ETH zürich

Globe

stay connected

The magazine of ETH Zurich and ETH Alumni

No. 4, December 2013

Focus Control

Everything under control

page 16

Dear readers

These days, vacuum cleaners hoover our flats while we are out and cars can drive into parking spaces all by themselves. These are just two of the most noticeable new applications made possible through the rapid development of control engineering. Here at ETH Zurich, engineers from a wide range of different departments work on control systems for devices and vehicles, but also robots and complex social networks. Some of these projects are featured in this issue of Globe.

Control systems for machines and networks are based on constantly reconciling the goal and the status quo and thus regulate progress – a topic that is also close to my heart as President of ETH Zurich. How can I take our university forward successfully together with all its members? What is the best way to regulate a university?

A conductor leads an orchestra along the path laid down by the composer. Universities have no such path. Science is meant to find and research virgin ground. But how do you find your way to new places on a blank map? The most promising strategy combines concrete goals with an openness for fresh knowledge. After all, Columbus discovered America, even though he had a different goal.

Minds are crucial to a universities success. Just as a football coach selects the right players, a university president guides the institution by choosing the right professors. ETH Zurich's "team" is a complex, autonomous system, and it only needs intervention if it is unsuccessful for a longer period of time.

This is where the culture of enablement and trust at ETH Zurich comes in. It creates room for creativity and encourages innovative ideas born at the frontier of current knowledge. The departmental organisational structure is flat and can quickly be adapted to the fresh demands of dynamic science. A subsidiary management culture enables the efficient handling of the variety that is essential for the long-term success of a university.

This culture is only possible thanks to the foresight of its backer, the Swiss Confederation: the government's framework conditions allow ETH Zurich to hold its own in the international competition for the best researchers and Master students, and enable its members to deliver top-flight teaching and research. Its major competitive advantages here are the initial endowment and the teaching and research infrastructure it can offer its researchers and students – coupled with a high degree of institutional autonomy, an autonomy based on trust.

I am delighted by the level of faith that you show our institution as readers of Globe and, as always, I wish you much enjoyment when reading this issue!

Ralph Eichler
President of ETH Zurich

Contents

Now also available in a free tablet version in German and English

Impressum

Globe is the magazine of ETH Zurich and the official organ of the ETH Alumni Association.

Publisher:
ETH Alumni Association/ETH Zurich

Editorial team:
ETH Zurich, Corporate Communications: Roland Baumann (head), Christine Heidemann, Martina Märki, Felix Würsten

Collaboration:
Andrea Lingk (picture editing), Angela Harp, Florian Meyer, Peter Rüegg, Samuel Schläfli, Norbert Staub

Advertisements:
Administration:
ETH Alumni Communications, globe@alumni.ethz.ch, +41 44 632 51 24
Management:
print-ad kretz gmbh, 8708 Männedorf, info@kretzgmbh.ch, +41 44 924 20 70

Design:
TBS & Partner, Zurich

Proofreading and printing:
Neidhart + Schön AG, Zurich

Circulation:
25 200, issued four times a year

Subscription:
Globe is available in a printed version in German by subscription for CHF 40 a year (four issues). Full membership of the ETH Alumni Association includes an annual Globe subscription. Send orders and changes of address to globe@hk.ethz.ch or, for ETH Zurich alumni, go directly to www.alumni.ethz.ch/myalumni.

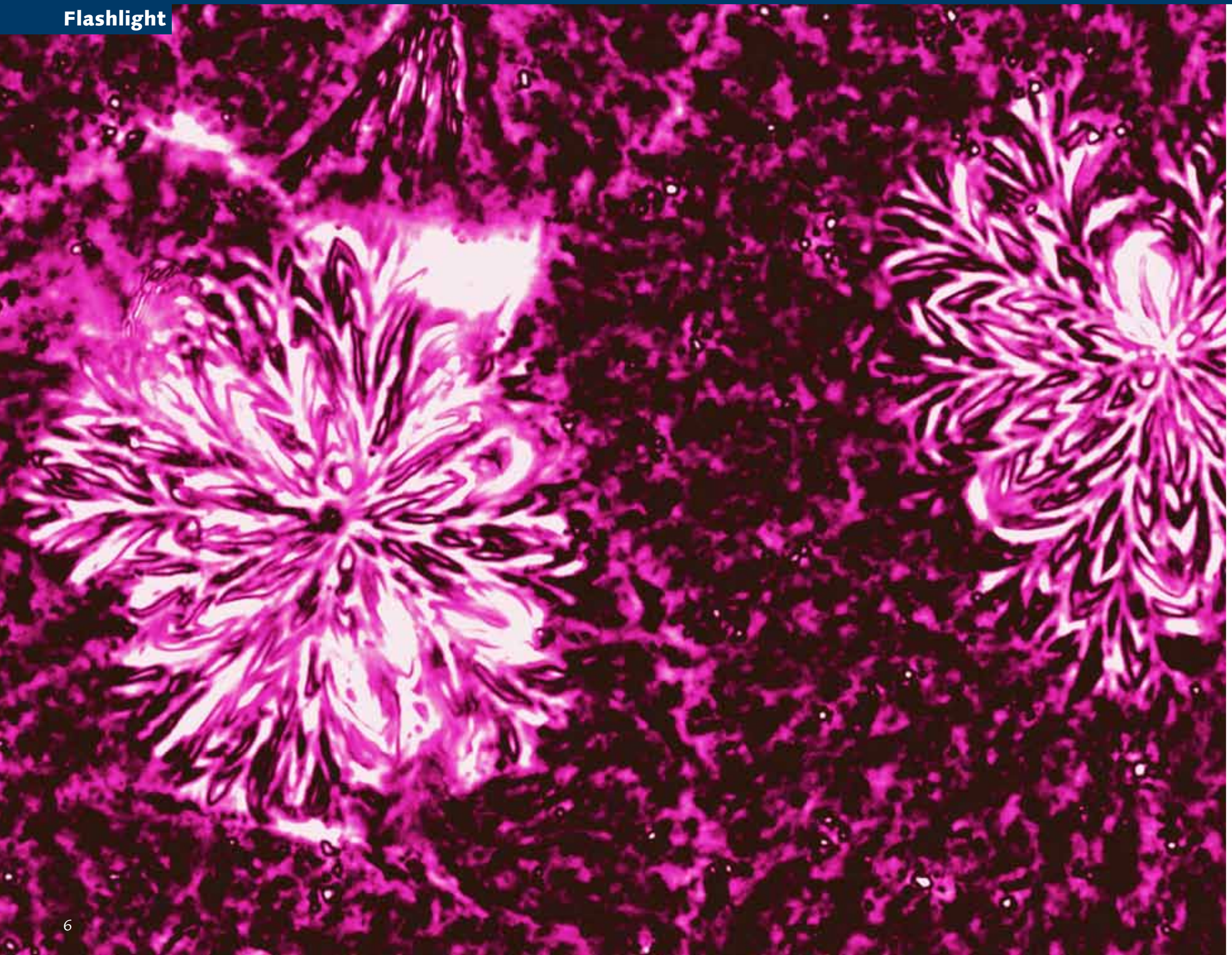
Further information and contact:
www.ethz.ch/globe, globe@hk.ethz.ch, +41 44 632 42 52
ISSN 2235-7289

Globe is also available in a free tablet version (iPad and Android) in German and English.

klimaneutral gedruckt
Energieeffizient gedruckt und CO₂ kompensiert
SQ-CH-1012/2009/1 • www.qualitech

FSC MIX Papier aus verantwortungsvollen Quellen FSC® C016008

Picture credits:
Cover: IDSC, ETH Zurich; **Editorial:** Giulia Marthaler; **Table of contents p. 4:** (bottom left) Peter Rüegg, (top right) IDSC, ETH Zurich; **p. 5:** (bottom left) Oliver Bartenschlager, (top right) Tom Kawara; **Flashlight:** Vahid Hosseini, ETH Zurich; **Ticker p. 9:** (centre left) Hansmeyer/Dillenburger, ETH Zurich, (top right) ETH Zurich; **p. 10:** (centre left) Peter Rüegg, ETH Zurich, (top right) Michael Ristow, ETH Zurich; **Reportage pp. 12–15:** Peter Rüegg, ETH Zurich; **Focus pp. 16/17:** IDSC, ETH Zurich; **p. 19:** Tom Kawara; **p. 20:** Oliver Bartenschlager; **p. 22:** IDSC, ETH Zurich; **p. 25:** Oliver Bartenschlager; **p. 27:** Oliver Bartenschlager; **p. 28:** Oliver Bartenschlager; **p. 31:** iStockphotos.com/José L. Gutiérrez; **Zoom p. 35:** Detlef Weigel, Max Planck Institute for Developmental Biology; **Inside p. 37:** Norbert Staub, ETH Zurich; **p. 38:** ETH Zurich; **Connected p. 40:** (top) Oliver Bartenschlager, (bottom) Tom Kawara; **p. 41:** (top left) Peter Rüegg, (top right) Monika Estermann, (bottom) Oliver Bartenschlager; **Profile p. 43:** Tom Kawara; **Anno p. 46:** ETH Library Zurich, Image Archive, **p. 47:** ETH Library Zurich, Image Archive; **Alumni life p. 48:** Monika Estermann; **p. 50:** Collection of Prints and Drawings, ETH Zurich.



Bizarre blossoms

Flowers – not exactly what Vahid Hosseini had been expecting. When this doctoral student from the Laboratory of Applied Mechanobiology removed the hydrogel samples he was using for his cell studies from the refrigerator and examined them under the microscope, they "burst into bloom". Some of them had dried out by accident and he was greeted by various micro-flowers around fifty micro-metres in diameter. As soon as he watered the polyethylene glycol (PEG) hydrogel again, however, it returned to its original flat form in the blink of an eye.

Having grown curious, the ETH Zurich scientist attempted to create the same flowers with other dried-out hydrogels, but to no avail. Only PEGs with a high molecular weight sprouted the peculiar flowers, the reddish colour of which is actually down to the microscope filter.

Although the image has no scientific use, it is certainly pretty to look at – which is why Hosseini entered it in the photography competition at ETH Zurich's Materials Research Centre. While it was not chosen as the winning photo by the judging panel, the Globe editorial team didn't have to think twice before selecting it for this issue's Flashlight.

www.appliedmechanobio.ethz.ch →

Therapy

Feeling happy reduces blood pressure

A team of researchers headed by Martin Fussenegger from the Department of Biosystems in Basel has discovered a way to use the body's own happiness hormone, dopamine, for therapeutic purposes. The scientists have created a synthetic gene module that can be controlled via dopamine. The module consists of several biological components of the human organism, which are combined to form an artificial signal cascade. In response to an increase in the "happiness messenger" in the blood, the module produces an antihypertensive substance. The treatment has already worked in an experiment with male mice suffering from high blood pressure, where the presence of a female triggered the corresponding feeling of happiness. Whether and when a dopamine-based treatment will hit the market, however, is uncertain.

The room from the printer can still be admired at the FRAC Centre in Orléans until 2 February 2014.

Architecture

Printed room

Two researchers from ETH Zurich's Institute of Technology in Architecture have created a room made of artificial sandstone using a 3D printer. It is sixteen square metres in size and over three metres high.

The architects developed highly complex algorithms for the project entitled "Digital Grotesque." A simple initial form was refined mathematically and folded geometrically until a filigree structure with over 260 million facets emerged. While the assembly only lasted a day and the printing a month, it took over a year to develop the design.

Their special printer produced over eleven tons of artificial sandstone for the work. One layer of sand was applied after another and fixed in place with a binding agent until the printer's entire print area was filled with sand. The excess sand was then sucked away and the finished sandstone element cleaned. The architects produced sixty-four individual blocks in this way, which they ultimately combined to make a room.

The new natural gas and diesel engine on the test bench.

Hybrid engine

Cleaner driving

Engineers from ETH Zurich have developed a natural gas and diesel hybrid engine that only releases 56 grams of CO_2 per kilometre into the environment and is up to three times below the current emission levels. They converted a diesel engine so that it can run up to 90 percent on natural gas. Instead of with an ignition plug, it ignites with diesel that is injected directly into the cylinder. Thanks to complex control and regulatory algorithms, the amount of diesel and the moment of injection is constantly adjusted to enable the engine to run highly efficiently. It is expected to go into production in five years.

7 million given away

The industrial concern Sulzer will be supporting the teaching and research of the initiative "Materials, Processes and Technology" to the tune of CHF 7 million over the next ten years. Thanks to this generous donation to the ETH Zurich Foundation, the university can set up a new chair in the field of "process intensification."

Ticker

Fighting crime

Reasons behind criminality

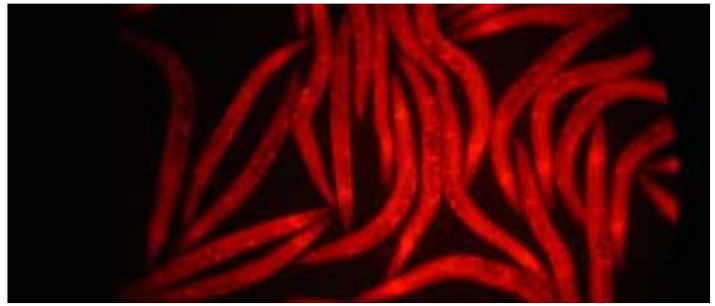
More punishment does not necessarily lead to less crime, as researchers from ETH Zurich conclude who have been using a computer model to study how criminality arises. In doing so, the scientists considered networks of social interaction. If we want to fight crime, we need to pay more attention to the social and economic backgrounds that encourage it.

Lino Guzzella (l.) will be taking over the helm from Ralph Eichler.

Executive Board

Lino Guzzella appointed President of ETH Zurich

In mid-September, the Federal Council elected Lino Guzzella, Rector of ETH Zurich and a professor of thermotronics, as the future President of ETH Zurich. He will succeed Ralph Eichler, who is to retire at the end of 2014. The Swiss government has therefore followed a unanimous proposal by the ETH Board. Guzzella is due to take over the reins on 1 January 2015. Assuming the role of president means that he will be giving up the position of Rector, so his present post will also need to be filled.



The one-millimetre-sized roundworms live longer with niacin.

Health

A vitamin as fountain of youth

Who doesn't want to live a long and healthy life? A well-known substance could help, as a team of researchers headed by Michael Ristow, an ETH Zurich professor of energy metabolism, has demonstrated in roundworms. When their food included vitamin B3 – also known as niacin – and its metabolite nicotinamide, the worms lived for around a tenth longer. According to Ristow, this is down to free radicals, which develop when the metabolism converts nicotinamide.

From his experiments, the researcher concludes that the low levels of free radicals and the oxidative stress they trigger have a health-enhancing effect, thereby contradicting the view of many of his peers. In earlier studies in humans, Ristow has already showed that the health-enhancing effect of endurance sport is mediated by an increased formation of free radicals – and that antioxidants cancel out this effect. Niacin, the researcher says, induces a similar metabolic state and tricks the body into thinking it is doing sport, even if it isn't.

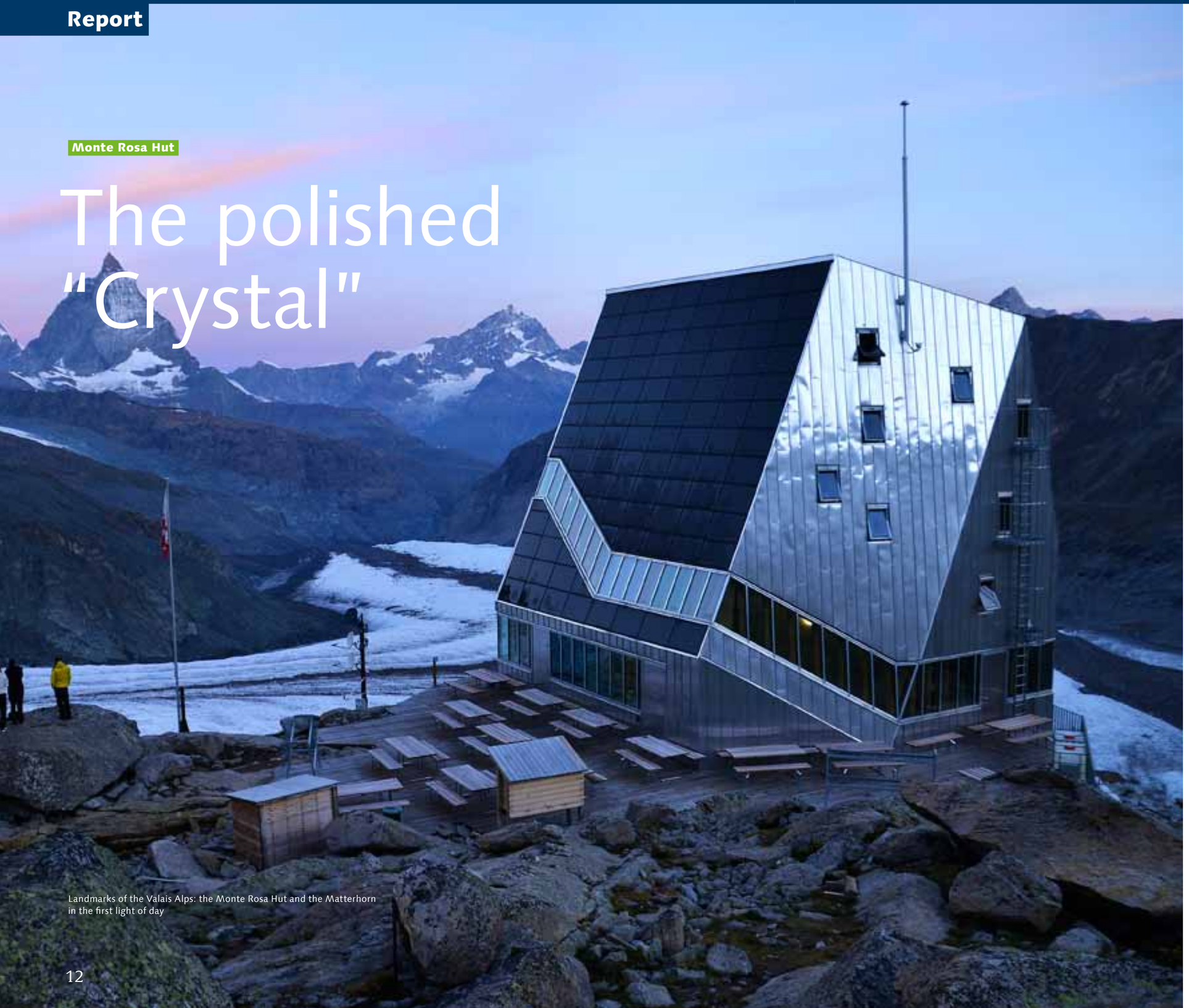
DNA analysis

End of the road for fake pearls

A team of researchers from ETH Zurich and the Swiss Gemmological Institute has managed what was previously believed impossible: they have isolated the oyster's genetic material from pearls, and thus determined the species of pearl oysters that produce them. Moreover, a parallel project was able to carbon-date the age of the pearls. Both methods are interesting for the jewellery industry in determining the origin and authenticity of these precious objects. Although the genetic fingerprint "only" allows the species of pearl-producing oysters to be identified for now, the team is also already working to determine the geographic origin of decorative pearls using DNA analysis. The aim is to pinpoint the region or even the lagoon the pearl-producing oysters come from.

Monte Rosa Hut

The polished "Crystal"



Landmarks of the Valais Alps: the Monte Rosa Hut and the Matterhorn in the first light of day

Peter Rüegg

The new Monte Rosa Hut was inaugurated four years ago. Globe author Peter Rüegg has taken a look on site at how reality caught up with this ambitious project, and how ETH researchers have solved its teething problems over the years.

The first rays of sunshine are just beginning to shimmer behind the Monte Rosa mountain range, much to the delight of the mountain climbers and hikers who set off on their way here in the early hours. On this glorious morning at the end of August, things are really busy at the Monte Rosa Hut. Rope teams arrive one after the other until the terrace is pretty full. One thing is clear: it's not just the surrounding summits that are magnets for mountain climbers and hikers; the mountain hut is a big hit, too. Not least thanks to its unique architecture, designed by ETH students.

The building, a project of ETH Zurich, was inaugurated four years ago in the autumn of 2009 to mark the university's 150th anniversary. Already during the planning and construction phases, the new Hut attracted the interest of journalists, architects, building planners and mountain climbers. Among the public at large it has also become the embodiment of ultra-modern, high-tech mountain accommodation. Since it opened, the "Crystal", as people call the Hut because of its shape, has recorded a consistently high influx of visitors. With over 11,000 overnight stays in 2011, it is by far the most visited hut of the Swiss Alpine Club (SAC).

However, this mountain accommodation was destined to set new standards not only in terms of its architecture. The building engineering specifications were also ambitious: 90 percent energy self-sufficiency (excluding cooking energy) was the target. Wastewater was to be processed in the building's own wastewater treatment plant and returned into circulation, but only if there was real demand. With this in mind, the ETH researchers had the remit of developing and installing a forward-looking energy management system. But scarcely had it been commissioned before the showpiece started suffering from teething problems. Negative headlines made the rounds. The energy requirements, for electricity in particular, were far higher than expected. So a large share of the energy needs had to be covered by the block-type thermal power plant. Among other reasons, this was because the wastewater treatment plant was running close to full capacity as a consequence of the high number of visitors. It needed more energy than estimated. The stream of mountain climbers and hikers is certainly pleasing, but the Hut and the building's service engineering were only designed to cater for 6,500 visitors a year.

Attraction Monte Rosa Hut: This modern accommodation offers mountain climbers and hikers not only a treat for the eyes, but also an unusually high standard of comfort in every respect, from the sanitary facilities down to the Hut's indoor climate.

The wastewater treatment plant (photo, left) needs more power than planned. To improve the energy supply, ETH researchers installed additional photovoltaic elements down from the Hut (photo, right).

The electricity shortfall was also caused by the photovoltaic panels overheating during sunny weather, despite the mostly wintery temperatures. And when they overheat, their output drops. In the spring of this year TV images also showed sewage sludge on the glacier and gave the impression that the situation surrounding the Monte Rosa Hut was indeed nasty.

Major improvements

What many people don't know: the ETH Institute for Dynamic Systems and Control has been involved in dealing with some of the teething problems of the Hut's technology since it opened in September 2009. Together with SAC and the companies involved in the construction, ETH Zurich has invested a six-digit sum in rectifying and optimising everything. Before they could begin their improvement measures, the ETH researchers – project coordinator Michael Benz and doctoral student Samuel Fux in particular – first had to make a thorough analysis of the energy data. Around 140 to 170 kilowatt hours of electricity were consumed by the Monte Rosa Hut every day, enough to cover the requirements of 15 average single-family houses. Up to one-third of this was consumed by the wastewater treatment plant, one-fifth by the air conditioning and heating plant. Another 20 percent were consumed by the kitchen. However, for around 40 to 50 kilowatt hours, it was not clear where they went. "The lighting in the Hut", says Benz, "could not explain this enormously high proportion." The researchers then had to take a closer look before they were able to identify several smaller and larger energy gluttons: a fridge in the cellar, a beer cooler and the cleaning machine were additional, unplanned consumers. Based on their analysis, Benz and Fux ultimately came up with a catalogue of measures which they implemented in cooperation with SAC and the companies involved in the construction.

The most visible indication that the power supply has improved are the new photovoltaic panels installed in the summer of 2013, which were mounted on a cliff above and below the warm water collectors. This plant feeds an additional eight kilowatts into the grid. Furthermore, the circuitry of the existing photovoltaic plant integrated into the façade was optimised. The original current regulators were replaced by a new generation. On sunny days, this led to an increase in output of up to 20 percent from the façade-integrated plant.

With these and numerous other improvements, the new Monte Rosa Hut's electricity provision has since this August been what it should be: at just under 90 percent self-sufficiency, not including cooking energy. "We didn't just improve the power supply; we made the entire system more reliable and easier to maintain", adds Michael Benz, not without pride.

Constant remote monitoring

The ETH researchers likewise improved and optimised the measurement and monitoring system. With the help of innumerable sensors, the indoor climate and other parameters can be constantly monitored from a distance – i.e. from a desk at ETH Zurich. This means that researchers can identify errors and shortcomings quicker. The heating system worked well from the very beginning. The solar collectors often supply more than enough warm water for heating or cooking. This saves on gas, as the excess hot water can be used for cooking. Thanks to its excellent insulation, the Hut only requires minimal heating. Around seven kilowatt hours are consumed per year and square metre. If the air conditioning is switched off, the temperatures inside can reach 30 °C. The insulation is so efficient that after the Hut closed at the end of September it took two and a half months for the inside temperature to cool down to 5 °C. The target value for heat supply was thus never at risk, according to the researchers. Benz stresses that without the kitchen they would be almost self-sufficient in heating energy.

But despite all the improvements, Benz says there is still one cause for concern: the wastewater treatment plant. Because of the massive number of visitors, the plant quickly reached its limits at the very outset and had to be altered. This meant there was no longer a wastewater holding tank, which was the prerequisite for targeted, forward-looking energy management. The idea was only to operate the wastewater treatment plant when it was permitted by the degree of occupancy at the Hut, by its power production and by the weather forecasts. Any wastewater that could not be treated, for instance because of a power shortage, would have been fed into the tank. Only when sufficient energy was available for treatment would the plant have started operating. "If you can't store anything, then you can't use forward-looking energy management either", says Samuel Fux. With the loss of the wastewater holding tank, the plant had to operate non-stop. For this former ETH doctoral student, the Monte Rosa Hut should have been a "test laboratory", as he wrote his dissertation on the topic of "Forward-looking energy management" and wanted to research, test and implement this in practice at the Hut. In the end he had to use computer simulations, though with real data from the Hut. Nevertheless, thanks to his analyses and simulations, the control of the Hut and the losses of the energy system were able to be minimised.

All in all, Michael Benz is happy with the results of the optimised building service engineering. "Since August 2013 the Hut has been functioning really well", he says. And Samuel Fux is convinced of it, too. "We have got the best out of it."

That quick tour of the Monte Rosa Hut in August 2013 also proved that guests feel at ease in and around this mountain accommodation. They praise the architecture, the sanitary facilities, the unusually high standard at this altitude and the beautiful rooms which have cast off the dubious dormitory "charm" of the old Monte Rosa Hut, where people lay shoulder to shoulder. And there's no point looking for unappetising traces on the "glacier", which in any case is not close to the Hut. ■

www.neuemonterosahuette.ch →

Everything under control

The technical systems we encounter in our everyday lives are becoming increasingly sophisticated. In order to exploit the full potential of technology, however, efficient control systems are needed. Researchers at ETH Zurich demonstrate what these look like in a wide range of fields: not only are they developing adaptable houses, machines that are capable of learning and flexible power grids, but also active prosthetics, automatic surgical aids and nanorobots that deliver drugs with pinpoint precision inside the human body.

The autonomous aircraft in the Flying Machine Arena learn how to perform complicated manoeuvres and acrobatic feats all by themselves.

"Control engineering has come on in leaps and bounds"

Interview: Felix Würsten

Driving aids in the car, self-regulating heating or intelligent anaesthesia units: nowadays, an increasing number of systems are equipped with sophisticated controls. Thanks to improved calculation methods, as Manfred Morari, a professor of systems dynamics and control at ETH Zurich, explains.

Professor Morari, your research deals with controlling such diverse systems as buildings, vehicles, chemical processes and electronic components. What have these systems got in common?

In all of these cases, we're talking about dynamic systems that we want to control with a particular goal. What these goals are in a given case varies from system to system. With buildings, for instance, it's all about improving comfort and saving energy and heating costs – and with investment costs as low as possible. In the case of assistance systems for vehicles, safety comes first – but costs are a central factor here, too. In order to control such systems, we use the basic principles of control theory, which enables us to abstract the systems on a higher level, describe them with the aid of mathematical models and calculate optimum operating processes.

How has control systems engineering developed in recent years?

The basic principles of control systems engineering have been known since the first half of the last century. That said, we have come on in leaps and bounds in recent years. Today, we can control systems in a way that was still utterly inconceivable ten, fifteen years ago as we are able to perform calculations in microseconds now which would have taken hours or even days in the past.

Where are such rapid calculations used?

Take engine control, for instance, as studied in Lino Guzzella's group: in a modern car, the fuel-to-air ratio is checked with the lambda probe. This data is then used to optimise the engine's operation constantly so that it consumes as little fuel and produces as few pollutants as possible. This requires calculations that are performed in the space of a few milliseconds. Today, we have come so far that the air that comes out of the back of a car is actually cleaner than the air that goes in the front. Another example is the Actelion building in Basel, which we fitted with a modern control system as a pilot project in conjunction with the company Siemens. Based on local weather forecasts, which we receive hourly from Meteo Schweiz, we can already pre-set the house's heating and ventilation in such a way that it is optimally geared towards the next day's weather.

When you consider that the building sector is responsible for over 30 percent of Switzerland's entire energy consumption, it becomes clear just how important such optimisations can be.

Where does this progress stem from? Faster computers?

Faster computers are a key factor. However, the more powerful algorithms that have been developed are equally important as they enable us to analyse complex issues in real time. Nowadays, we are able to perform calculations a million times faster than ten years ago. This acceleration is half down to the computers and half to the calculation methods, which is why we can control extremely rapid processes with precision today. We teamed up with IBM, for example, to develop atomic force microscopes, which enable measurements with sampling rates in the megahertz range. We have also developed control processes with the EPFL that allow multi-core processors be used in such a way as to optimise the computational speed but stick to the operating temperature limits.

Sensors that provide the basic data for the control system have also got better and better in recent years. Where do you still see a need for development in this field?

There is especially room for improvement in concentration measurements. Basically, we can measure everything under the sun these days – but at what effort and what expense?

The key thing is that we can identify chemical substances cheaply, reliably and yet accurately. For example, in one project we used CO_2-measuring devices that were supposed to be operated via wireless networks in order to monitor the air quality in rooms. One major problem was the fact that these devices required a relatively high amount of energy, which meant they could barely be operated with batteries. Such aspects are also important.

Various researchers at ETH Zurich are focussing on systems that are capable of learning. How do you perceive their role in the future?

Systems that are adaptive or capable of learning are an age-old dream and keep growing in importance. And they are an extremely interesting field for research. However, you have to understand that such systems – at least for now – are less reliable than their "conventional" counterparts. Consequently, systems that are capable of learning are unlikely to be used any time soon wherever safety is of essence.

To what extent are biological systems an inspiration for control engineering?

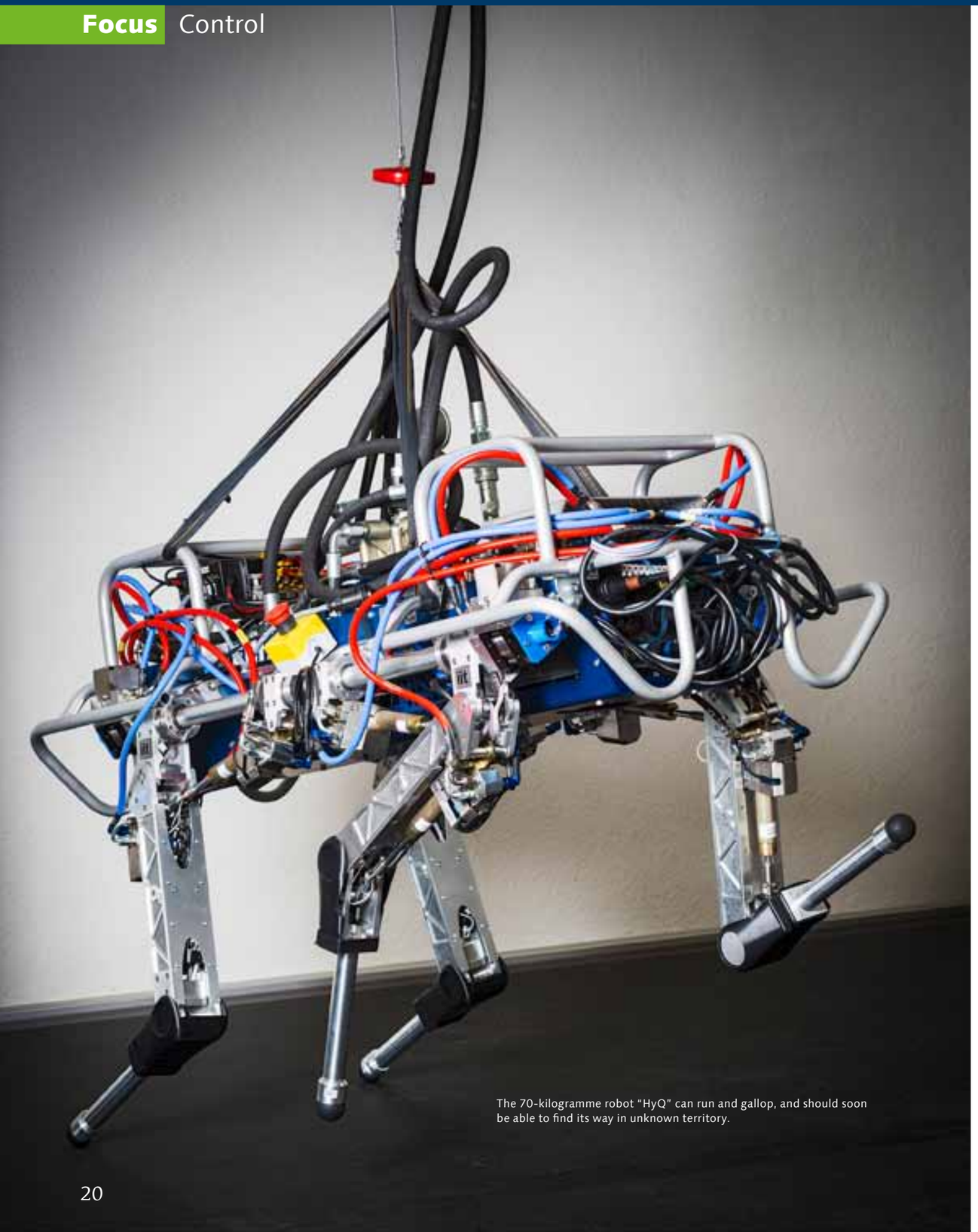
Nature makes a suitable role model for technical systems only to a limited extent – and with good reason: a living organism faces different tasks from a robot. For a person, it is impossible to position one's hand precisely in free space. For a robot, however, it's a piece of cake. Conversely, unlike humans, robots find it extremely difficult to grip a fragile object that happened to be lying on my desk. Or to put it a different way: it never worked when humans tried to fly with fake bird wings like Icarus. It was only when we began building aeroplanes that we were finally able to take to the skies. For certain issues, however, it makes absolute sense to study biological control mechanisms. Take my colleague John Lygeros who is studying how metabolism is controlled in cells. In other words, the right approach for a particular task needs to be reassessed depending on the situation.

Where do you see the biggest challenges for the future?

About the person

Manfred Morari studied chemical engineering at ETH Zurich. After completing his doctorate, he became a professor at the University of Wisconsin and at Caltech in the USA. In 1994 he was made a full professor of systems dynamics and control at ETH Zurich. His main research interests include the modelling, analysis and control of continuous and switched systems, and their application in vehicle technology, power electronics and biomedicine. He was General Chair at the European Control Conference, which was held at ETH Zurich in mid-July.

The systems we work with today are becoming increasingly complex. In a high-end car, for example, hundreds of millions of programme lines are required now to control all the systems the vehicle is equipped with. This complexity makes it increasingly difficult to determine whether the software systems are working perfectly or at least explain how an error occurs in the event of a malfunction. After all, the number of vehicle recalls due to faulty control elements has increased in recent years. So the question is how to master the ever more complex systems in such a way that their functionality can still be guaranteed. Making a system work in a controlled environment is one thing; constructing the control system so that it also works in exchange with an environment that is largely unpredictable is a whole new ball game. ■



The 70-kilogramme robot "HyQ" can run and gallop, and should soon be able to find its way in unknown territory.

When machines learn

They fly breathtaking manoeuvres, balance on only one corner and conquer unfamiliar terrain all by themselves: the robots developed by researchers in their labs at ETH Zurich impress not only with their skills, but also their ability to learn.

Felix Würsten

Two artists from the Cirque du Soleil were Raffaello D'Andrea's inspiration for the project. They performed breathtaking acrobatic routines, during which they both had to maintain a critical balance. Neither artist could have held his position by himself, and would have toppled over. But their skilful routine succeeded because they worked together.

D'Andrea is a professor of dynamic systems and control who always attracts a lot of attention with his seemingly fun projects. He used this performance as a springboard to develop a robot that is also able to maintain a state that in itself is actually unstable. This balancing cube is remarkably big – its edge is over a metre in length. But, place it on any edge or corner and it remains in the same position – even if you nudge it gently from the outside with your hand so that it briefly loses its balance.

One arm alone is not enough

This feat is possible because the cube is equipped with moving arms. These enable the robot to keep adjusting its centre of gravity in such a way that the device remains in the desired position. "It's impossible to balance the cube with only one arm", explains D'Andrea. "It takes at least two, but three to six are even better." The question now is how to coordinate the movement of the arms as optimally as possible, for the robot can only maintain its balance if the arms constantly exchange information with each other on the movements they perform.

Together with his team, D'Andrea developed a control algorithm that enables the arms to learn the position in which they are best able to maintain their state of equilibrium, based on position data compiled with sensors. As opposed to the arms being controlled centrally, each arm calculates its optimum position separately for itself before exchanging information with the other arms. Every arm calculates fifty times a second how it needs to move, and informs the other arms of this around ten times a second.

Even if the cube might look like a bit of fun, ultimately it is not a game for D'Andrea: he wants to understand physical relationships better. "We develop model-based control algorithms that use clear-cut physical laws", he explains. As for the balancing cube, these regularities are well known in principle. In practice, however, this is not enough. The challenge is to cope with the minor variations of the real world. For instance, the joints do not move quite as smoothly as the physical models suggest.

The physical principles in the experiments D'Andrea conducts in the "Flying Machine Arena" are far more unclear. In this room, he and his group let autonomous flying quadrocopters whiz around and accomplish various fascinating feats.

For instance, the aircraft play tennis with each other, perform breathtaking routines or juggle with little balls. "At face value, we can describe the machines' behaviour well during normal flight movements", D'Andrea explains. "If the flying objects perform extreme manoeuvres, how-

The "balancing cube" holds itself in equilibrium on one corner or edge. Even if you nudge it gently from the side, it keeps its balance.

ever, suddenly changing direction or speed, for instance, it is a different story." During such manoeuvres, the aerodynamics, which are very difficult to reproduce in the model, are particularly complex. Precisely because the behaviour is so difficult to predict in such moments, the flying objects are just the ticket for developing algorithms that are capable of learning.

In their experiments, the researchers set the machines a concrete task each time – such as flying in a perfect circle or juggling with balls. The idea now is not for the researchers to design the best possible control algorithms. Instead, they want to develop programmes that enable the machines to discover how they can best master the tasks for themselves. Thus the flying objects should gradually adapt their strategy for approaching the problem based on their own experiences. To a certain extent, this means that they are capable of learning: they complete the task, and then determine how well they achieved the goal set. They adapt their behaviour accordingly in the next attempt, based on their deviation from the ideal condition. Instead of acting alone, the machines have to find their way together with other flying objects. "Although every single device learns for itself, this learning is also influenced by the behaviour of other machines", explains D'Andrea.

"Consequently, the individual flying robots have to make assumptions as to how the other machines will behave during the next attempt."

Although the question as to how the robots can learn from their experiences is central, D'Andrea is not necessarily interested in human learning. "Our research is not inspired by biology. Instead, we work with physical models", he explains. "Of course, there are analogies between human learning and that of the machines. But there are also major differences. If a basketball player learns to make a basket, for instance, it is not as easy to transfer this to other people. With machines, however, this is possible."

The engineer as artist

Instead, D'Andrea finds the question of optimal architecture far more exciting. "Many research groups focus too much on developing algorithms in their work", he finds. Not enough research is conducted into the question of how to design an optimum system, however. "We currently lack a coherent theory of systems architecture." This concerns fundamental questions that are crucial for performance: how do you construct the system? Where should the sensors be placed that record the position of the flying objects? How many sensors do you actually need? How much computational power is generated on the aircraft, how much outside? And how is the information exchanged between the devices?

"If the architecture is poor, even the best algorithm is useless", D'Andrea notes. "And conversely, nor is a decent system architecture very helpful if the control processes aren't up to scratch." Bringing the two sides together is D'Andrea's declared goal. Ultimately, it all boils down to the question of the optimum design. And if you perceive design as art, then the engineer becomes an artist. Aesthetically beautiful objects that astonish us and make us think – that is what fascinates D'Andrea. "As a researcher, I want to develop things that nobody has done yet, without immediately having to think about a concrete use", he says. And sometimes, as we keep being reminded, unexpected applications that nobody had thought of beforehand suddenly arise from precisely this open curiosity.

Up steps and across crevices

Compared to D'Andrea's filigree flying objects, the research object of Jonas Buchli, an SNSF-funded professor at the Institute of Robotics and Intelligent Systems, seems like a big, burly monster. Over a metre long, the robot the scientist works with in his lab weighs in at seventy kilograms. HyQ, as the unwieldy machine with four slender legs is called, moves autonomously over rough terrain, elegantly negotiating obstacles as it goes. "Such robots could one day be used in disaster areas", explains Buchli.

He already started dabbling in robots that move independently during his stint as a postdoc in the USA, where he was involved in the development of LittleDog, a three-kilogram device that travels across different landforms in the lab. Not only does LittleDog scuttle nimbly over rough terrain and cross dangerous crevices; it is also capable of hopping up steps. Despite this impressive agility, however, the robot lacks key skills. For instance, it is unable to gauge its surroundings independently and needs precise terrain coordinates as guidelines. And it did not learn movements such as hopping all by itself; they were predetermined by the programmers as a stereotypical pattern

Precise control

With HyQ, however, Buchli now has a research object that has its own perception and thus is already fairly independent. And soon enough the robot should also find its way in unfamiliar surroundings. He originally developed the machine together with colleagues at the Istituto Italiano di Tecnologia in Genoa and has now brought a copy of the robot to Zurich. "I'm interested in the development of new control algorithms", he notes. "Instead of building a robot myself, it makes more sense for me to fall back on existing hardware I already know is well-conceived thanks to a past collaboration."

The key thing about HyQ is that every joint on the robot is fitted with force sensors, which enable it to set the rigidity of the joints with high precision. "If a robot is supposed to move across unfamiliar terrain, it needs to be capable of adapting to unexpected changes immediately at any moment. That's why it's important for it to be able to regulate the rigidity of its joints in a flash." HyQ is also controlled with a model-based system. Therefore, the robot calculates which force it might have to apply for a particular movement in advance and constantly adapts it to the actual circumstances. "Our models are based on highly complex, non-linear equations, which we have to work out in a very short space of time", says Buchli, describing the challenge. Not only do the control algorithms have to be able to keep a machine with twelve degrees of freedom stable; they also have to combine extremely different time levels. On the one hand, the robot has to control its movements in every single moment; at the same time, however, it also needs to be able to develop a longer-term strategy as to how it wants to reach the target destination.

Galloping without springs

The videos that Buchli shows reveal that the control algorithms are already extremely advanced. If you give HyQ a kick from the side, instead of falling over the machine compensates for this unexpected impulse with surprising elegance. And the machine has another distinguishing feature: it can gallop, meaning that every so often all four legs are off the ground. "HyQ is the first running machine to master this form of movement and only have a dynamic control system," explains the researcher. "All other robots that are able to gallop have additional springs that support the joints and make them easier to control."

Buchli's goal is to hone HyQ into a device that is capable of learning. The robot should one day find its way in a completely unfamiliar environment. To do so, it has to be able to take experiences it had in earlier situations into account. For this to work, Buchli is supplementing the existing mathematical models with statistical approaches that are used to describe experience-based knowledge mathematically. "Ultimately, we want to develop a robot that can do everything: walk, climb, run", says Buchli, looking to the future. "And if it has arms, too, it should also be capable of gripping objects and performing actions independently." ■

Institute for Dynamic Systems and Control:
www.idsc.ethz.ch →

Institute of Robotics and Intelligent Systems:
www.iris.ethz.ch →

Nanorobots join fight against cancer

Samuel Schläfli

Bradley Nelson is building micro and nanorobots for the medicine of the future, which could enable drugs to be transported precisely to the site of cancerous tumours or infections. The researcher draws his inspiration for the drive and control systems in his tiny machines from bacteria.

The world's smallest medical robot stems from a lab at ETH Zurich, as the Guinness Book of Records has stated since 2012. It is barely sixty micrometres long and five micrometres wide – about a hundredth of a hair's breadth. Its creator is Bradley Nelson from the US, who has been developing robots for almost twenty years: microrobots that are just about visible with the naked eye, and nanorobots that can only be followed under the microscope.

Nelson joined ETH Zurich as a professor of robotics and intelligent systems in 2002, where he set up an interdisciplinary team of engineers, computer and material scientists, biologists and chemists. His research has been devoted to micro and nanorobots and their application in medicine ever since. This ETH-Zurich researcher is convinced that the tiny machines will first be used in the medical sector.

The 1966 film Fantastic Voyage was an early prelude to what such applications might one day have in store for us: a millimetre-long submarine with a five-man crew zooms through the veins of a scientist to zap a life-threatening clot in his brain. After an hour of totally unexpected obstacles, the mission has been accomplished and the patient is saved.

Although Fantastic Voyage is one of Nelson's favourite films, he draws even more inspiration from nature than Hollywood.

E. coli as a role model

Especially when it comes to the trickiest aspects of his robots, namely the drive and control systems. "By observing bacteria, we stumble across movement strategies that we'd never have come up with by ourselves", reports Nelson. After all, the smaller the objects become, the more challenging their propulsion gets: "On the scale we work on, objects stop behaving as we would expect from everyday life." Bacteria have an advantage here: over thousands of years, they have developed techniques to move with minimum of energy expenditure.

The E. coli bacterium, which is found by the million in our intestines and protects us from the spread of pathogens, is particularly interesting for Nelson and his team. In 1973 the American biophysicist Howard Berg discovered that E. coli propels itself with a small corkscrew tail called a flagellum. "When we took a closer look at the fluid dynamics of these flagella, we realised how efficient this 'motor' is in propelling tiny objects in liquids", explains Nelson enthusiastically. With his team, he began to recreate the spiral-shaped flagella of the micrometre-sized E. coli rotary engine.

For this, they used semiconductors, as this is the best way to control the manufacturing processes on a nanometre scale. The engineers vapour-deposited ultra-thin layers of magnetic nickel on the spirals, which were twenty-five to sixty nanometres in length. These are necessary to make the artificial flagella rotate later on through an external magnetic field, the direction and intensity of which can be controlled exactly. As soon as the spirals start spinning, the nanorobot swims, much like the E. coli bacterium. Such a control system for the robots via electromagnetic fields is promising for medical applications. For although the fields are very weak and harmless for the body, they penetrate most biological materials. Nelson recently patented the system, which comprises eight individually controllable magnetic coils, and the ETH Zurich spin-off Aeon Scientific is currently working on marketing the technology.

Pinpointing tumour treatment

With the aid of the electromagnetic control system, the scientists are looking to control the flagella-propelled nanorobots through arteries and vessels with high precision in future. The target could be an infection or cancerous tumour, for instance. Once it arrives, the robot would release the drug it has been transporting, which means the treatment would be considerably more specific. Patients could be spared "inundating" their bodies with medication, as is commonplace in chemotherapy today, and thus all the side effects.

For this to work, however, not only would medical practitioners have to be able to control the robot exactly; the dispensation of the drug at the target would also need to be controlled.

In the search for suitable concepts for the latter, once again the researchers turned to the realm of bacteria: many are actually known for changing their form depending on environmental conditions such as light, temperature or pH value. Nelson's team looked for materials in order to copy this adaptability for their micorobots' drug delivery and happened upon the biopolymer chitosan, which is biodegradable and harmless for humans. What makes it so special: a hydrogel produced with it alters its form depending on the pH level. And as the pH level is mostly slightly lower near tumours or infections than in the rest of the body, the drug delivery could be activated independently by the microrobots without any impulse from outside the body. In the initial lab experiments, forty to eighty micrograms of agent per square centimetre of robot area could be delivered to the surroundings in a controlled fashion for three weeks.

Another highly promising approach with which agents can be manipulated are miniscule vortices in a liquid medium. With this in mind, Nelson's team developed a "rod bot", a polymer cylinder sixty micrometres wide and 300 micrometres long with cobalt-nickel inlays. If an external magnetic field is applied, the cylinder begins to turn on its longitudinal axis – much like the nanoflagella. This creates tiny micro-vortices in the liquid film at the ends of the rod bots. In pictures taken under the microscope, the researchers have proved that they can hold miniscule polystyrene balls with the vortices, control them by manipulating the magnetic field exactly and deposit them at the desired location. Sensitive objects such as cells, micro-organisms or protein crystals can thus be transported without actually coming into contact with the carrier. A further advantage of this method: the transportation works independently of the magnetic, optical or electrical properties of the objects to be transported. In an initial step, the rod bots are to be used to isolate protein crystals in x-crystallography. In the long run, however, the vortices could also transport drugs through the human body.

"For the first time, we are not only working on our robots' drive or control systems now but also solutions to enable them to gauge their surroundings in a complex system like the human body and interact with it," Nelson explains.

And how long will it be before the first microrobots will set off through the body like the millimetre submarine in Fantastic Voyage? "We'll be in humans in five years," the ETH Zurich researcher is convinced. ■

Institute of Robotics and Intelligent Systems:
www.iris.ethz.ch/msrl →

The small black mark near the pinhead is the nanorobot that is meant to transport drugs to the right place with pinpoint accuracy.

Robotic devices in control during sleep

Cleverly controlled devices are taking on more and more tasks in medicine. They help the disabled to walk, support the rehabilitation of stroke patients and may someday even perform minor operations. Soon they may help us to get a better night's sleep.

Felix Würsten

It has actually been common knowledge for a long time that if you rock a baby in a cradle, it will fall asleep more easily. Regular movements, for instance in a hammock or on a moving train, help adults to get to sleep as well. But exactly how these movements work, and whether they could help people with sleep disorders has scarcely been investigated up to now. Robert Riener, Professor for Sensory-Motor Systems, intends to fill this gap. Together with Peter Achermann, who heads the Group for Chronobiology and Sleep Research at the University of Zurich, he has developed special beds to examine the relationship between motion and sleep. One bed makes a gentle pendular movement, like a cradle. The other pushes the sleeping person to and fro horizontally, either crossways or lengthways, and rises and falls as required. There is a reason for clearly separating the movements, explains Riener, "If we mix the three patterns, then it's more difficult for us to examine their impact. And the test persons become nauseous more quickly."

Soft and silent

Right now, the beds are in the test phase. The test persons are fitted with measurement sensors in the sleep lab, which provide information on the depth of sleep. Besides brain waves the researchers also measure respiratory rate and heart rate. Using the data recorded, they wish to establish how the movements affect sleep onset behaviour and sleep quality. The next step involves the bed being directly controlled by the physiological data. As soon as the device notices, based on brain waves and heart rates, that the test person is sleeping less deeply, it endeavours to prevent from that person waking up by means of corresponding movements. If it succeeds, this could help people with sleep disorders to achieve deeper and more refreshing sleep. Reiner can also envisage other applications: "Movements of this kind during sleep could also prove beneficial for people with psychological disorders."

For Riener, who as an engineer has been involved for years in the development of medical devices, there are, however, several technical questions. For instance, the construction of the bed constitutes challenges that should not be underestimated. The motors have to move the bed – that together with the test person weighs more than 100 kilos – without the slightest jolt. Furthermore, it must be practically noiseless to avoid sleep being disturbed by side-effects. It will be even more demanding when it comes to linking the mechanics to human physiology. "The depth of sleep is not a parameter which one can simply determine using a set value", says Riener.

Adjusting specifically to the individual plays a key role in another project of this ETH engineer. Together with his group he is developing an active prosthesis by means of which patients whose leg has been amputated can carry out movements which simulate those of the healthy leg. "Most prostheses are passive substitute organs", explains Riener. "Our model is different. The artificial knee is equipped with a motor that moves the artificial lower leg."

To enable the movements to mimic the natural model more closely, the joint also has mechanical springs which support the motor and protect against sudden jolts. With the active prosthesis, the wearer can climb stairs more easily or walk on uneven ground. And the prosthesis can do something else too. It is equipped with pressure sensors which allow the patient to feel how heavily he is treading on the ground by means of electrodes fitted to his back.

The gentle rocking motion of the bed aims to help the test subject enjoy a deeper, more refreshing sleep.

Man must retain control

According to Riener, the biggest challenge for this device is interaction with the wearer. "The prosthesis should automatically recognise the intentions of patients to enable them to really use it like a healthy leg." Right now, control is exercised via sensors attached to the clothing of the healthy leg. Based on these sensors, the prosthesis recognises what movement the patient wishes to make. This automatic adjustment is only possible because the researchers use sophisticated control algorithms which drive the motor quickly and flexibly. The important thing is for the human to retain control. "The prosthesis must adapt to the man and not vice versa, otherwise the patient will not accept it", insists Riener.

The knee prosthesis is also currently in the test phase. "Our device is actually only intended for a limited target group, for older patients to be exact", explains Riener. Young, strong patients found it far easier to climb stairs and didn't necessarily need a device of this kind. The example of the active prosthesis demonstrates very clearly that the successful development of such devices is dependent on close cooperation between engineers and doctors, nursing staff and patients. "As an engineer I have to know what problems patients are confronted with in their daily lives and where there is a need for mechanical support", comments Riener. "Otherwise, we will be developing devices that nobody needs."

Roger Gassert, Assistant Professor of Rehabilitation Engineering, has also positioned his projects at the interface between the engineering sciences and medicine. Like Riener, who developed the motion robots "Armin" and "Lokomat", innovative devices for stroke patients, Gassert looks at novel approaches to rehabilitation too. In one of his projects, he consciously focuses on hands. "There are already numerous devices which support the movements of the shoulders, elbows and wrists", explains the engineer. "But what are still missing to a large degree are robotic devices that train hand functions." These would, however, be particularly important for stroke patients as they normally find it difficult to open their hands and grasp objects. Often, their sensory skills are also impaired along with their motor skills. In this case, patients can no longer really feel how strongly they are grasping an object.

Gassert and his team have developed a robot which promotes the exchange between hand and brain in both directions. In one exercise, blindfolded patients have to pick up

This first prototype of an automated surgical robot can take samples from the test material, stitch up wounds and excise tissue.

wooden bricks of various lengths with their fingers and then recognise which brick they are holding, based on the hand position. The robot developed by Gassert mimics this exercise. The patients pick up the virtual bricks by pressing two movable grips against each other. The robot defines via the control how long the grips can be moved freely, and when they have to be blocked. The patient then feels how big the virtual bricks are.

With the robot, sensory skills can be measured objectively. Gassert is convinced that "In their day-to-day practice the therapists have a keen sense of whether someone is making progress. But if we want to move forward in this field, we need more objective measurement data." At the present time, the device is being tested in a rehabilitation clinic in Canton Ticino. The first results are encouraging: the work with the therapy robot seems to lead to a substantial improvement, not least because with this device the intensity of the exercise can be increased gradually.

Incise, prick, stitch

A second project, on which Gassert is working intensively right now, has a completely different objective. In collaboration with researchers from other universities, he is in an EU project to develop a surgical robot which should be capable at a later stage of carrying out certain simple operations. The goal is to relieve the burden on doctors. "Similar to the control of an airplane, a human would in future primarily assume the more complex phases, whereas for the simpler ones he would simply have to monitor the machine", explains Gassert. But the scientists are still a long way from this. Right now they are constructing the first prototype. If it functions as planned, it will be able to carry out three tasks: remove a tissue sample by puncture, stitch up a small wound and excise tissue from a wound. The robotic device is controlled using data that are collected before and during the operation, using imaging techniques. This enables the machine to react if organs shift during the operation. In concrete terms, the surgical robot consists of two movable "hands", each having two "fingers" to grasp something. The hands are fixed via two movable "arms" to a rotatable board which is attached, in turn, to a rail system. "The construct mimics a doctor who is bending over the patient", explains Gassert. In total, the device has 18 degrees of freedom – so the control requirements are correspondingly high.

Feeling the force correctly

One major innovation is that the device is fitted with force sensors. During the operation the robot can recognise the force being exerted on the tissue. This means it is possible to avoid damage to the organs. When a doctor is stitching up a wound, it is good to be able to measure the force too. In the case of today's surgical robots, the doctor can see on the screen that the thread is taught, but not how much force is being applied to it.

The various parts of the robot, developed at numerous universities, were assembled in Gassert's laboratory this autumn. "Here in Zurich we have concentrated on the development and control of the robot", he reports. "The other teams developed data collection and monitoring." If everything goes according to plan, the engineers will soon be practising the first operation steps on animal organs with doctors at University Hospital Zurich. "It will be a few years before the robots can carry out operations independently", comments Gasser dampening any overly high expectations. "Amongst other things we have to clarify a few safety issues, such as what happens to the patient if an unexpected error occurs during the operation." ■

Sensory-Motor Systems Lab:
www.sms.hest.ethz.ch →

Rehabilitation Engineering Lab:
www.relab.ethz.ch →

Power systems under transformation

Roland Baumann

An increasing amount of electricity comes from renewable energy sources. As wind turbines and photovoltaic power plants produce electricity at irregular intervals, however, new approaches are needed to compensate for the fluctuations on the power grid.

Renewable energy sources such as photovoltaic power plants feed electricity into the grid at irregular intervals and require new approaches to control.

Only a few years ago, Europe's electricity market was rather boring – and easy for pumped storage power stations. At night, when the prices were low, they drew electricity and filled their reservoirs, only to empty them during the lunch break when demand and thus electricity prices were at their highest. Those days are over. Now, the prices are far less predictable. The photovoltaic power plants are the main culprits as they feed the most electricity into the grid at around lunch time and cause the highest prices to tumble.

Balance needed

"New electricity generators – besides photovoltaics, especially wind power – are turning the whole power system upside down", observes Göran Andersson, a professor at ETH Zurich's Power Systems and High Voltage Laboratories. The reason behind this is a peculiarity of the power system: as no electricity can be stored in the power grid, the generators collectively have to produce every second precisely the amount of electricity that is consumed at that moment.

"Until now, it was easier said than done to control the generators so that they produce the right amount of electricity at that very moment", says Andersson. After all, electricity consumption fluctuates hugely in the course of a day, a week and a year and requires a constant adjustment of the generator output. Traditionally, however, this adjustment could easily be planned. To put it simply, nuclear power stations and certain thermal plants provided the basis with so-called base-load energy. The balance between consumption and production was achieved with gas and hydropower stations.

Now, nuclear power stations are increasingly being replaced with wind turbines and photovoltaics in Europe. This brings a new volatility to both the demand side and the production side. "The fluctuations are thus growing much bigger overall and new solutions for a balance need to be found", says Andersson, summing up the situation. "Flexibility" is the buzzword of the hour, and energy researchers are not just asking technical and organisational questions; new business fields are also opening up.

Compensating for fluctuations

One challenge lies in regulating wind turbines and photovoltaic power plants, which naturally produce electricity at irregular intervals. If no energy is to be lost, we need storage facilities. These could be pumped storage power stations, which thus still have a future. "In order to operate them as economically as possible, however, new models are called for that predict peaks more effectively", Andersson points out.

Batteries are the second storage option. They are currently even more expensive than pumped storage facilities, even if costs are decreasing. Moreover, battery performance declines over time. Andersson's group is currently developing a model that indicates how to best operate batteries to receive the longest possible service life.

Andersson's group is also looking into organisational approaches to balance out fluctuations on the power grid. One possibility is to create larger, so-called regulation zones – areas where the fluctuations have to be compensated. According to today's agreements, for instance, Germany has to find a balance if it operates new wind turbines in the north. According to Andersson, it would make more economic sense to balance out the fluctuations within Europe – like in Switzerland with its hydropower stations.

In this respect, the idea of establishing so-called capacity markets is being discussed, where the operators are only paid for being available in the event of an emergency – much like the fire brigade. These could be operators of gas turbines, for instance. For while gas turbines are more expensive to operate than base-load power stations, they can be started up extremely quickly.

Controlling electricity consumption

For all of these ideas, researchers are still only developing the decision-making basis. "Nobody knows where the journey will take us yet", says Andersson, before mentioning another promising approach: "Instead of the generators, we can also control certain burdens – the electricity consumers, for instance." Thermal loads such as heat pumps, electric boilers or refrigeration facilities are especially ideal here. Refrigeration facilities, for instance, can easily be cooled by a few more degrees if there is a lot of electricity, only to return to the normal temperature again afterwards if less electricity is produced, or if the electricity is needed elsewhere.

In the USA, controlling air-conditioning units, in particular, is a hot topic, where there is also the possibility of turning the temperature down – or up. "We don't feel a difference in room temperature of half a degree", explains Andersson. "However, it has a major influence on the load, in other words the amount of electricity consumed at that moment." With these shifts, quite a lot can be achieved. That said, it is not about saving energy here. The temperature is solely adjusted to keep the grid in balance – without any noticeable effect.

What might sound straightforward is more complicated in reality, of course, especially as far as controlling loads is concerned. The research projects in the field are suitably varied. They also give rise to new business opportunities. In his doctorate under Andersson, Stephan Koch concentrated on controlling loads and subsequently developed special software to model and control the large number of decentral units in a project funded by ETH Zurich's Pioneer Fellowship Programme. Meanwhile, he and two colleagues are about to officially found the spin-off Adaptricity, which provides software solutions for power systems.

The idea of achieving load regulation with electric cars shows the way forward. Thilo Krause, a senior assistant in Andersson's group, is involved in the project THELMA, which examines the impact of electromobility on Switzerland as a whole. In his subproject, Krause is analysing the impact of electric cars on the power grid, where he also sees a need for action: "If everyone went home after work and immediately started charging their cars, new peaks would be created." As the cars won't be used again until the following morning, however, the charging of the individual vehicles could be staggered throughout the night. Here, too, this raises questions about control and communication between electricity providers and consumers.

"So-called aggregators are needed that bundle the information flows in a suitable way", explains Andersson. Such an aggregator, for instance, manages 10,000 consumers and receives the signal from the grid operator Swissgrid to increase or restrict consumption – depending on how much electricity is available. In other words, it is responsible for maintaining the balance and is compensated by Swissgrid for this regulation service. It can distribute part of its income among the customers. "Studies we've conducted, however, reveal that there isn't very much money to be dished out", Andersson points out – somewhere in the range of twenty to thirty francs a year. Consequently, the customer has little incentive to provide his or her car for an offset. One idea is now not to distribute the money, but to hold a sort of lottery among the participants where the winner takes all, 100,000 francs, for instance. ■

Power Systems and High Voltage Laboratories:
www.eeh.ee.ethz.ch →

Adaptricity spin-off:
www.adaptricity.com →

Statistics

Getting closer to reality

Florian Meyer

Sara van de Geer started out by wanting to understand people better. Then she discovered how fascinating the theoretical and philosophical aspects of statistics are. Today she is a professor of mathematics, and she is delighted that more and more students are showing an interest in her subject.

Mathematical statistics. When we hear these words, fascinating research is not necessarily the first thing that springs to mind. We are more likely to see it as a necessary evil – as tables and diagrams, for example, that are an essential part of any piece of scientific work.

Mathematical statistics is the research area of Sara van de Geer, professor of mathematics at ETH Zurich. It is also a specialist field that is becoming more and more important. Because the computing speed of computers is constantly increasing, it is possible to store more and more data faster, and at a lower cost. Anyone who wants to interpret and understand this data has to be able to record and evaluate it statistically.

The internet in particular supplies vast amounts of data that can be used, for example, to analyse how people behave when they want to buy something and how they reach their decision. Searching the internet would also be impossible without statistics. Likewise, many tasks that are subject to risk nowadays, such as predicting storms, granting bank loans or controlling nuclear plants, are almost impossible to carry out without the requisite statistical knowledge.

Accordingly, statisticians are very much in demand. The Swiss research magazine "Horizonte" reported in September that almost 200,000 additional experts with a background in statistics would be needed in the USA by 2018. Sara van de Geer has noticed that the subject is already becoming more popular with students: "When I started with the main lecture in statistics at ETH Zurich in 2006, only around twelve students turned up. Today roughly 80 students are registered in the course." According to van de Geer, the number of students studying statistics is also increasing at a global level. She believes that the reason for this increased interest is that not only scientists, but also other professionals have to deal with more and more data on an everyday basis.

Reducing complexity

But researchers like van de Geer and her team do not provide the students with any ready-made solutions. Instead, they teach them processes to reduce complexity: "We live in a complicated world, but there is an underlying structure. We want to find that structure, and statistics is the way to gain meaningful information from the multitude of data", says the scientist, whose research and teaching is mainly involved with empirical processes, estimation methods and model selection.

Put simply, every statistic relates to data that is recorded, modelled, evaluated, understood and presented. But for a theoretical statistician like van de Geer, it is not about a single dataset, a particular model or an exclusive area of application.

Instead, she systematically examines the fundamental relationships between datasets, models and their interpretation. Her focus is on searching for ideal models that provide results that are as reliable as possible, even for complex issues that involve many different dimensions and unknowns.

In modern science, models are pretty much the interface between theory and reality. In empirical research they depict reality, compressing this reality into authoritative theoretical features and properties. In pure mathematics, a model proves that there are certain principles (axioms) for the structures of a quantity that apply to them without contradiction.

Statistics as practised by Sara van de Geer is somewhere between these two poles: Theoretically, she deals with the general properties of various classes of models that can be used in many areas. Mathematically, she describes how to decide whether a model does in fact represent the data.

How data affects models

Adjusting models to data is not as simple as it sounds. Random events and probabilities are key components of the models. Furthermore, even the most precise measurements cannot prevent the data quantities from containing errors and contradictions. With very complex data that contains many dimensions and unknowns, there is a risk of seeing a structure there that does not actually exist.

Van de Geer develops methods that help to avoid such misinterpretations and that lead to forecasts and results that are as reliable as possible.

Statistical methods such as the Lasso method can be used to look at thousands of genes and identify those that are probably the most important for plant growth, as trials with thale cress have demonstrated (shown here in different mutations).

Because data is so complex nowadays, the classic method of least squares, for example, which stems from a method developed by the German mathematician Carl Friedrich Gauss, has been extended to include a contemporary version known as Lasso.

Using Lasso for the ideal model

Lasso is a method that allows precisely what up until recently had been strictly forbidden in the realm of statistics: a model with significantly more parameters p than observations n. Lasso can be used to make forecasts that already come very close to the ideal model.

It's not only the statistician herself who benefits from the results, but also empirical researchers, for instance in the fields of earth system sciences, systems biology and computer science.

If plant scientists or biologists want to determine how genes influence the growth of a plant, then they have to measure data quantities of up to 20,000 genes for each individual plant. That's too much data – some of which is often even contradictory – to find out reliably which genes actually influence plant growth. "But statistical methods can narrow it down to around ten genes that are probably the most important for growth", explains van de Geer.

Such collaborations can thus yield mutual benefits: the mathematician encounters new and exciting issues that contribute to the further development of statistical theory, while the scientist in question obtains more reliable results as well as ideas for interesting new hypotheses.

From the very outset, van de Geer was fascinated by the clear mathematical descriptions and the striving for objectivity that theoretical statistics involved. "I started my degree in mathematics because I was interested in people and in the quantitative methods of the social sciences", she says, "but over time I noticed that data and measurements in every scientific discipline are never unambiguous and that theoretical statistics is dedicated to precisely this aspect of scientific research." In any case, she is well able to cope with the uncertainty that is inherent in the nature of statistics. ■

http://stat.ethz.ch →

Singapore-ETH Centre

"ETH Zurich made the right choice in going to Asia"

Interview: Angela Harp and Norbert Staub

Professor Schmitt, what impressed you the most during your stint as Director of the Singapore-ETH Centre?

Gerhard Schmitt: The new Asia as I have experienced it is extremely different from that of the 1990s. In the countries of Southeast Asia, you can sense a positive awareness of independence, a spirit of growth and a sensitivity to the future development of these nations in society, the business world, politics and academia. The absolute figures show that Asia now exhibits the highest urbanisation rate in the history of mankind.

Why is the academic sector developing so rapidly in Asia?

The economic development has had a huge impact on the academic sector. With a more stable economy, the countries in the region have managed to attract experts from all over the world and send their own off to renowned institutions around the globe to analyse and learn their best practices. China is attracting former students back to the country as lecturers, especially from the USA and Europe, and specialists from Singapore, China and India are coming to Switzerland to study our education system at all levels. In doing so, they see the advantages of the dual system that forms the basis for innovation, employment, added value, social integration and scientific excellence. However, it is no mean feat to implement such a system in another environment. As far as the Singapore ETH Centre is concerned, we definitely made the right choice to base it in Asia. Singapore currently boasts the continent's highest-ranking university, where it is possible to work on fascinating projects with scientific peers in a living lab that couldn't be conducted in Switzerland for geographic and climatic reasons.

What was your greatest success while working in Singapore?

Paving the way for the development of sustainable cities with a high quality of life. That was our goal right from the word go in 2006, back when sustainable urban development wasn't a high priority in any region of the world. This meant we had to work hard to boost public awareness of the topic of sustainability. As for urban development, ETH Zurich was one of the first to see key research potential for the future in it, with enormously positive economic and environmentally relevant consequences. Today, this research field is a permanent fixture in public discourse.

Hence the Future Cities Laboratory (FCL)?

Yes. Meanwhile, the phenomenon of the city, urbanisation processes and their impact are recognised as important fields the world over. The FCL, our transdisciplinary research centre, studies urban sustainability in a local and global context and has established itself as one of the top names in the field. Over 200 people from thirty nations work intensively on models for the city of tomorrow and its environmental compatability, quality of life, added value and social integration factors. We'd like to understand, shape, transform, implement and coordinate the urban and rural fabric of the future.

What challenges did you initially have to overcome?

It wasn't all that easy to get a research institute on its feet as a non-profit institution over 10,000 kilometres from Switzerland, fifty kilometres north of the equator, in a completely different cultural landscape, without directly having ETH Zurich's excellent infrastructure and administration to fall back on. The support of the Executive Board and especially the President was essential. We started out in September 2010 with two people in Singapore and initially focused on the most important aspects to get the research centre up and running: staff, infrastructure and funding. Fortunately, we knew what works best at ETH Zurich, so we were able to set up an analogous, extremely flat and efficient structure in Singapore.

What results has the Future Cities Lab delivered thus far?

Besides achieving the performance objectives, such as publications and research with doctoral students, the most important results emerge from transdisciplinary collaboration. The exhibition opened in September, halfway through the project, showcases the cooperations and project proposals of researchers from different disciplines. The results include novel material development out of bamboo fibres and polymers, for instance, which could revolutionise construction in parts of the world and could reduce both its CO_2 footprint and costs. Discoveries from the analysis of big data, which reveal how you can influence the centrality of cities, or findings on the crucial interplay between mobility and multi-functional urban planning, are also worthy of mention. All results are fundamental for the further development of sustainable cities.

What's next in the pipeline?

The second SEC research programme on Future Resilient Systems is already undergoing preliminary checks, then another programme could follow after 2015. We will also be addressing the increasing warming and decreasing quality of life in tropical cities with the scheduled project "Cooler Calmer Singapore". In 2015 a second phase of the Future Cities Laboratory is also due to get underway and we are developing alternative forms of implementing urban-planning research results. In Asia, Africa and South America, there is a shortage of hundreds of thousands of architects and planners. Design research studios, "blended learning" – the combination of classroom and e-learning – and Massive Open Online Courses would all be possibilities.

Our aim is to give the ETH Centre a permanent spot at a top-class research location in Asia and develop it into a recognised research facility in the region. At the same time, it represents a key research platform for ETH Zurich in Asia, where students and lecturers can familiarise themselves with ETH Zurich before deciding on a stint in Switzerland.

Gerhard Schmitt is a professor of information architecture at ETH Zurich. His main research interests include understanding, formalising and simulating urban and rural systems while taking the growing significance of crowd sourcing, big data and data-driven design into account. The inaugural director of the SEC will continue to run the simulation platform at the Future Cities Laboratory after his return to Zurich. The practical goal is to equip urban planning with locally usable, scenario-based planning instruments all over the world.

In October 2013 he was succeeded as Director of the SEC by Peter Edwards, a professor of plant ecology at ETH Zurich and until recently Head of the Department of Environmental Systems.

What advice would you give your successor Peter Edwards?

The people and institutions in Singapore have received and supported our multinational SEC community very positively, and the Swiss embassy and Swissnex Singapore have also helped tremendously in this respect. I'm delighted that Peter Edwards is taking over the reins from me and offer him one simple piece of advice: listen, be committed and aim forwards. ■

www.futurecities.ethz.ch →

Inside

ETH Zurich's main building is to be freed of its unsightly extensions in the coming years.

Real estate

Building for the future

Felix Würsten

ETH Zurich is running out of space at both its Zentrum and Hönggerberg campuses. As a result, the university is looking for solutions as to how it can find the additional space it needs. And it is also thinking about what an inspiring space for the research and education of the future might look like.

The ETH Zurich Hönggerberg Campus will see dramatic change in the coming years. Together with private investors, ETH Zurich will create five buildings that will provide space for a total of 1,000 students. This means that in future the campus will be a vibrant place where people from all over the world can meet – not just during the week, but also in the evenings and at the weekend. Although this is a very positive step, with this and the seven other buildings for research and education that the university intends to build at Hönggerberg by 2020, ETH Zurich will soon reach its capacity limits at this location. "With the buildings planned at the moment, we will soon reach the permissible above-ground construction mass, which is defined in the special construction regulations from 2007", explains Drazenka Dragila-Salis, who has been in charge of the Building and Constructions Infrastructure Division since the beginning of September. "This is why we now have to work together with Zurich city council to find solutions to safeguard the further development of ETH Zurich in good time."

Streamlining the main building

The same applies to the Zentrum campus, where ETH Zurich is also struggling with the problem of tight spaces. The future of this location will be determined by the master plan for the "Hochschulgebiet Zentrum" project, which is currently in the formal consultation phase. This master plan shows how the development of ETH Zurich, University of Zurich and the University Hospital can be made possible at this central location without the three institutions getting in each other's way. At the moment the assumption is that ETH Zurich will receive additional floor space of 70,000 square metres – space that the university urgently needs.

In the coming years, ETH Zurich will also realise various challenging projects at the Zentrum campus. If all goes to plan, construction of the new building on Gloriastrasse can commence in the summer of 2014. That is where, after 2019, the researchers from the Health Sciences and Technology Department will be housed. At the same time, next year will also see the start of planning work for renewing the mechanical engineering lab. Dragila wants to make the refurbishment of ETH Zurich's main building into a landmark project. "Step by step, we will rid the main building of its unsightly extensions", she explains. "The main building should once again become a building worthy of adequately representing ETH Zurich."

Longer-term planning

ETH Zurich already has a large portfolio of real estate, and in the coming years it will continue to invest large amounts in building extension measures. Consequently, it is clear to Dragila that the university will have to have an even longer-term real estate planning strategy than hitherto.

"We can plan the majority of our investments well in advance", she explains. "If we optimise the planning processes further, we can use resources more efficiently."

For her, it is not only about improving processes and establishing commitment in all directions. "We also have to consider what inspiring spaces could look like in a university of the future." Particularly in education, she sees a need for new ways of thinking, especially as students nowadays no longer acquire their knowledge in the same way as before. For this reason, Dragila has not only got in touch with the experts involved in new forms of teaching at ETH Zurich, but also endeavours to speak to the students so that they can bring their needs into the planning process. ■

Connected

ETH Day 2013

Honorary titles awarded

At this year's ETH Day, ETH Zurich's Rector Lino Guzzella (centre) presented the following people with an honorary doctorate (from left): Peter Jenni, a particle physicist and head of the ATLAS experiment at CERN's Large Hadron Collider; Noga Alon, a professor of mathematics and IT at the University of Tel Aviv; Eric A. Brewer, a professor of Computer Science at the University of California in Berkeley; and Jillian F. Banfield, a professor at the University of California's Department of Earth and Planetary Sciences in Berkeley. The following were awarded the title of Honorary Councillor (from right): ETH Zurich's donors Max Rössler, Martin Haefner and René Braginsky, and Georg Edwin Felix Schoop, Head of the Baden Forest Administration.

Visit

Star director at robotics lab

A breath of Hollywood wafted through ETH Zurich when Swiss film director Marc Forster visited the university's robotics labs at the beginning of October. The director of films such as Monster's Ball, Kite Runner and World War Z was in the city as President of the Jury at the Zurich Film Festival. During his visit he was given demonstrations of various robots – including the flying robot sFly, which so excited him that he immediately captured it on camera.

Alumni business event

Dual education and innovation

ETH Alumni held their business event twice this autumn. And once again they were able to welcome some exciting guest speakers: Hans Hess (l.), the president of the industry association Swissmem, spoke about the importance of dual education in embarking on a career; and Urs Rohner, President of the Board of Directors at Credit Suisse, talked about the power of innovation and the challenges that the bank of the future faces. Numerous visitors attended the talks and seized the opportunity to engage in a lively discussion.

Collaboration

Strong partners

At the "Journées Scientifiques et Pédagogiques", Lino Guzzella (l.), Rector of ETH Zurich, and Philippe Gillet, Vice-President for Academic Affairs at EPF Lausanne, laid down the objectives for better networking between the two top Swiss universities. This regular exchange between professors and staff from EPF Lausanne took place at ETH Zurich for the first time.

75 years

VIPs at KOF anniversary

Notable well-wishers gathered to mark the 75th anniversary of ETH Zurich's Swiss Economic Institute (KOF). As guest speakers and panel members, the visitors lauded the KOF's work and discussed the relevance of economic forecasts and analyses. From left to right: Josef Ackermann, former CEO of Deutsche Bank; Hans Hess, President of Swissmem; Federal Councillor Johann Schneider-Ammann; presenter Alenka Ambroz; Jan-Egbert Sturm, a professor of applied economic research and Director of the KOF; Thomas Jordan, President of the Swiss National Bank; President of ETH Zurich Ralph Eichler; and Christoph Schär, a professor at the Institute for Atmospheric and Climate Science.

ETH Zurich alumnus Michel Liès

A mathematician of the world

Roland Baumann

Michel Liès, CEO of Swiss Re, headed out into the big, wide world when still a young mathematician. For the last thirty years he has been active on the international stage for the Swiss reinsurance company.

150 years of Swiss Re – how does it feel to be the sesquicentennial CEO of the second-biggest reinsurance company in the world? "I'm proud and very happy to have got to this position", says Michel M. Liès, who has been working for the company for over thirty years and took over the helm in February 2012. For him it is a special honour – especially in a company whose success is founded on trust and sustainability.

When it comes to explaining why risk management is so important for our world, this native Luxembourger is in his element: "As a mathematician, I have always found it fascinating to be able to create a successful business model with scientific analyses." It is every insurance company's business to deal with trust based on mathematical formulae. International orientation is a hallmark of every reinsurer. And being internationally active was always a dream for Liès: "When I travelled to Brazil after my degree, I met many engineers who were building motorways and bridges all over the world. Hearing stories like that, I almost regretted being a mathematician." However, the reinsurance company gave him the opportunity to combine his subject with an international dimension.

Liès ran divisions in Latin America and Europe before becoming responsible for all customer relations as head of Swiss Re Client Markets for six years. Apart from French, his mother tongue, he also speaks fluent English, German, Italian, Portuguese and Spanish. How important are these language skills alongside the "global language" of mathematics?

"Mathematics is an international language. But it has also got its pitfalls", says Swiss Re's CEO. Don't think for a minute that our planet only listens to the laws of mathematics and models. "Mathematics might be good at describing the facts, but in our industry the perception of people is no less pivotal." After all, at the end of the day people only take out insurance if they are afraid that they might be affected by a particular event.

> "I find it fascinating to create a successful business model with scientific analyses."
>
> Michel Liès

And the perception of risks depends on the cultural context, as a large-scale study impressively demonstrates in which Swiss Re surveyed 22,000 people in nineteen different countries to coincide with its birthday celebrations. For instance, people in many Latin American countries primarily fear criminality, whereas Europeans tend to worry more about the global economic situation. Just how much perception is shaped by subjective feelings is also reflected in the fact that 22 percent of the respondents in North America indicated that they had gone hungry once in the last year; in India, however, it was only 19 percent.

Potentially, the difference between perception and reality also opens up opportunities for insurance companies, such as if someone estimates a risk as being higher than it

actually is and is prepared to pay more as a result. However, this prospect does not necessarily pay off for insurance companies in the end. "In the long run, we have to work on reconciling perception and reality. Our credibility depends on the fact that we realise useful projects and actually do something for society", says Liès.

The fact that short and long-term perspectives differ is also evident in disasters. If insurance companies have to fork out next to nothing after severe floods or earthquakes, this might be seen positively by the financial markets. However, that is a very short-term view.

> "Our credibility depends on our realising useful projects."
>
> Michel Liès

After all, if the injured parties do not enjoy any insurance cover, this also means that the insurance companies in the regions affected are not doing any business. An analysis conducted by Swiss Re, for instance, revealed that, on average, only some 20 to 25 percent of the economic damage in disasters is covered, and in certain regions the rate is close to zero percent. Consequently, there is great market potential.

"If we want to provide the market with insurance services more effectively, we can go one of two ways", explains Liès: "We can sit back and wait until everyone belongs to the middle class and can afford private insurance cover. Or we can develop concepts and products for new potential customer segments, such as governments." At the same time, micro-insurance solutions need to be developed for those who cannot really afford insurance. In order to take this route, Swiss Re founded the Global Partnerships Department a number of years ago.

As Chairman of Global Partnerships, Michel Liès spent two years talking to government officials to familiarise them with insurance instruments. "In my conversations with finance ministers about insurance, I realised that their knowledge of it was often limited", he says, looking back. Gradually, the conversations bore fruit. Mexico and the US state of Alabama bought insurance services, for instance. And not only for the state's assets, but also for individual goods of their citizens. After all, these governments realised that they have to jump in after a disaster, when people have lost everything.

Essentially, however, these conversations were far more about sharpening the consciousness for dealing with risks than about individual business transactions. One of the biggest success stories in this respect, he says, was the fact that the US Treasury Department decided to appoint a Chief Risk Officer to identify the country's main risks and develop scenarios for how to tackle them.

When Swiss Re comes up anywhere around the world, Switzerland is ever-present in the name. Sustainability, trust and innovation – values that are central to insurance companies – are often associated with Switzerland, too. And so it is no coincidence that Zurich has blossomed into one of the world's main hubs for insurance companies. Plus there are the city's many educational opportunities, which Liès describes as "fantastic." And of course there is the possibility of research collaboration. For instance, Swiss Re is one of the founding partners of ETH Zurich's Risk Centre.

"A company can position itself across the world as strongly as it wants, but it will never be as international or possess as much raw talent at the cutting edge as a university", says the CEO, explaining his company's commitment. To mark the company's landmark birthday, the Swiss Re Foundation has renewed this research partnership for a further five years. Here, too, it is all about sustainability, as Liès explains: "Our involvement at ETH Zurich might incur costs in the short term, but it helps us to keep our eye on the ball in the long run." ■

About Michel Liès

Michel Liès completed a degree in mathematics at ETH Zurich in 1974 and joined Swiss Re four years later. This native Luxembourger was initially involved in the Latin American markets. From 2000 to 2005 he ran the Europe Division before assuming responsibility for all customer relations worldwide as Head of Swiss Re Client Markets. In 2011/12 Liès was Chairman of Global Partnerships and devoted himself to cultivating long-term relationships with representatives of governments and NGOs. He has been CEO of the reinsurance company since 1 February 2012.

Anno

Exposure studies in an outdoor laboratory. UV research of the Photographic Institute on the Jungfraujoch, 1936

1886

Science through the Lens

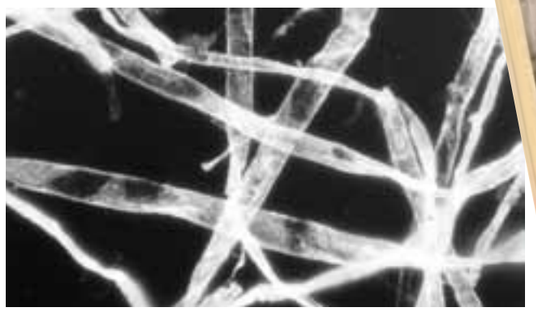
Martina Märki

For almost a century, the Photographic Institute recorded images of the work of ETH researchers. A new illustrated book presents a selection of these and other image collections from the photo archives of the ETH library.

From the microcosm of crystals, x-rays of the interior of the body over mountain and glacier landscapes down to the macrocosm of constellations, from the noble researcher in a pristine white lab coat down to expedition participants in dusty hiking gear: the Photographic Institute has left ETH Zurich more than 40,000 images. Monika Burri tells their story in the accompanying text to the illustrated book "Forschung im Fokus" (Focus on Research) (see box). The historical collection from Photographic Institute is, at the same time, about a documentation of the role of images in science.

Several methods for photographic image production were introduced in the 1820s and 1830s. One of them, Daguerreotypy, named after its inventor Louis Daguerre, was even purchased by the French state as a patent and made available at no cost to the world at large. This act of state in 1839 shows that experts were quick to grasp the potential importance of the new image-producing options. What was particularly fascinating was their supposed ability to reproduce "facts in a natural and prejudice-free manner" as Burri says – photography seemed to be the ideal medium for newly emerging positivist science.

ETH Zurich, founded in 1855, incorporated the first lectures on the subject of photography into its curriculum i 1869. However, it wasn't until 1880 that the subject was introduced on a regular basis. The Austrian Johannes Barbieri, a chemistry lecturer in the Department of Elective Subjects, was put in charge. Barbieri must have been a lecturer who was as much enthralled as he, in turn, enthralled his students. He devoted himself to photography, conducting many practical experiments. Test images of the most diverse kinds testify to his critical examination of photographic technology, for instance photos of explosions, the formation of clouds and lightning strikes and urban scenarios. Scarcely had the Lumière brothers launched the first method for colour photography on the market than Barbieri turned his attention to this technology and carried out experiments on colour photo images of works of art, his own still lives and ladies in colourful costumes. Nor did he shy away from a hands-on approach in the service of science: a series of photos from around 1880 shows the former cavalry officer in a dashing, straight-as-a-rod posture on a pushbike and then falling off a bicycle with one hand helplessly fishing for his cap which has skidded away on the ground. His own handwritten



Microphotographic studies of papermaking fibres.
Photographic Institute for the cellulose factory Attisholz,1943

Johannes Barbieri: If you hadn't gotten on, you wouldn't have fallen off. Professor Barbieri himself, after 1880

captions testify to the professor's sense of of humour, "If you hadn't got on, you wouldn't have fallen off."

However, for this Professor all the signs pointed to promotion. In 1886 he was appointed Director of the newly founded Photographic Institute that was equipped with a laboratory, a glass workshop and three dark rooms. In 1916 the Institute was assigned larger premises and an auditorium with a seating capacity of 100. This shows just how much the demand for photographic expertise had increased in many disciplines. The remit was "to give clear instructions to students who need photography for their area of study." Barbieri gave lectures and ran exercises in astrophotography, microphotography, colour photography and photogrammetry. In addition, the Institute was to undertake photographic tasks within ETH too.

This remit was still in place under Barbieri's successor, Ernst Rüst. From 1926 onwards he turned the Institute into a real service company. Besides this, Rüst enthusiastically focussed on another development in imaging methods, namely cinematography. Rüst saw manifold scientific applications for moving film images, such as the study of flow conditions in turbines or the business management analysis of workflows. Depending on what was needed, the Photographic Institute also developed special scientific imaging techniques, for instance for crystallography.

Although this all sounded very progressive, the Swiss School Council was not completely happy with the direction the Institute was taking. When Rüst submitted an application for a loan in 1936 for the further expansion of the Institute, the School Council complained that one didn't expect a university to come up with "any solutions for concrete individual problems but rather viable industrial expertise, developments, products and patents." However, Rüst stuck to his practical approach. It was only on his retirement that the School Council energetically changed direction by appointing in 1946 the most renowned photochemist in Europe, John Eggert, as his successor. Eggert was the founder and former director of the scientific laboratory of the Agfa film factory. He directed his attention to research, staged international scientific congresses and promoted contacts with industry. His successor, the physicist Wolfgang F. Berg, who for many years had been Director of research at Kodak, continued this scientific orientation from 1961 onwards. New technologies appeared on the horizon, including holography and electronic imaging techniques above all. At the beginning of the 1970s image data could be reduced to chip size. The electronic imaging sciences saw the light of day. For the Photographic Institute, this marked the beginning of its heyday up to 1979 when it was shut down and attached to the Institute of Communications Technology as the Department for Visual Studies. From here the path takes us straight to the present day: The expert group "Visual Studies" eventually culminated in today's Computer Vision Laboratory. ■

Monika Burri: Forschung im Fokus. Wissenschaftsfotografien aus dem Bildarchiv der ETH-Bibliothek. (Focus on Research. Scientific photos from the image archives of the ETH library). Published by Michael Gasser and Nicole Graf. Series: Bilderwelten. Fotografien aus dem Bildarchiv der ETH-Bibliothek, Volume 3, ISBN 978-3-85881- 395-4, CHF 59.
The book is available in book shops, the ETH store or in the ETH libraries.
Numerous collections in the image archive can be viewed online, too
www.e-pics.ethz.ch →

Donald Tillman, Managing Director of the ETH Zurich Foundation (left), and Max Rössler, whose donation helped to found the Institute of Theoretical Studies.

ETH Zurich Foundation

Every contribution has an impact

Felix Würsten

In recent years, private donations have allowed ETH Zurich to implement strategically important projects at a faster pace. Donations from alumni have made an important contribution in this respect. One person who has supported ETH Zurich with generous sums is Max Rössler. With his donations, he wants not only to give something back to the university, but also make a contribution that will ultimately benefit society as a whole.

In a move that significantly strengthens the position of basic research at ETH Zurich, the university founded a new Institute of Theoretical Studies (ITS) at the beginning of June. It is intended to promote collaboration in the field of basic research.

The ITS will invite between four and six high-profile scientists to Zurich for research stays of up to one year in duration, choosing them from the disciplines of mathematics, theoretical natural sciences and theoretical computer science. The Institute will also enable ten talented postdocs to work as junior fellows at ETH Zurich. The founding of this Institute was made possible by generous donations from two alumni members: Martin Haefner and Max Rössler promised the university CHF 25 million to set it up. "The first time that I heard about this project from Ralph Eichler, the President of ETH Zurich, I was immediately enthusiastic about the idea", Rössler told us.

Rössler studied mathematics at ETH Zurich. After completing his doctorate and a subsequent research period at Harvard University, he then lectured and researched at ETH Zurich for some ten years. With his donation, he wanted to give something back to his alma mater. He explains his motivation by saying: "I want to use my wealth to do something that benefits society as a whole. In my view, strengthening the position of basic research is an excellent investment in the future."

Investing in minds

Although Rössler provided an extraordinary amount of money for ETH Zurich to found the ITS, he is certainly not alone as a supporter of the university. "Almost 2,000 alumni have now supported ETH Zurich by giving what they can in the form of a donation", explains Donald Tillman, Managing Director of the ETH Zurich Foundation. "We appreciate every single franc", he says emphatically. "Without these private donations, it is the unconventional but brilliant ideas that remain unrealised. Alumni have used their good education at ETH Zurich to lay the foundations for their later success, so they have a very real understanding of this."

In close cooperation with the university, the ETH Zurich Foundation has launched a whole range of campaigns in recent years that it uses to support ETH Zurich in certain areas. "The objective is always to make important breakthroughs possible. Progress starts with better education and more research, and that is where the donors can make a decisive contribution", says Tillman. Certain alumni wish to support a research area that is particularly close to their heart. Others want instead to facilitate more entrepreneurship. And a third group decides to invest in brilliant minds in a targeted manner – with good reason. Ultimately, those are the people who will guarantee the university's long-term success.

One particularly attractive programme for alumni, for example, is the "Excellence Scholarship and Opportunity Programme." The ETH Zurich Foundation drew attention to it in a recent letter sent to all alumni. The programme involves granting scholarships for academic excellence to particularly gifted Master students. "Many alumni look back fondly on their own university years. Maybe they would also have been happy to have had the support of a scholarship at the time", says Tillman.

Max Rössler has also made an investment in clever minds, giving a large donation to ETH Zurich six years ago. That donation was used to establish the renowned Rössler Prize at the university. It is awarded annually to an up-and-coming scientist who has carried out outstanding basic research in the fields of natural sciences and technology. The researchers who are awarded the prize receive CHF 200,000 that they can use at their discretion for their academic work.

Long-term planning

Similar to its other initiatives, this represents another of ETH Zurich's long-term strategies, as the prize money is financed from the interest income on the original donation. It is this long-term focus in particular that is important to the university. "We are not looking for short-term success, but want to enhance ETH Zurich over the long term", explains Tillman. In doing so, ETH Zurich decides what areas it wishes to highlight and where it needs additional funding from private individuals in order to implement its projects at a faster pace.

The idea of obtaining financial support from private donations for universities in Switzerland is gaining momentum. This is also reflected in the funding provided to the ETH Zurich Foundation. For Tillman, however, it is not the amount of money promised to the ETH Zurich Foundation that matters most, but rather what ETH Zurich achieves with this funding. "The most important thing is that we use the money in a targeted manner", he explains. "It's like with a hot-air balloon: It's the additional bit of hot air that makes the balloon rise up faster.

Philanthropy can change the world – we have seen proof of that often enough." Time and time again, the alumni too have made decisive contributions in this regard – as the example of Max Rössler shows. While he doesn't describe himself as a role model for others, he admits that "I am of course delighted if my involvement inspires other alumni to make a donation." ■

Be a part of it!

Would you like to support ETH Zurich with a donation? Whether it's a contribution to a specific initiative – for example in the areas of neuroscience, global nutrition, medical technology or sustainable construction –, or an investment in dedicated, talented students by means of a donation to the "Excellence Scholarship and Opportunity Programme", or a donation that is not earmarked for a specific purpose: the ETH Zurich Foundation will be happy to advise you on how your involvement can be structured in the most effective way.

You can also support ETH Zurich with a bequest or a legacy: If you choose to bequeath your estate or a part of it to the ETH Zurich Foundation, you can make a valuable contribution to societal development even beyond your own life. A legacy is a particularly appropriate way of doing this, as it allows you to bequeath clearly defined assets to the Foundation.

If you have further questions regarding the planning of your estate, Donald Tillman, Managing Director of the ETH Zurich Foundation, will be happy to assist you.
Tel.: +41 (0)44 633 69 62,
email: donald.tillman@ethzfoundation.ch

Agenda

Alumni business events

Philip Mosimann
Bucher Management AG
25 March 2014
Networking aperitif from 5:30 p.m., event begins at 6:45 p.m., ETH Zurich, main building, Dozentenfoyer
Register at:
www.alumni.ethz.ch →

Alumni Events

Personal self-management
Careers seminar with Martin Ghisletti, Head of the ETH Career Center, and Günter Fleischer, a freelance consultant
16/17 January 2014
Balsthal
Registration by e-mail:
events@alumni.ethz.ch

Social media – what I have to know today
Careers event with Anne Forster
4 February 2014
ETH Zurich, Alumni Pavillon
Info at:
https://www1.ethz.ch/career/event/index →

Music at ETH Zurich

Chamber music evening
Winner of the 7th International Tchaikovsky Competition 2012
14 January 2014, 7:30 p.m.
ETH Zurich, main building, Semper Aula

Klavierabend
Konstantin Scherbakov
4 February 2014, 7:30 p.m.
ETH Zurich, main building, Semper Aula

The Collection of Prints and Drawings presents works from the Robert Landolt collection in the exhibition Dialogue with drawings, including the painting Landscape with St Christopher Crossing the River by an Antwerp master from 1525–1540.

Exhibitions

Umsicht – Regards – Sguardi 2013
For the third time, the Swiss Society of Engineers and Architects (SIA) has awarded prizes to outstanding projects that advocate the sustainable design of living space. An exhibition by the Institute for the History and Theory of Architecture (gta).
Until 16 January 2014
ETH Zurich, main building, main hall
www.ausstellungen.gta.arch.ethz.ch →

Dialogue with drawings
Works from the 15th to 18th centuries from the Robert Landolt collection.

Pablo Bronstein
Prints and drawings
Until 17 January 2014 Collection of Prints and Drawings
ETH Zurich, main building, E53
www.gs.ethz.ch →

Earth in our Sights
Observing Earth from space
Touring exhibition on new methods and findings from remote sensing satellites
Until 23 February 2014
FocusTerra, Sonneggstrasse 5, Zurich
www.focusterra.ethz.ch →

Alumni Symphony Orchestra

15th concert, winter 2014

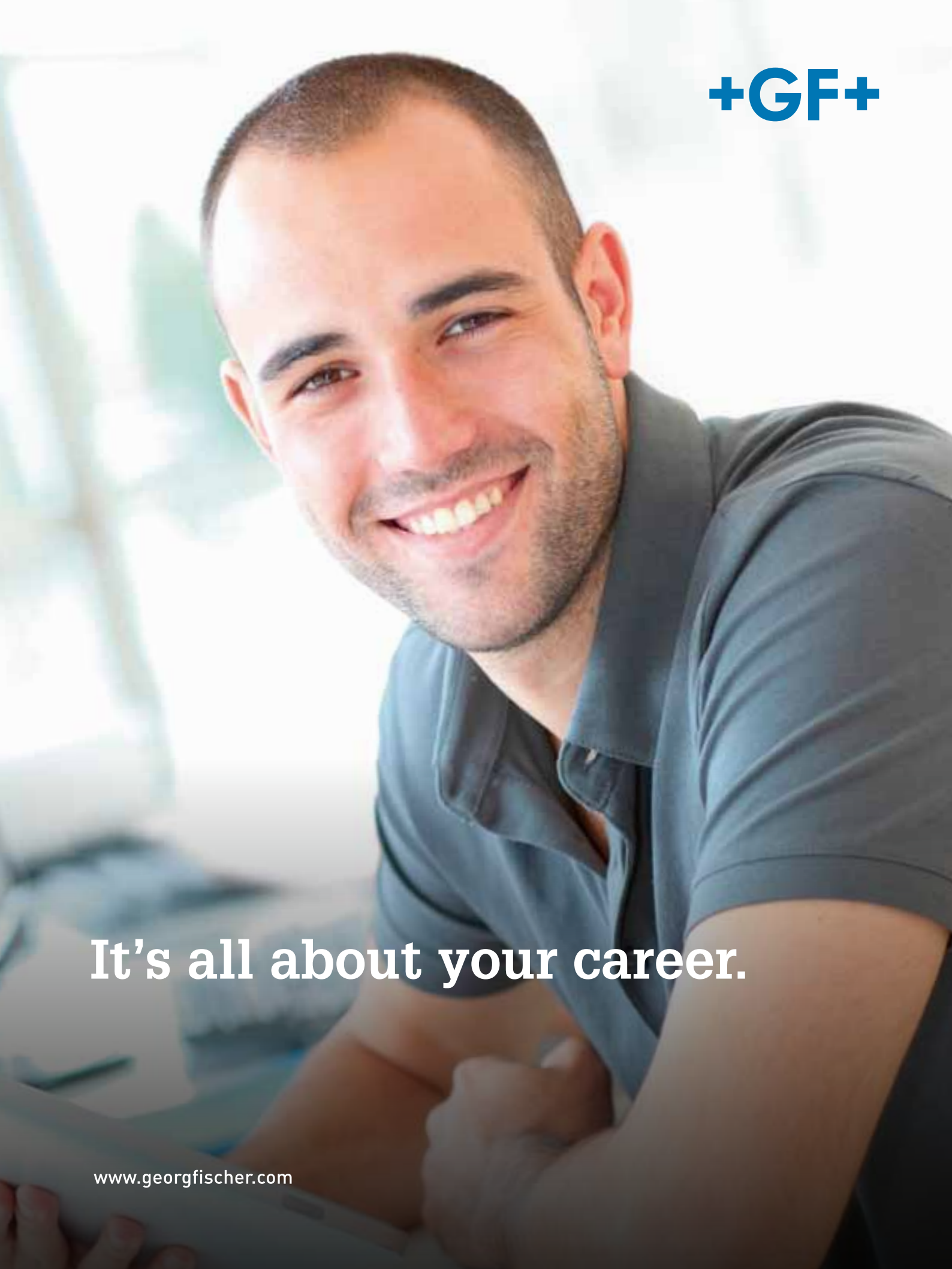
Johannes Brahms (1833–1897)
Piano Concerto No. 1 in d minor, op. 15

Jean Sibelius (1865–1957)
Symphony No. 1 in e minor, op. 39

19 January 2014, 5 p.m.
Casino Frauenfeld

2nd Risk Center dialogue event

Already for the second time, the ETH Zurich Risk Center is inviting representatives from industry, science and the public sector to a dialogue event. After introductory talks by scientists from ETH Zurich in the morning, the afternoon's focus session will address the topic of "The Eurozone and Switzerland: A Network of Risk."
17 January 2014, 10 a.m. – 4 p.m., ETH Zurich, ML D 28
www.riskcenter.ethz.ch/Dialogue_Event_2014 →


+GF+
It’s all about your career.
www.georgfischer.com