robotics

Swiss National
Centre of Competence
in Research

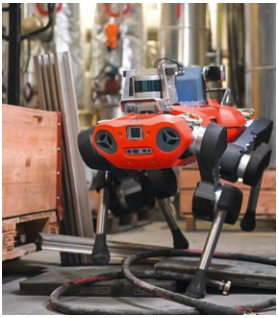
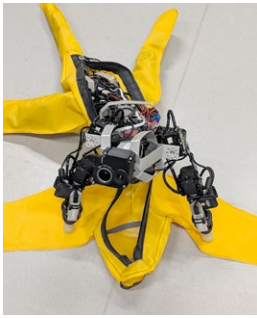
INFORMATION PACK

FNSNF

Fonds national suisse
Schweizerischer Nationalfonds
Fondo nazionale svizzero
Swiss National Science Foundation





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The National Centre of Competence in Research (NCCR) Robotics is a federally funded programme bringing together robotics laboratories from EPFL, ETH Zurich, University of Zurich, University of Lugano, University of Bern and Empa to work on wearable, rescue and educational robots.

Please sign up for the news bulletins on our website to receive cutting edge news from NCCR Robotics as it happens.

For queries or to arrange to speak to one of our research scientists please contact nccr-robotics@epfl.ch

ABOUT US

NCCR ROBOTICS

INTELLIGENT ROBOTS FOR IMPROVING THE QUALITY OF LIFE

The National Centre of Competence in Research (NCCR) Robotics is a Swiss nation-wide organisation funded by the Swiss National Science Foundation (SNSF) pulling together top researchers from all over the country with the objective of developing new, human-oriented robotic technology to improve our quality of life. The Centre opened on 1 December 2010, and binds together experts from six world-class research institutions: Ecole polytechnique fédérale de Lausanne (EPFL, leading house), Eidgenössische Technische Hochschule Zürich (ETH Zurich, co-leading house), Universität Zürich (UZH), Istituto Dalle Molle di Studi sull'Intelligenza Artificiale (IDSIA) Lugano, University of Bern (UNIBE) and the Swiss Federal Laboratories for Materials Science and Technology (Empa) for a period of up to twelve years.

We are at the forefront of robotics research and we develop robots that co-exist symbiotically with humans in order to enable them to help both individuals and society.

EPFL
EPFL is Europe's most cosmopolitan technical university with students, professors and staff from over 120 nations. A dynamic environment, open to Switzerland and the world, EPFL is centered on its three missions: teaching, research and technology transfer. EPFL works together with an extensive network of partners including other universities and institutes of technology, secondary schools and colleges, industry and economy, political circles and the general public, to bring about real impact for society.

ETH ZURICH
Founded in 1855, ETH Zurich has more than 20,600 students from over 120 countries, including 4,100 doctoral students. If offers an inspiring working environment to researchers and a comprehensive education to students. Twenty-one Nobel Laureates have studied, taught or conducted research at ETH Zurich, underlining the excellent reputation of the university.

UNIBE
With roots in the 1500s, the institution is based in the heart of the Swiss capital, Bern, and counts Albert Einstein as a former lecturer. 17,500 students benefit from a full range of courses in most disciplines. With notable strengths in space

science, dentistry, climate science and biomedical engineering, the University of Bern is also a leading house for five national competence centres.

UZH

The University of Zurich (UZH) is a member of the League of European Research Universities and numbers among Europe's most prestigious research institutions. UZH's international standing is reflected in the many renowned academic distinctions conferred upon its members, including twelve Nobel Prizes. As Switzerland's largest university, UZH has a current enrolment of over 25,000 students and offers the most comprehensive academic program in the country. Nearly 5,000 excellent members of staff teach and perform research at one of the University's 130 departments, including 675 professors. UZH also looks back on a rich history, having been founded in 1833 as Europe's first university to be established by a democratic political system.

IDSIA

The Swiss AI Lab IDSIA is a not-for-profit research institute for artificial intelligence, affiliated with both the Faculty of Informatics of the Università della Svizzera Italiana and the Department of Innovative Technologies of SUPSI, the University of Applied Sciences of Southern Switzerland. IDSIA focuses on machine learning (deep neural networks, reinforcement learning), operations research, data mining, and robotics.

EMPA

As an interdisciplinary research institute of the ETH Domain, Empa, the Swiss Federal Laboratories for Materials Science and Technology, conducts cutting-edge materials and technology research. Empa's R&D activities focus on meeting the requirements of industry and the needs of society, and thus link applications-oriented research to the practical implementation of new ideas. As a result, Empa is capable of providing its partners with customized solutions that not only enhance their innovative edge and competitiveness, but also help to improve the quality of life for the public at large. Through an efficient technology transfer Empa is turning research results into marketable innovations.

KEY MEMBERS

DIRECTOR

PROF. DARIO FLOREANO

LABORATORY OF INTELLIGENT SYSTEMS (LIS), EPFL

Dario Floreano is the director of the Laboratory of Intelligent Systems and director of the NCCR Robotics. His research activities focus on aerial robotics, soft robotics, wearable robotics and evolutionary robotics. He published almost 400 peer-reviewed articles and four books on Artificial Neural Networks, Evolutionary Robotics, Bio-inspired Artificial Intelligence, and Bio-inspired Flying Robots. His research and communication activities resulted in two companies, senseFly and Flyability, and in the online robotics news platform RoboHub.org. Dario Floreano has supervised almost 45 PhD students and more than 20 postdocs, many of whom hold professorships and started companies. He is or has been on several boards, such as the Future and Emergent Technologies of the European Commission, the International Society of Artificial Life, Inc., the General Agenda Council on robotics and smart devices of the World Economic Forum, the International Society for Neural Networks, and several research centers and programs.

CO-DIRECTOR

PROF. ROBERT RIENER

SENSORY MOTOR SYSTEMS LAB (SMS), ETH ZURICH

Robert Riener is Full Professor for Sensory-Motor Systems at the Department of Health Sciences and Technology, ETH Zurich, and at the Medical Faculty of the University of Zurich (double-affiliation with the Spinal Cord Injury Center of the Balgrist University Hospital). Robert obtained his doctoral degree from the TU München in 1997. Since he began working in Zurich in 2003, he has developed robots and interaction methods for rehabilitation and sports. He published about 200 journal articles and filed 24 patents. Robert is the founder and head of the Cybathlon, for which he has received many awards and distinctions, including the Honorary Doctor of Medicine of the University of Basel.

PROF. ALEXANDRE ALAHI
VISUAL INTELLIGENCE FOR TRANSPORTATION LAB. (VITA), EPFL

Alexandre Alahi is a Tenure-Track Assistant Professor at EPFL leading the Visual Intelligence for Transportation lab. Before joining EPFL, he worked as a Postdoc and Research Scientist at Stanford University. His research lies at the intersection of computer vision, machine learning, and robotics applied to self-driving cars, social robots, and digital twins. He envisions a new type of AI called socially-aware AI: perception and planning augmented with social intelligence. He was awarded several grants such as the SNSF "early and advanced researcher grants", the CVPR Open Source Award and the ICDSC Challenge Prize. His research has been covered internationally. He has also co-founded multiple start-ups such as Visiosafe, won several start-up competitions and was elected as one of the Top 20 Swiss Venture leaders in 2010.

PROF. DAVID ATIENZA
EMBEDDED SYSTEMS LABORATORY (ESL), EPFL

David Atienza is Professor and Director of the Embedded Systems Laboratory (ESL) at EPFL, Switzerland. He received his PhD degree from UCM and IMEC, Belgium. His research interests focus on design methodologies for Internet of Things (IoT) and high-performance edge AI computing systems, including thermal-aware design for 2D/3D MPSoCs and ultra-low power smart wearables. In these fields, he has co-authored more than 300 publications in prestigious journals and conferences. Also, he is or has been Associate Editor of IEEE T-CAD, IEEE Trans. on Computers, IEEE TSUSC, ACM Computing Surveys, IEEE L-ES and Elsevier Integration, and President of IEEE CEDA, member of the Board of Governors of IEEE CASS.

PROF. ORI BAN-NUR
REGENERATIVE AND MOVEMENT BIOLOGY LAB. (RMB), ETH ZURICH

Ori Bar-Nur received his PhD degree with distinction in 2012 from the Hebrew University of Jerusalem for his research on human induced pluripotent stem cells. Following his PhD studies, he completed postdoctoral training at Harvard University, where he investigated the role of transcription factors and small molecules during cellular transitions. Since 2018 he serves as a tenure-track assistant professor in the Department of Health Sciences and Technology at ETH Zurich. The primary long-term goal of his laboratory is developing stem cell-based therapeutic approaches to treat degenerative loss of muscle mass. In respect to robotics, he is interested in investigating tissue engineering of skeletal muscle as a potential bioactuator for use in soft robotics. Dr. Bar-Nur's work has been published in prestigious journals including Nature Biotechnology, Nature Methods and Cell Stem Cell. During 2019 he was a recipient of the Eccellenza Grant from the SNSF.

PROF. AUDE BILLARD
LEARNING ALGORITHMS AND SYSTEMS LABORATORY (LASA), EPFL

Aude Billard is a Full Professor at EPFL and head of the Learning Algorithms and Systems Laboratory (LASA). She has a PhD in artificial intelligence from the University of Edinburgh and moved to EPFL in 2006 where she was first an Associate Professor, becoming a Full Professor in 2014. Aude Billard's research interests include control, automation, neural modelling and computation.

PROF. OLAF BLANKE
LABORATORY OF COGNITIVE NEUROSCIENCE (LNCO), EPFL

Olaf Blanke is the director of the Laboratory of Cognitive Neuroscience at EPFL and is Professor of Neurology at the Department of Neurology at the University Hospital of Geneva. His research is dedicated to the neuroscientific study of multisensory body perception and its relevance for self-consciousness by using a broad range of methods such as neuropsychology, invasive and non-invasive electrophysiology and brain imaging in healthy subjects, neurological and psychiatric patients. Most recently he has pioneered the joint use of engineering techniques such as robotics and virtual reality with techniques from cognitive neuroscience and their application to systems and cognitive neuroprosthetics and neuro-rehabilitation.

PROF. MARGARITA CHLI
VISION FOR ROBOTICS (V4RL), ETH ZURICH

Margarita Chli is an Assistant Professor at ETH Zurich leading the Vision for Robotics laboratory. She is the vice-director of the Institute of Robotics and Intelligent Systems of ETHZ and an Honorary Fellow of the University of Edinburgh. She holds Bachelor and Master degrees in Information and Computing Engineering from the University of Cambridge, and a PhD in Information Theory for efficient robot navigation from Imperial College London. Previous posts include the Chancellor's Fellowship of the University of Edinburgh, and currently holds an SNSF Professorship. Her interests lie in developing vision-based perception for robots, while her work contributed to the first vision-based autonomous flight of a small helicopter. Margarita received numerous academic scholarships, as well as international recognition for her work earning her a place in Robohub's 2016 list of "25 women in robotics you need to know about" and the biannual Zonta Prize 2017. Margarita's work was featured in Reuters and she was a speaker at the World Economic Forum in Davos in 2017.

PROF. STELIAN COROS
COMPUTATIONAL ROBOTICS LAB (CRL), ETH ZURICH

Stelian Coros is an assistant professor in the Computer Science Department at ETH Zurich. Prior to joining ETH, he was a faculty member in the Robotics Institute at Carnegie Mellon University. Dr Coros received his PhD in Computer Science from the University of British Columbia, Canada in 2011, and his research interests are in computer graphics and robotics, spanning the areas of physics-based animation, character animation, optimal control, reinforcement learning, and computational biomechanics. His work was honoured with an Intel Early Career Faculty Award, a Research Initiation Award by the US National Science Foundation, and in 2020 he was the recipient of an ERC Consolidator grant.

PROF. GRÉGOIRE COURTINE
G-LAB UPCOURTINE, EPFL & CHUV

Gregoire Courtine was trained in Physics and Neurosciences. His passion for translational neurosciences has fueled his research in the development of neurotechnologies to improve recovery from neurological disorders. After obtaining the Chancellor Award during his post-doc at the University of California Los Angeles (UCLA), he established his own laboratory at the University of Zurich in 2008 before joining the Swiss Federal Institute of Technology Lausanne (EPFL) in 2012. He is now Full Professor of Neuroscience and Neurotechnology in the Center for Neuroprosthetics at EPFL and in the department of Neurosurgery at the University Hospital Lausanne (CHUV) where he is director of the Defitech Center for Interventional Neurotherapies (NeuroRestore), together with Prof. Jocelyne Bloch. He is also Chief Scientific Officer (CSO) of GTX medical, a start-up he founded in 2014 to translate the neurotechnologies developed in his laboratory into clinical treatments.

PROF. TOBI DELBRUCK
INSTITUTE FOR NEUROINFORMATICS (INI), ETH ZURICH AND UZH

Tobi Delbruck studied Physics and Applied Mathematics as an undergraduate in San Diego and then Computation in Neural Systems as a graduate student at Caltech. He joined the Institute for Neuroinformatics at UZH-ETH Zurich in 1998 and co-directs the Sensors Group which develops neuromorphic AI sensing and computing technology from analog and digital transistor to complete system level. His breakthrough Dynamic Vision Sensor neuromorphic event camera from 2006 is now poised for mass production by Samsung and Sony. Currently the Sensors group focuses on AI hardware accelerators, efficient deep neural network inference, and machine learning applied to control and dynamical systems.

PROF. PIERRE DILLENBOURG
COMPUTER-HUMAN INTERACTION FOR
LEARNING & INSTRUCTION (CHILI), EPFL

Pierre Dillenbourg is a former teacher in elementary school. He graduated in educational science (University of Mons, Belgium) and started his research on learning technologies in 1984. He obtained a PhD in computer science from the University of Lancaster (UK), in the domain of artificial intelligence applications for education. He has been Assistant Professor at the University of Geneva. He joined EPFL in 2002. He is currently Full Professor in learning technologies in the School of Computer & Communication Sciences, where he is the head of the CHILI Lab (Computer-Human Interaction for Learning & Instruction). His lab is conducting several projects on educational robotics. With EPFL colleagues, he recently launched the Swiss EdTech Collider, an incubator with 60 start-ups in learning technologies.

PROF. LUCA GAMBARDELLA
IDSIA, UNIVERSITY OF LUGANO

Luca Maria Gambardella is full professor at USI in Lugano and member of IDSIA, Dalle Molle Institute for Artificial Intelligence USI-SUPSI which he directed from 1995 to 2020. His main interests are in the areas of machine learning, simulation, swarm robotics, metaheuristics, applied to academic and real-world problems (he studied and developed recognized optimization algorithms inspired by colony behavior (Ant Colony Optimization) to solve transport, assignment and scheduling problems).
He is responsible for projects for the SNSF, the Hasler Foundation, Innosuisse, the EC and in the industry and has been a member of the BRIDGE (Swiss CTI-FNS) Discovery evaluation panel since 2016. In the private sector he is co-founder, CTO & head of Applied AI at Artificially SA, a company based in Lugano that deals with projects and solutions in the field of artificial intelligence. In the artistic field he has co-realized in Lugano the “NeuralRope#1. Inside an Artificial Brain” (2019), a permanent interactive installation reproducing an artificial neural network. He is also a novelist: “Il suono dell’alba” (2019) is his latest work.

PROF. ROGER GASSERT
REHABILITATION ENGINEERING LAB (RELAB), ETH ZURICH

Roger Gassert received an MSc degree in microengineering and a PhD in neuroscience robotics from EPFL in 2002 and 2006, respectively. In 2008 he joined ETH Zurich as Assistant Professor of rehabilitation engineering where he is now Full Professor and applies robotics, wearable sensor technologies and non-invasive neuroimaging to the exploration, assessment and restoration of sensorimotor function.

PROF. MARCO HUTTER
ROBOTIC SYSTEMS LAB (RSL), ETH ZURICH

Marco Hutter is Assistant Professor for Robotic Systems at ETH Zurich. After studying mechanical engineering, he conducted his doctoral degree in robotics at ETH Zurich with a focus on design, actuation and control of dynamic legged robotic systems. Marco's research interests are in the development of novel machines and actuation concepts together with the underlying control, planning, and machine learning algorithms for locomotion and manipulation. His research group is participating in several research projects, industrial collaborations, and competitions that target the application of autonomous, mostly legged robots like ANYmal in challenging environments for search and rescue, industrial inspection, space exploration, forestry or construction operation.

PROF. AUKE IJSPEERT
BIOROBOTICS LABORATORY (BIOROB), EPFL

Auke Ijspeert is a professor at EPFL, head of the Biorobotics Laboratory (BioRob), and IEEE Fellow. He has a PhD in artificial intelligence from the University of Edinburgh and has been at EPFL since 2002, where he was first an SNSF Assistant Professor, then an Associate Professor (2009), and since 2016 a Full Professor. His research interests are at the intersection between robotics, computational neuroscience, nonlinear dynamical systems and applied machine learning. He is interested in using numerical simulations and robots to gain a better understanding of animal locomotion and movement control, and in using inspiration from biology to design novel types of robots and locomotion controllers. He is also interested in the control of exoskeletons for lower limbs.

DR MIRKO KOVAC
AERIAL ROBOTICS LABORATORY,
MATERIALS AND TECHNOLOGY CENTRE OF ROBOTICS, EMPA

Mirko Kovac is Director of the Aerial Robotics Laboratory and Head of the Materials and Technology Centre of Robotics at Empa Material Science Institute in Switzerland. He is also Reader in Aero-structures and Royal Society Wolfson Fellow. His research focuses on the development of novel, biologically inspired flying robots for distributed sensing in air and water and on autonomous robotic construction for digital infrastructure systems. His research group is a world leader in developing novel bio-inspired aerial robots. He is also Director of the Centre for Infrastructure Robotics Ecosystem (CIRE) at Imperial and is very active in government engagement, industrial collaboration and international partnerships.

Before his appointment in London, he was a Postdoc researcher at the Harvard University in Cambridge, USA. He obtained his PhD from EPFL and his M.S. degree in Mechanical Engineering from ETH Zurich. He has been a research associate with the University of California in Berkeley USA, RIETER Automotive Switzerland, the WARTSILA Diesel Technology Division in Switzerland, and CISERV in Singapore.

PROF. STÉPHANIE LACOUR
LABORATORY FOR SOFT BIOELECTRONICS INTERFACES (LSBI), EPFL

Stéphanie P. Lacour holds the Bertarelli Foundation Chair in Neuroprosthetic Technology at the School of Engineering at EPFL. She received her PhD in Electrical Engineering from INSA de Lyon, France. Her research focuses on the materials, technology and integration of soft bioelectronic interfaces including artificial skin, ultra-compliant neural electrodes for in vitro platforms as well as in vivo implants.

PROF. LAURA MARCHAL-CRESPO
MOTOR LEARNING AND NEUROREHABILITATION LAB. (MLN), UNIBE

Laura Marchal-Crespo is an Assistant Professor at the Motor Learning and Neurorehabilitation Laboratory at the University of Bern. Laura Marchal-Crespo obtained her MSc and PhD degrees from the University of California at Irvine, USA, in 2006 and 2009, respectively. In 2010 she joined the Sensory-Motor Systems, ETH Zurich, as a postdoc researcher. In 2017 she obtained an SNSF Professorship and joined the ARTORG Center for Biomedical Engineering Research at the University of Bern as medical faculty. She carries out research in the general areas of human-machine interfaces and biological learning, and, specifically, in the use of robotic assistance and virtual reality to aid people in learning motor tasks and rehabilitate after neurologic injuries.

PROF. SILVESTRO MICERA
TRANSLATIONAL NEURAL ENGINEERING LABORATORY (TNE), EPFL

Silvestro Micera holds the Bertarelli Foundation Chair in Translational Neuroengineering at the School of Engineering at EPFL. He received a Laurea degree in Electrical Engineering from the University of Pisa and a PhD in Biomedical Engineering from the Scuola Superiore Sant'Anna. Prof. Micera's research interests include the development of hybrid neuroprosthetic systems (interfacing the nervous system with artificial systems) and of mechatronic and robotic systems for function and assessment restoration in disabled and elderly persons.

PROF. FRANCESCO MONDADA
BIOROBOTICS LABORATORY (BIOROB), EPFL

Francesco Mondada received his MSc in micro-engineering in 1991 and his Doctoral degree in 1997 at EPFL. His interests include the development of innovative mechatronic solutions for mobile and modular robots, the creation of know-how for future embedded applications, and making robot platforms more accessible for education, research and industrial development.

PROF. JAMIE PAIK
RECONFIGURABLE ROBOTICS LAB (RRL), EPFL

Prof. Jamie Paik is the Founder and Director of the Reconfigurable Robotics Lab (RRL) at the Swiss Federal Institute of Technology (EPFL). RRL's develops novel interactive platforms that aim at improving human lives through unconventional robots that often push the physical limits of materials and mechanisms. RRL's self-morphing origami robot, Robogami, transforms its planar form into 2D or 3D shapes by folding in predefined patterns and sequences, just like paper art. RRL's Robogami and work in soft robots continue to receive international attention and press (TED, CES, BBC, Reuters, Wired, RTS, etc.).

PROF. STANISA RASPOPOVIC
NEUROENGINEERING LAB (IRIS), ETH ZURICH

Stanisa Raspopovic is an Assistant Professor of Neuroengineering at the Department of Health Sciences and Technology at ETH Zurich. He received his PhD in Biorobotics, from Scuola Superiore Sant'Anna, Pisa, in 2011. His research is focused on the development of innovative mechatronic devices for treatment of neurologically disabled persons. In particular he develops wearable neuroprosthetic systems directly interfacing the environment with the residual nervous system. Recently, he achieved pioneering results in the field of the sensory restoration in lower-limb amputee patients, enabling them to gain functional and health benefits. Presently he is developing personalised medicine systems for diabetic and bioelectronic applications. He co-founded SensArs Neuroprosthetics, a spin-off company that develops neuroprosthetic systems for amputees. He is presently the PI of the ERC starting grant FeelAgain, which aims at developing the novel bionic legs and systems for the treatment of a diabetic neuropathy.

PROF. SELMAN SAKAR

MICROBIOROBOTIC SYSTEMS LAB (MICROBS), EPFL

Mahmut Selman Sakar has been an Assistant Professor of Mechanical Engineering and the head of the MicroBioRobotic Systems (MICROBS) Laboratory at EPFL since 2016. MICROBS is committed to develop the science and techniques of microrobotics, where materials science and microelectromechanical systems technology meet robotics, creating micromachines operating in complex environments. He obtained a PhD in Electrical and Systems Engineering from the University of Pennsylvania. He was part of the team that developed the first optogenetic skeletal muscle-powered biological robots at the Massachusetts Institute of Technology. Working as a research scientist at ETH Zurich with Prof. Bradley Nelson, he introduced some of the most advanced 3D-printed magnetic microrobots and developed adaptive bioinspired microswimmers from magnetic hydrogels. He has co-authored more than 40 articles in international peer-reviewed journals including Nature Materials, Nature Communications, PNAS, and Science Advances. He has been awarded ERC Starting and Proof of Concept Grants to work on robotic solutions for life sciences and medicine.

PROF. DAVIDE SCARAMUZZA

ROBOTICS AND PERCEPTION GROUP (RPG), UZH AND ETH ZURICH

Davide Scaramuzza is Professor of Robotics and Perception at both departments of Informatics (University of Zurich) and Neuroinformatics (University of Zurich and ETH Zurich), where he does research at the intersection of robotics, computer vision, and neuroscience. Specifically, he investigates the use of standard and neuromorphic cameras to enable autonomous, agile, navigation of micro drones in search-and-rescue scenarios.
He did his PhD at ETH Zurich and a Postdoc at the University of Pennsylvania. He led the European project sFly, which introduced the PX4 autopilot and pioneered visual-SLAM-based autonomous navigation of micro drones. For his research contributions he won several awards (IEEE Robotics and Automation Society Early Career Award, SNSF-ERC Starting Grant, Google Research Award, KUKA, Qualcomm, Intel awards, European Young Research Award, Misha Mahowald Neuromorphic Engineering Award) and several conference paper awards. He coauthored the book “Introduction to Autonomous Mobile Robots” and more than 100 papers in top-ranked journals and conferences.
In 2015, he cofounded a venture, called Zurich-Eye, which later became Facebook-Oculus Switzerland. He was also the strategic advisor of Dacuda, which later became Magic Leap Zurich. Many aspects of his research have been prominently featured in wider international media, as well as in technology-focused media.

PROF. HERBERT SHEA
SOFT TRANSDUCERS LABORATORY (LMTS), EPFL

Herbert Shea is a professor at EPFL in Switzerland. He studied physics at McGill University and at Harvard University (PhD 1997). After two years as a post-doc at IBM's Watson Research Center, he joined Lucent Technologies' Bell Labs where he became the technical manager of the Microsystems Technology group. In 2004 Herb moved to the EPFL, where he heads the Soft Transducers Lab (LMTS). Herb is a pioneer in the field of electro-active soft actuators. His research is centered on elastomer-based transducers for wearable haptics and for soft robotics. Herb has published over 100 peer-reviewed papers, and is the president of the EuroEAP society.

PROF. ROLAND SIEGWART
AUTONOMOUS SYSTEMS LAB (ASL), ETH ZURICH

Roland Siegwart has been a Full Professor in autonomous systems at ETH Zurich since July 2006. He has a Master and PhD in ME from ETH Zurich and was ten years professor at EPFL. He was ETH's VP Research and is since 2015 co-director of the Wyss Zurich. Roland Siegwart's research interests are in the design, control and navigation of robots operating in complex and highly dynamical environments. His major goal is to find new ways to deal with uncertainties and enable the design of highly interactive and autonomous robots. Prominent examples are novel fixed- and rotary-wing drones, vision based autonomous navigation and intelligent and mobile service robots. He is among the most cited scientist in robotics and over fifteen startup companies have originated in his lab.

PROJECTS

NCCR Robotics focuses on three main research strands: the Wearable Robotics Grand Challenge, the Rescue Robotics Grand Challenge and the Educational Robotics Grand Challenge. Although the strands each have a distinct aim, certain aspects such as soft robotics, control and sensors do overlap, thus strengthening the collaborative objectives of the NCCR and enhancing Switzerland's position as a global leader in these areas.

Wearable Robotics Grand Challenge

Rescue Robotics Grand Challenge

Educational Robotics Grand Challenge

WEARABLE ROBOTICS GRAND CHALLENGE

The goal of the NCCR Robotics Grand Challenge on Wearable Robotics (WR-GC) is to develop a novel generation of wearable robotic systems, which will be more acceptable for patients and more extensively usable in the clinical environment. These new technological solutions will facilitate the sensorimotor recovery of locomotion and grasping after cerebrovascular accident (CVA) and Spinal Cord Injury (SCI) and will provide long-term assistance.

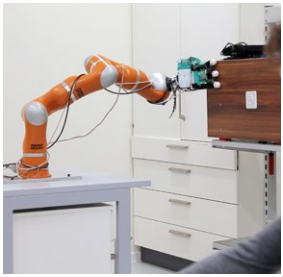
This goal will be reached through a combination of robotic systems and neuroprosthetic technologies, which will enable rehabilitative solutions defined by the following unique characteristics:

- **Personalisation** – advanced computational models and neuroimaging techniques will allow to define the optimal (hardware, software, rehabilitation protocols) characteristics of the WR-GC devices, personalised for different neurological deficits, and tailored to patient-specific impairments and their evolution.
- **Symbiosis** – the use of natural and bidirectional "neuro-to-machine" interfaces will allow the user to seamlessly interact with the WR-GC devices and increase the level of cortical plasticity.
- **Softness** – the use of novel soft materials (and more compliant control algorithms) will increase the usability, effectiveness and comfort of the technological solutions developed by the WR-GC.

Within the various projects of the WR-GC our researchers work on exoskeletons, soft robotics, prosthetics, implants and Brain Computer Interfaces (BCI).

Key projects within the WR-GC include **SOFT 3**, which focused on soft robotics; **ReGait** and its continuation, **ReGait++,** a research that develops a conceptual framework to identify the mechanisms underlying the recovery of leg motor control during EES (epidural electrical stimulation); **ReHand**, which sought to exploit natural control signals for the operation of a soft hand/arm exoskeleton; **Third Arm**, a recently launched project that investigates the use of a robotic limb together with the natural ones.

WEARABLE ROBOTICS GRAND CHALLENGE HIGHLIGHTS

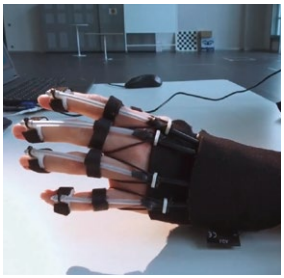


THIRD ARM

The goal of this project, launched at the end of 2018, is to allow subjects to control an additional robotic limb in combination with the natural arms and hands, while performing activities of daily living. To achieve this goal, NCCR Robotics researchers are going to develop a novel bidirectional human-machine interface (HMI). Decoding will be based on the combined processing of electroencephalographic (EEG), electromyographic (EMG) and kinematic information from areas such as neck and trunk while sensory feedback will be provided using non-invasive techniques. In parallel, a wearable robotic device – i.e. the "third arm" – will be developed. It will enable complex motion behaviour combined with intuitive user control, and it will be adaptable to different tasks and users.

REGAIT / REGAIT ++

Between 2014 and 2018, the ReGait project developed new solutions to restore walking in people with Spinal Cord Injury (SCI) such as the multidirectional bodyweight support system (Rysen), a textile-powered lower-limb exoskeleton (MyoSuit), and an implantable electrode array to activate the human spinal cord with epidural electrical stimulation (EES).
Now the ReGait++ project goes further by integrating these three technologies, testing them with SCI patients and developing new soft stimulating and recording interfaces.



REHAND

The ReHand project (2014–2018) sought to exploit natural control signals for the operation of a soft hand / arm exoskeleton in order to restore the cortico-peripheral structure naturally used to control the hand during grasping. This encompassed three phases:

- Develop new approaches to decode grasping commands using cortical and muscular signals.
- Develop two new robotics solutions to achieve usable and effective hand exo-skeletons.
- Develop wearable control and feedback prosthetic systems to reactivate muscles by using neuromuscular electrical stimulation.

SOFT 3

SOFT 3 was a key project during the second phase of NCCR robotics (2014–2018) and grouped three research projects focusing on “soft” components:

- Soft sensors, which were developed for monitoring the position of the fingers.
- Soft Pneumatic Actuator (SPA) skin with integrated soft sensors and design customisation for specific wearable applications.
- Multi-contact strategy using variable impedance control and stabilisation of conditions for grasping in robotic hands.

RESCUE ROBOTICS GRAND CHALLENGE

The goal of the Rescue Robotics Grand Challenge (RR-GC) is to investigate and develop robotic technologies for search and rescue operations and to address the key scientific questions on perception, navigation, locomotion, embodied intelligence and bio-mimetic engineering necessary to approximate the agility and versatility of animals moving in unstructured terrains. The aim is to create a heterogeneous robot team that 1) is composed of legged and flying robots, 2) is capable of multimodal locomotion, 3) is compliant and enables rich interaction with the environment, 4) is able to adapt and learn, and 5) allows symbiotic cooperation between robots and human operators.

The RR-GC is split into three main projects: legged robots, flying robots and collaboration and coordination. Each project has interaction and field test evaluations at model disaster sites with stakeholders on a regular basis, to ensure that the robots are being developed with the end users in mind. This work has led to state-of-the-art perception, control, and navigation controllers for robots that can move in complex unstructured terrains. It has also led to the design of new robots such as:

- **ANYmal** – a quadrupedal robot that features a compact main body filled with powerful computers, networking devices, power electronics and batteries for about three hours of autonomous operations.
- **Krock-2** – a bio-inspired amphibious quadrupedal robot, able to move both on solid ground and in water that can now both surpass obstacles twice its height (15 cm), move under narrow passages of the same height, locomote upside-down, and transmit normal and thermal videos to a remote operator. It has also served as basis for the reconstruction and study of locomotion of Orobates, one of the early tetrapods.
- **PackDrone** – a drone surrounded by an origami-inspired foldable protective cage, which allows safe deliveries of items up to 500 grams. One of the NCCR Robotics spin-offs, Dronistics, is developing and commercializing this technology, offering delivery services (see Spin-offs section).

RESCUE ROBOTICS GRAND CHALLENGE HIGHLIGHTS

ANYMAL

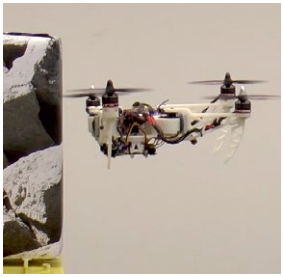
ANYmal is one of the two quadrupedal robots that have been developed in order to be deployed on the field and work in harsh conditions. It is designed for autonomous operation in challenging environments. Thanks to incorporated laser sensors and cameras, the robot can perceive its environment, accurately localize, and autonomously plan its navigation path and carefully select footholds while walking. With a weight of about 30 kg, ANYmal can be easily transported and deployed by a single operator. In the third phase, NCCR Robotics (2018—2022) researchers are further improving the locomotion skills of ANYmal and thus make it capable of dealing with situations that might be encountered in a search and rescue scenario; and they will integrate an arm on ANYmal. This way, the machine will become even more versatile: it will have the potential to manipulate objects, to move through closed doors, or simply to use the arm as an additional point of contact.

KROCK-2

Krock-2 is another quadruped robot which reuses the sturdy base of the previous Krock-1 and expands it with additional features, sensors and subsystems to make it suitable for disaster response missions. In particular, the inclusion of force sensors gives the robot the ability to feel its immediate environment, which can be used to improve its locomotion capabilities. Krock-2 can now both surpass obstacles twice as high as the robot itself (15 cm) and move under narrow passages of the same height. In addition, the construction of the robot is modular, meaning that pieces can be replaced easily on the field. It also presents mechanical symmetry from top to bottom, front to back and left to right, making the robot able to operate in any condition after a fall. A similar robot developed by NCCR Robotics researchers was used to recreate the gait of an extinct animal, based on its fossil remains – a study that was featured on Nature's cover in January 2019.

PACKDRONE

It is a quadcopter surrounded by a foldable cage that provides an all-round protective structure that physically separates the propellers from the environment, ensuring the safety of people in the vicinity. The whole structure of the drone can be easily folded with a single movement, significantly reducing its size for ease of storage and transportation. This new drone, designed by Dronistics (see Spin-Off section) allows safe last-cm delivery of parcels, directly to the user and in areas with no traditional landing site. It can be used in emergency situations or for civilian applications, such as aerial delivery to remote areas.



FOLDABLE DRONE

Inspired by birds that fold their wings in mid-air to cross narrow passages, this new drone can squeeze itself to pass through gaps and then go back to its previous shape, while continuing to fly. And it can even hold and transport objects. Its four independently rotating arms can fold in various ways, while a control scheme that can take into account the current morphology of the vehicle guarantees stable flight.

SYMBIOTIC DRONE ACTIVITY

Piloting drones with current interfaces, such as joysticks and remote controllers, requires extensive training and constant cognitive effort during flight. The Symbiotic Drone Activity consists of exploring novel interactions, mainly the bidirectional link between the physical bodies and control systems of the robot and the human, in order not only to enable a more intuitive control of drones, even for novices, but also to provide users with immersive sensations of flight, in a way which is not rendered in current interfaces. We are developing a smart jacket, which is a soft exosuit equipped with inertial measurement units for gesture control. It can be operated as a remote controller for drones in both open and cluttered environments.

EDUCATIONAL ROBOTICS GRAND CHALLENGE

Our economy is missing engineers, and our society needs a better education in technology in general and in robotics in particular. The Education Robotics Grand Challenge (ER-GC) aims at making the educational community – teachers and students alike – more aware of the possibilities offered by new technologies and help classrooms deal with them, thus improving the acceptance of robotics and encourage more students to pursue technological subjects.

While natural science, mathematics and partially computer science are topics addressed in schools, many other technologies – including robotics – are rarely part of the educational programme.

The ER-GC investigates how robots could trigger rich learning activities. New palm-sized robots have been developed to hold key properties: they interact with paper (localisation), they can be manipulated by users, they provide haptic feedback, they can behave as a swarm and they are affordable. The combination of these four features has created an unprecedented experience.

EDUCATIONAL ROBOTICS GRAND CHALLENGE HIGHLIGHTS

CELLULO

Cellulo has been designed to address classroom integration in three ways:

- Its behaviour depends upon its position on paper and each paper sheet can be tailored to a specific learning activity. Regular structured (printed dot patterns) paper is used.
- It constitutes a tangible interface: it moves by itself, as any robot, but can also be moved by kids, like a game token. It relies on magnetic-ball drives for holonomic motions, allowing the robot to be used for haptic feedback which paves the road for very creative learning activities.
- Since each Cellulo can be located, the behaviour of multiple robots was coordinated and hence developed into swarm behaviour. The learner's action can be propagated to the whole swarm through programming, such that the degree is decided by the designer. The combination of swarm and tangible is unique in education.

Current research aims to use Cellulo to support learning in teams, an important practice in schools, and for children with special needs (visual impairment, motor problems).

THYMIO

Thymio was developed through NCCR Robotics and is an affordable teaching
robot which uses open-source hardware and software.

It allows young users to discover the universe of robotics and learn a robot's language with the aim of programming it and carrying out numerous experiments. With Thymio, the basics of robotics and programming become notions everyone can discover, whatever their age.

Since 2013, over 1,000 teachers in Switzerland have been trained to use Thymio in the classroom, more than half of them were trained in 2017 alone, showing the rapid growth in interest.

INDUSTRY AND SOCIETY ACTIVITIES

NCCR Robotics has four main industry and society activities: Public Outreach, Knowledge and Technology Transfer, Education and Equal Opportunities.

PUBLIC OUTREACH

CYBATHLON

Conceived and headed by Prof. Robert Riener, NCCR Robotics co-director, the Cybathlon is a global initiative which first took place in Zurich in 2016, under the NCCR Robotics umbrella. The Cybathlon was launched as a platform for exchange between people with disabilities, technology providers and the public in order to raise awareness to the challenges faced by those with disabilities and to promote the development of assistive technologies.

70 pilots with 56 teams from 25 nations competed in six races: Brain-Computer Interface (BCI) Race, Functional Electrical Stimulation (FES) Bike Race, Powered Arm Prosthesis Race, Powered Leg Prosthesis Race, Exoskeleton Race and Powered Wheelchair Race.

The next Cybathlon will be organised by ETH Zurich on 19—20 September, 2020 in Kloten, Switzerland.

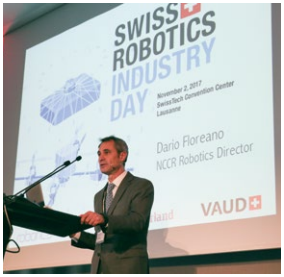
DRONE DAYS

This event was initiated by NCCR Robotics in 2017, and now runs as an independent franchise by EPFL. Over this 2-day event, more than 5,000 people were treated to drone races, a robotics showcase, a conference and demonstrations on EPFL's campus.

The second edition, in 2018, ran for three days and included a spectacular drone race, involving 60 international racers.

The third edition of the Drone days was part of EPFL's 50th anniversary events, and took place between 13 and 15 September 2019.

KNOWLEDGE AND TECHNOLOGY TRANSFER



SWISS ROBOTICS INDUSTRY DAY

This one-day annual event is exclusively designed for industry to showcase the activities of NCCR Robotics and selected Swiss start-ups active in the field of robotics through a series of robot and technology demonstrations, posters and panel discussions. In synergy with this unique programme, participants are offered the opportunity to exchange views on current and future needs and challenges facing the industry through talks by research and industry leaders. This is a unique opportunity for the industry to gain an insight into technology research performed within the NCCR Robotics Consortium and to get privileged access to new and emerging technologies. In 2018, the 4th edition had more than 300 participants from over 90 world-wide renowned robotics companies. The next edition of the Swiss Robotics Industry Day will be held on the 5th of November 2020.

As part of our KTT activities we also present the “Swiss Robotics” initiative. Swiss Robotics provides Swiss start-ups with unique opportunities:

- to exhibit at the Swiss Robotics Industry Day.
- to network with other robotics companies and researchers.

For further inquiries related to our KTT activities and start-ups please contact our KTT Officer (techtransfer@nccr-robotics.ch) and/or visit the industry section of our website for details.

SPIN-OFFS

NCCR Robotics is committed to knowledge and technology transfer between the laboratory and industry. To fulfil this aim we exhibit at international conferences and trade fairs. We also further support the creation of start-ups from NCCR Robotics research projects through the NCCR Robotics spin fund. Since 2014, NCCR Robotics has supported fifteen spin-offs, some of which in the meantime have been acquired by larger companies or investors.

ANYBotics. The next major step in robot evolution will see robots leave the structured factory floor. This requires versatile and highly mobile mechanical devices to move and act autonomously in unstructured environments, collaborating where needed with humans. For this to become reality, robot capabilities need to be massively improved in three areas: mobility, interaction and autonomy. anybotics.com

Dronistics is a Swiss start-up developing drones and software for person-to-person last-centimetre aerial deliveries. The safe drones are enclosed in a protective cage and can be folded to fit inside a backpack for easy storage and transportation. They fly autonomously and are commanded by users through the Dronistics web and smartphone application. These unique features enable the precise delivery of packages directly to users' hands even in remote locations where there is no suitable landing zone. dronistics.epfl.ch

Feeltronix developed a breakthrough technology platform that stretches the mechanical limits of electronics and provides solutions for robust and ultra-compliant rubber-based systems. Applications include smart bands for the next generation of wearables in sports, healthcare, AR/VR and fashion.

FES-ABILITY aims at developing proprietary technology for personalized neuro-rehabilitation treatments thanks to active body reconditioning with functional mobilization and electrical stimulation (FES). With online monitoring of sensorimotor function we also provide deeper recovery insight to support clinical decisions. fes-ability.ch

Flyability is a Swiss company building safe drones for operating indoors, in complex and confined spaces, and in contact with people. The company's main market is in industrial inspection where it avoids sending people in dangerous and confined spaces for the inspection of power generation, oil & gas, maritime and chemical infrastructures. It is also active in search & rescue and public security to assess emergency situations without putting humans at risk. flyability.com

Foldaway is developing ultra-portable and low-cost haptic interfaces that interact with human fingers by tracking their motion and providing force, stiffness and texture perception. foldaway-haptics.ch

Fotokite creates tethered UAS for Public Safety teams to gain situational awareness, helping them save lives and preserve property. Firefighters and first responder teams are using Fotokite systems, which integrate into their fire trucks and public safety vehicles, to gain aerial thermal and visual video perspectives with the single push of a button. Fotokite is a 30 person ETH Zurich spin-off company with offices in Zurich and Syracuse, NY. 1st Prize winner of the 2018 Genius NY competition, 2017 euRobotics Tech Transfer 1st Prize winner, and 2015 Qualcomm European QPrize winner. fotokite.com

FrameLess is an integrated sensing solution for robots that need to interact with humans and their environment. While having integrated electronics and utilizing other sensors with an innovative way, it can detect contact forces with extreme accuracy at dynamic environments. Frameless is extremely resistant against impacts, temperature changes and EMI. As such, this technology can enhance robotic manipulators, healthcare and medical solutions, construction robots and flying robots. Emphasis is given for applications with collaborative robots, which is a technology that nowadays, is changing our working style.

Intento has developed an easy-to-use, effective solution to help severely paralyzed stroke patients recover motor function in upper limbs. Even several years after the stroke. intento.ch

MyoSwiss develops the Myosuit, a garment-like set of active and passive layers designed to assist people with muscle weakness when performing movements. myo.swiss

Noonee is a Swiss based exoskeleton company, spin-off of ETH Zurich, founded in 2014. The company is focusing on exoskeletons for industrial application to improve the working environment and assist industrial workers in their daily tasks. noonee.com

SensArs mission is to restore complete functionality of upper and lower limb amputees, as well as those that had nerve-damage. The solution SensArs proposes, a neuroprosthetic device, is called Sensy: a unique device, which allows amputees, unlike currently available prostheses, to feel again from missing limbs. sensars.com

Sevensense develops innovative technology based on computer-vision to overcome the limitations of today's navigation systems and push the frontier of service robotics forward. Service robots have the potential to drastically increase efficiency in various industries by taking over repetitive tasks. However, operating in unstructured environments and public spaces represents a major challenge for autonomous mobile robots. sevensense.ch

Suind. Autonomous Beyond Visual Line-of-sight (BVLOS) drone operation requires a high safety standard to ensure that a drone can safely land in all circumstances without posing a threat to itself or its surroundings, which can include people and infrastructure. However, the lack of a dedicated environment-aware safety system on drones as well as a high reliance on GPS for navigation are highly inadequate to ensure a high safety standard. To solve these challenges, we have developed an AI based dedicated drone safety suite that can be attached to any commercial drone. This device has one job: To get a drone from air to ground as safely as possible.

Twiice is a modular exoskeleton for walking assistance that allows spinal cord injury paraplegics to regain independence in their daily activities. twiice.ch

EDUCATION

In the field of education, NCCR Robotics excels at promoting robotics to the next generation. We have regular outreach events which we run in collaboration with the Equal Opportunities office at EPFL. As part of our drive to encourage educational activities we offer internships and exchanges at Master, PhD and Postdoc levels, both to external candidates wishing to work at NCCR Robotics and internal candidates who wish to partake in a short-term project elsewhere.

MASTERS IN ROBOTICS

- EPFL offers a Master in Robotics (master.epfl.ch/robotics).
- ETH Zurich offers a Master in Robotics, Systems and Control (master-robotics.ethz.ch).

PhD/POSTDOC EXCHANGE PROGRAMMES

Every year, NCCR Robotics opens a call for proposals for projects for PhD and Postdoc candidates who wish to spend a period of 3–6 months in an NCCR Robotics lab. This also applies to NCCR Robotics PhD and Postdoc students who wish to visit another lab.

DOCTORAL SCHOOL

The partner institutions of NCCR Robotics are committed to further education and, as a result, they offer different Doctoral Programmes and PhD opportunities. Please note that any questions should be directed directly to the partner universities.

EQUAL OPPORTUNITIES

The number of women working in robotics-related academic fields is very low, especially when it comes to professorships and top positions in general. NCCR Robotics is addressing this problem with dedicated initiatives and opportunities that promote women's involvement and help them developing their career.

Every year, NCCR Robotics opens a call for the Master Scholarships for Women, a programme for female Master students who wish to spend a period of 3–6 months in an NCCR Robotics lab. So far, more than twenty female students have benefitted from these grants.

We also work with the Equal Opportunities offices at our partner universities to provide courses on robotics specifically for women. For example, "Robots are indeed for girls" is a robotics workshop destined to girls aged 11 to 13 years old, where they are taught to build and program a robot. The workshop is open to 50 girls per semester, and has already welcomed 400 girls since its launch.

Our Equal Opportunities Committee constantly elaborates and adjusts internal and external strategies to ensure equal opportunities are guaranteed. In 2018, we started to sponsor networking / lunch meetings at our various institutions especially oriented to female researches in the robotics field.

In 2019, two new funding programs were introduced: (1) the Scientific Visibility Award aims to help finance the participation of female students (with ties to NCCR Robotics) to present their papers/posters at (inter-)national conferences; and (2) a grant to promote the invitation of keynote speakers to conferences organized by NCCR Robotics PIs in Switzerland.

In 2020 we announced the Award for Career Development, dedicated to the promotion and expansion of female researchers' careers.

Keep up to date with our activities

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June 2020

Photo credits: **Soft 3** – Inaki Iturrate and CNBI Lab // **Rehand** – RELab // **ReGait** – SMS Lab, ETH Zurich // **Third Arm** – LASA // **ANYmal C** – ANYbotics AG // **Foldable drone** – University of Zurich / Armasuisse // **Thymio** – Ramun Riklin and Thymio // **Cybathlon** – Alessandro Della Bella and Cybathlon // **Krock-2**, **PackDrone**, **Symbiotic Drone Activity**, **Cellulo**, **Swiss Robotics Industry Day** & **Drone Days** – Alain Herzog and NCCR Robotics