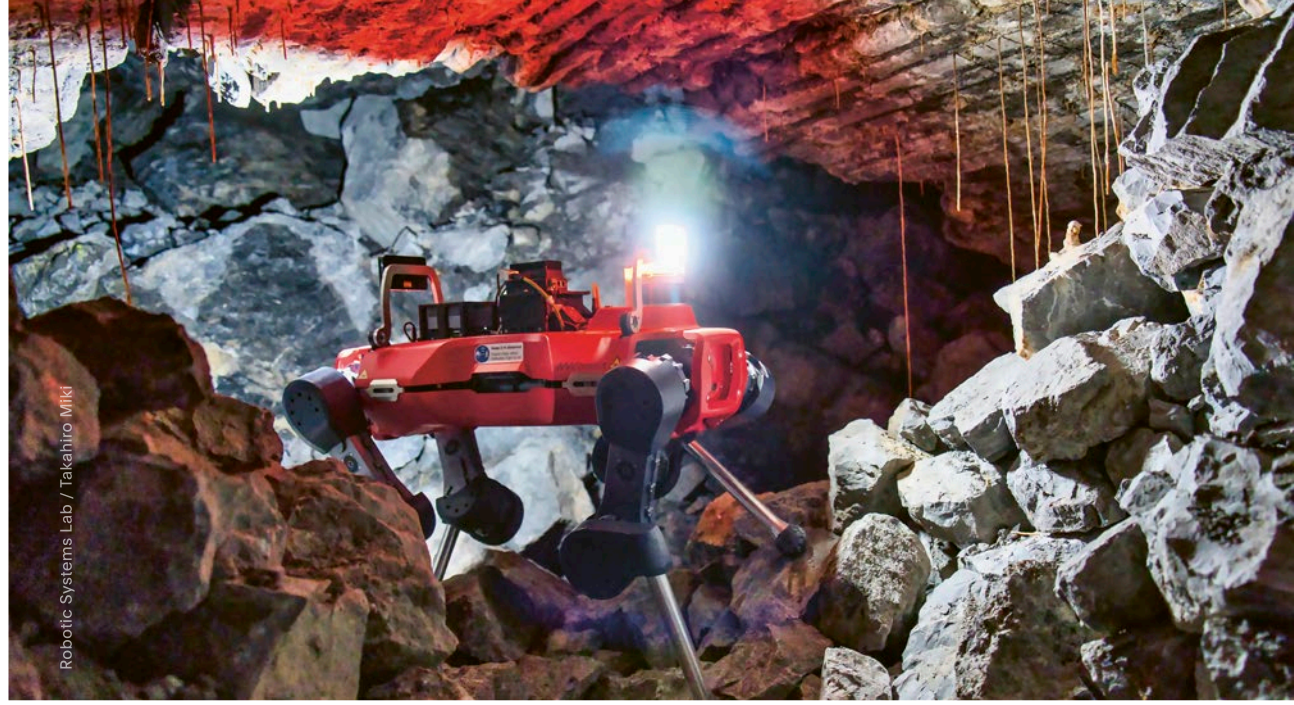
*Your Robotics Systems Lab generates a large output of start-ups – such as ANYbotics, that's put the four-legged walking robot ANYmal on the market. How does the ecosystem work?*
The start-ups and their outreach make Zurich even more attractive for top students. In terms of what they mean to our lab, they show that our research doesn't just end up in a paper but achieves an impact that extends much further, and this is incredibly motivating. There's also a feedback loop between the two parties. For example: ANYbotics robustified the technology that is in ANYmal, and which was first developed here. When I was doing my doctorate, we built the initial prototypes – but they always quickly broke down. Now, thanks to our start-up, ANYmal is a reliably functioning product. The lab can use these robust and mature systems for research missions in difficult terrain and develop new expertise. A key part of the journey was our ETH Pioneer Fellowship grant. This carried us through the time when the technology was insufficiently developed for investors until the company was founded.

**"Robotics can provide the answer to many of today's problems."**
Marco Hutter

*In 2021, your team won the DARPA Subterranean Challenge, the biggest robotics competition in the world. What did that mean to you?*
It was a fantastic success! Never before had a group with a European lead won a DARPA competition like this. And we used almost only Swiss robotic systems. The win was also a boost for the walking robots field, especially since they'd long been seen as a gimmick.

*At the end of last year, ETH announced that the DDPS (Department of Defence, Civil Protection and Sport) was supporting selected robotics projects that could be used in future by rescue and security forces in unarmed missions.*
Robotics has a huge amount to offer when it comes to rescue and clean-up operations, such as after a storm or accident. But organisations like the fire services don't have the money for ten years of robot research. We're working with the DDPS to test technology with end users, so that they understand what's available and we understand what's needed. Every year we go to a training village for a week and test our systems in fields of debris or in buildings with radioactive material. I'm convinced that in just a few years we'll be able to build effective robots that can be deployed in situations of genuine danger.






ANYmal's batteries last for two hours of autonomous work in a harsh environment. The robot is equipped with lidar sensors, visual and thermal cameras, microphones and gas-detecting sensors.

*What do you say to criticism about possible warfare applications?*
We're very aware of this problem which, incidentally, has long been a subject for many technologies. This is why we're transparent and have clear guidelines and regulations, which also apply to the start-ups.

*How might robotics one day change our daily lives for the better?*
Unfortunately, there are still many jobs that are so dangerous that no person should be doing them: in mines, for example. Robots would be better here. Certain industries, like the construction industry, are having difficulties to find labourers. This is also where robots could step into the breach. Robots represent a huge opportunity for enabling agriculture to produce on a more profitable and sustainable basis. By the way, that doesn't mean that robots will take away our work: robotics is creating many new jobs and will form part of a societal restructure. And: this week we did tests with a paralysed person who struggles with everyday tasks. By opening doors, or grasping an object, robots offer chances to make such people's lives significantly easier.

*Why are philanthropic funds well invested in robotics?*
Because there's a huge amount of young potential available to drive the field to new levels. One of the largest pools of students at ETH is formed by the Master's programme in robotics and there are so many possibilities for transferring research into a commercial enterprise. But: robotics needs a lot of time. By contrast, if you develop an app, the business is much simpler and quickly scalable. In robotics, we need a lot of staying power until systems are economically profitable. And also because robotics is an important pillar for Switzerland and its future.

*What would you still like to experience in your research career?*
I've always been fascinated by space research. And now it's really taking off. I'd like to see our technology used on the Moon or Mars.

# Robotics on the rise

**Increasing numbers of ambitious researchers at ETH Zurich are taking the plunge and founding commercial enterprises. Some particularly promising young entrepreneurs have been – or are being – supported by donors to the Pioneer Fellowship programme. We present a selection:**

## *Gravis Robotics*

**Autonomous construction machines:**
the technology is used in settings like clearing streets after natural disasters where human lives would otherwise be endangered.

## *incon.ai*

**AR for construction projects:**
the technology combines computer vision and digital models with augmented reality to place building components with precision.

## *Fixposition*

**High-precision positioning:**
the spin-off supplies real-time navigation systems with levels of previously unattainable precision for self-driving cars, robots and industrial drones.

## *Tethys Robotics*

**Underwater drones:**
a drone that uses acoustic sensors to navigate waters and can be sent on assignments like search missions in strong currents.

## *Auterion*

**Drone software:**
in 2022, the company signed a million-dollar deal with US supermarket chain Walmart for its drone delivery service.

## *No-Touch Robotics*

**Contactless robot grippers:**
the use of acoustic levitation forces enables the grippers to manipulate sensitive objects in the micro range such as is required in the watch or semiconductor industry.

## *Scewo*

**Electric wheelchair:**
the ETH spin-off's unique wheelchair can climb stairs.

## *Auxivo*

**Exoskeletons:**
the spin-off launched by the Rehabilitation Engineering Lab develops wearable solutions for various sectors to reduce the strain on workers lifting and holding heavy weights.

## *Caterra*

**Weeding robot:**
small, light and free of chemicals – the laser-based robot designed by Caterra removes weeds efficiently and ecologically.

Find out more:
ethz-foundation.ch/en/pioneer-fellowship

# Building better with robots

Tool manufacturer Hilti funds a professorship at ETH Zurich's RobotX Center. We talk to Hilti CEO Jahangir Doongaji who explains the reasons for the partnership.

*Why is Hilti supporting robotics research at ETH Zurich?*
**JAHANGIR DOONGAJI –** We were already looking into the use of robotics technology in the construction sector back in 2016 and had started looking around for partners to work with us on this challenging development. ETH Zurich is one of the world's leaders in the field of robotics and, as a Liechtenstein company, Hilti feels a natural affiliation. The university offers us access to the latest findings and outstanding talent, which is why we've formed this long-term research collaboration. We're also funding – together with the Hilti Family Foundation Liechtenstein – a professorship at the RobotX Center, founded in 2019. Joining forces with ETH is also valuable because it's important for Hilti as a company to be seen as a serious employer in terms of the future technologies of robotics and computer vision. The research partnership with ETH and the involvement of students in the company through internships and Master's theses reinforce this perception.

*Which aspects of research and teaching in the RobotX environment are of particular relevance to Hilti?*
Our focus lies in areas like navigation, positioning, control technology, and perception and interpretation of an environment. The activities at the Center are also interesting for many of our innovation fields, such as those around mechatronic and digital solutions.

*In recent decades, robots have found their way into many industries in which tasks can be automated – and now they've reached the still very traditional construction industry. What is Hilti hoping from robotics here?*
The construction industry is undergoing a fundamental transformation. To meet its rising challenges – including inadequate productivity, skilled worker shortage, occupational health and safety requirements, as well as sustainability – the industry is increasingly turning to possibilities offered by digitalisation. This allows processes to be industrialised and automated, with robotics potentially able to make a huge contribution. Our customers are looking for solutions like these, and an increasing number of start-ups are looking at how robotics can be deployed in the construction industry. At Hilti we're convinced that, with our close customer relations, technical expertise and understanding of applications on construction sites, we can drive developments forward and help our customers through this transformation. They're the reason why we focus our efforts on transforming new technologies into solutions that will ultimately enable them to build more productively, safely, sustainably and simply "better".

Hilti / Lukas Gruber

Over twenty years at Hilti, and CEO since January 2023: this is Jahangir Doongaji, who grew up in Mumbai with his Indian architect father and Swiss mother.

**“The construction industry is undergoing a fundamental transformation. To meet its rising challenges, the industry is increasingly turning to possibilities offered by digitalisation.”**

Jahangir Doongaji

*How should we imagine the interplay between human and robot on construction sites in the future?*
Robots such as the Hilti Jaibot, our semi-autonomous drilling robot, enable end-to-end digitalisation of all tasks in a work process: from planning to automatic and precise execution of the tasks through to feedback in the building’s digital model on the work performed. Robots can be used to identify and exploit efficiency potential at many points along the value chain. For example, 500 drilled holes per hour are now feasible. Humans will take on the role of coordinators on the construction site and therefore perform fewer of the tasks themselves. Human-robot collaboration also helps resolve the shortage of skilled workers in the construction industry: new, IT-supported responsibilities, such as operating a robot, make the industry more attractive for young workers. When robots take over the most strenuous tasks – like serial drilling overhead – work on construction sites becomes less physically challenging. It also significantly increases occupational safety.

*Let’s finish off with two personal questions for the ETH alumnus: what memories do you have of your studies as a mechanical engineer?*
I have great memories of my time at ETH! I feel very emotionally connected to ETH. In those days, coming from India, I had to take the entrance exam and was pretty proud when I cleared that hurdle. At ETH I learned to really learn things, to get to the root of something and not let go until I’d fully understood it. I still benefit from that to this very day. And in terms of interpersonal relations, ETH was formative. I found friends for life at the university. As I’d left my social life behind in India, the friendships I made during the early days in Switzerland and at ETH were all the more important. And I’ll always remain indebted to my professor for fluid dynamics, Hans-Peter Thomann. I wrote my thesis paper under his supervision and also spent some time working at the institute after graduating.

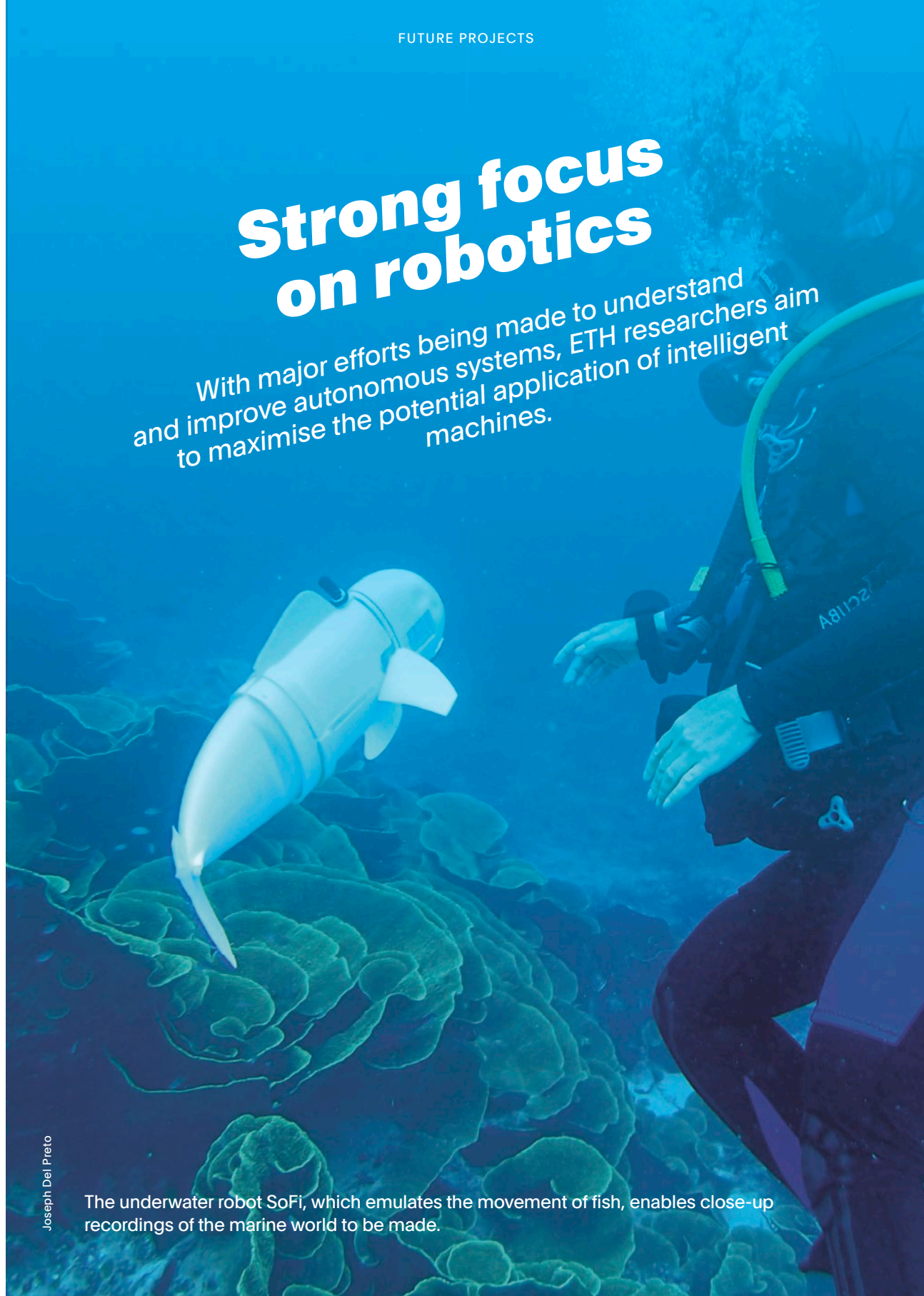
*How do you view ETH now?*
It makes me proud that we in Zurich have one of the best technical universities in the world. My education at this university has enabled me to pursue a very exciting career and so I’m naturally delighted that two of my three children are now studying at ETH too.





# Strong focus on robotics

With major efforts being made to understand and improve autonomous systems, ETH researchers aim to maximise the potential application of intelligent machines.



Joseph Del Preto

The underwater robot SoFi, which emulates the movement of fish, enables close-up recordings of the marine world to be made.

When imagining a robot, most people think of a machine built of plastic and metal, whirring or humming as it goes about its business. Robert Katzschmann's robots are different: in the Soft Robotics Lab at ETH Zurich, he and his team are working on machines made of soft and compliant materials equipped with silent artificial muscles that convert electrical energy directly into muscular contractions. The modelling, control and learning techniques being developed in Professor Katzschmann's lab enable the construction of intelligent systems that resemble living organisms and can be used in a range of applications. For example, the robotic fish SoFi swims like a real fish, moving its tail smoothly from side to side. It integrates itself into the environment and – by not creating noise and turbulence that would drive marine life away – provides researchers with valuable insights into underwater ecosystems.

Research in the Soft Robotics Lab shows how rapidly the field of robotics is developing and how broad the potential for autonomous systems and intelligent machines is. ETH intends to leverage this potential with two additional professorships in the Department of Information Technology and Electrical Engineering and the Department of Mechanical and Process Engineering, thereby maintaining its prominent position in the drive to develop safe and effective autonomous systems.

**"We want to build robots that are as diverse, adaptable and safe as living organisms."**

Robert Katzschmann's professorship is supported by Credit Suisse Asset Management.





**New professorships**
One area of focus will be set on the interplay between system theory and algorithms, with research conducted on the deployment of system theory methods for the analysis and design of novel algorithms in machine learning and beyond. Conversely, by adapting the latest algorithmic developments – in game theory or machine learning, for example – automation systems can be programmed to be more reliable and efficient. And the safer the systems are, the more socially acceptable they become.

The second area of focus concerns the control of automation systems that have complex, physical interactions with the world, with humans, and with other automation systems. Examples include robots, autonomous vehicles, and industrial automation systems. Areas of interest include novel approaches to the design of control, communication, and decision-making strategies that can ensure that these systems are not only efficient but also safe and reliable in real-world settings.

**Rich ecosystem**
The proposed professorships bridge the fields of computer science and electrical, mechanical and process engineering and cover the entire spectrum of automation systems. Benefitting from the rich ecosystem of initiatives and institutes available at the university – such as RobotX, the ETH AI Center and the Center for Sustainable Future Mobility – they will ensure that the latest technology is transferred to industry through spin-offs and corporate partnerships.

Find out more:
ethz-foundation.ch/en/automation

**"Whether in medicine, the construction industry or agriculture: the field of robotics presents great opportunities for our society. Thanks to philanthropy and partnerships, ETH can continue to predict and help shape technological developments in these sectors."**

Dr Paul Hälg
Member of ETH Foundation Board of Trustees,
Chair of Boards of Directors at Sika and Dätwyler

Autonomous River Cleanup is a student project that tackles water pollution. Robotic arms equipped with cameras sort river debris according to material. Biomass is returned to the water, and waste removed and recycled where possible.

# Your support

Science and technological innovation are of greater importance than ever. After all, we urgently need answers to the most pressing challenges of our time. Great potential lies in the field of robotics: from agriculture to the construction industry to our health. What makes a difference are talented individuals with groundbreaking ideas, excellent research and teaching, strong partners – and you! **Play your part and support robotics too!**

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