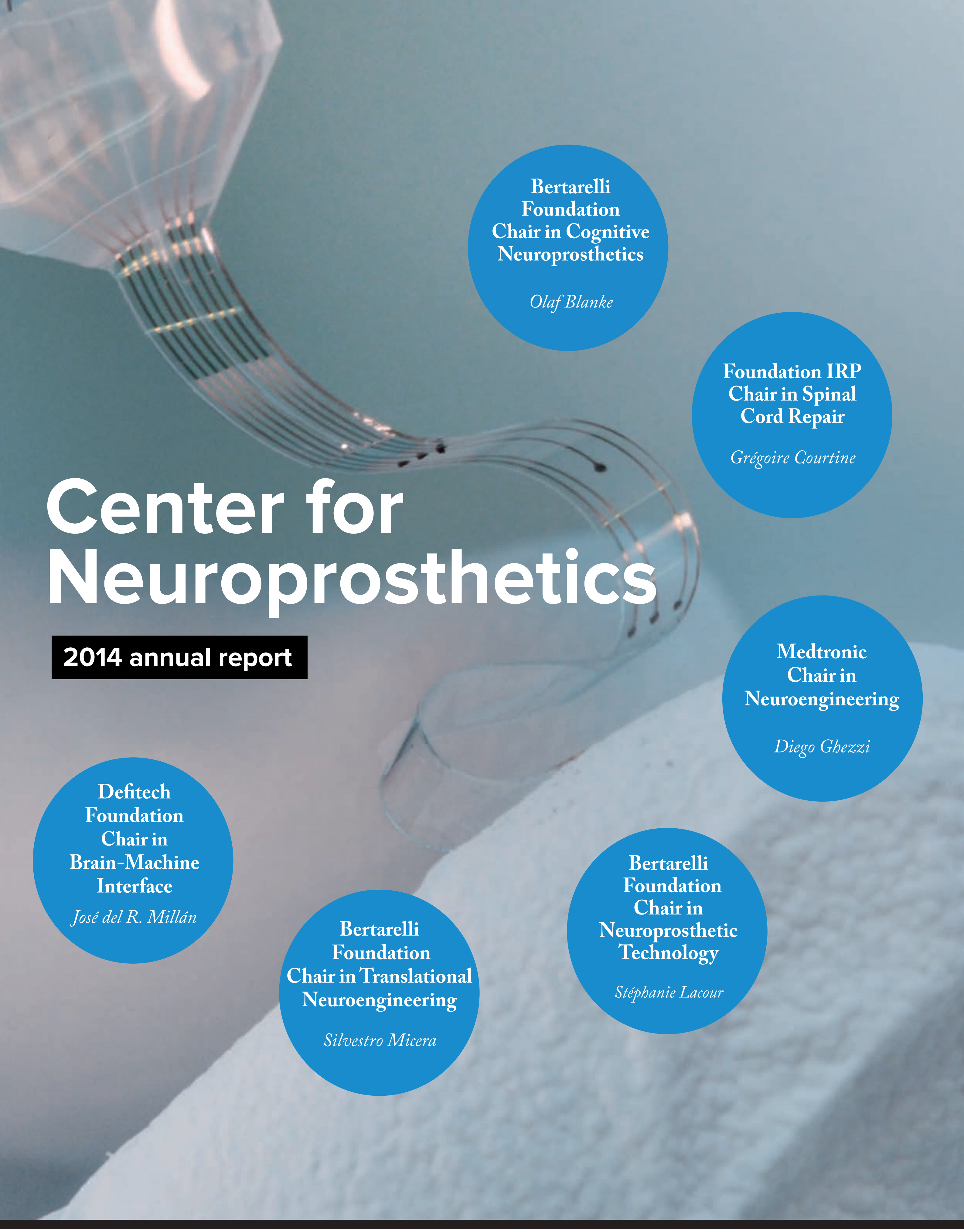

Center for Neuroprosthetics

2014 annual report

Bertarelli Foundation Chair in Cognitive Neuroprosthetics
Olaf Blanke

Foundation IRP Chair in Spinal Cord Repair
Grégoire Courtine

Medtronic Chair in Neuroengineering
Diego Ghezzi

Defitech Foundation Chair in Brain-Machine Interface
José del R. Millán

Bertarelli Foundation Chair in Neuroprosthetic Technology
Stéphanie Lacour

Bertarelli Foundation Chair in Translational Neuroengineering
Silvestro Micera

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

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defitech fondation

IRP

Medtronic

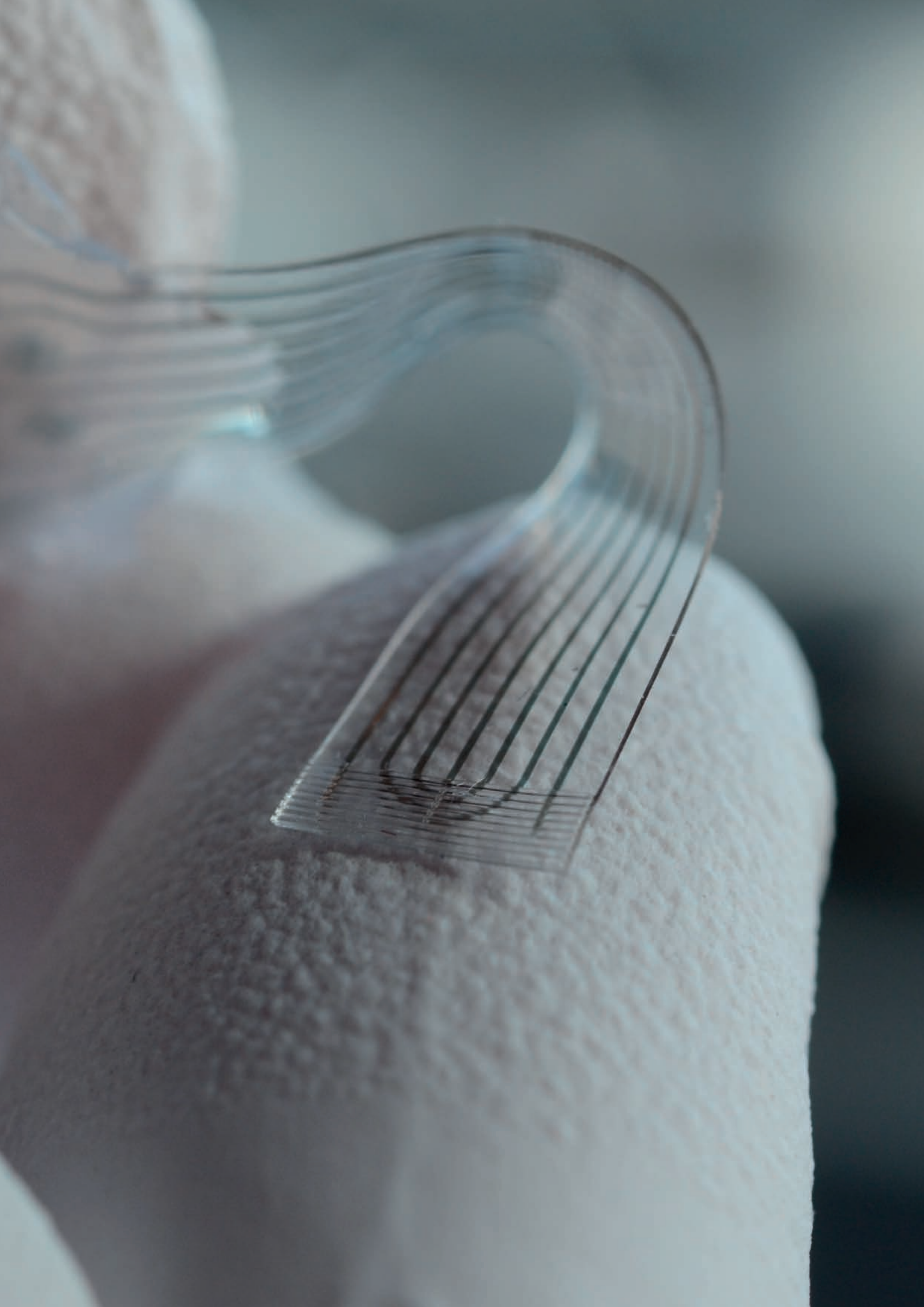
Welcome

The 20th Century witnessed major advances in the investigation and understanding of the brain and its diseases. This culminated in the 1990s with the "decade of the brain", which also saw the massive arrival of systems and cognitive neuroscience in humans based on the development of non-invasive brain imaging techniques. The field of neuroengineering also made breathtaking advances in biotechnology and microelectronics, as well as neural implants that make it possible to target specific regions in the brain, the spinal cord, and the peripheral nervous system. Next to inspiring new insights into the functioning of the brain, these revolutionary neuroengineering techniques hold great promise for novel personalized treatments for a large number of debilitating and often devastating brain diseases. This acceleration and success in the neurosciences and neuroengineering was complemented by a third revolution: information technology and the birth of the digital age with major advances in computing power, new computing devices, e- and m-health, and wearable communication technologies, including virtual and augmented reality.

The Center for Neuroprosthetics enthusiastically embraces these revolutions and is establishing a truly interdisciplinary area of study for scientific discovery and neurotechnological design through cutting edge research in neuroscience and engineering, medicine and computer science. To meet our ambitious translational goals in neuroprosthetics —that is, the repair and substitution of impaired sensory, motor and cognitive functions— we have over the last year created several start-up companies and further strengthened our strategic clinical partnerships with the University Hospitals in Geneva and Lausanne, the Swiss Rehabilitation Clinic in Sion, and Harvard Medical School.

Stay tuned.

Olaf Blanke
Director of the Center for Neuroprosthetics
Ecole Polytechnique Fédérale de Lausanne (Switzerland)



CNP

Mission

The Center for Neuroprosthetics (CNP) capitalizes on its unique access to the advanced bio- and neurotechnologies and state of the art brain research present at EPFL. We strive to develop new technologies that repair, replace and enhance functions of the nervous system. The development of such technologies or devices, called neuroprostheses, requires a fundamental understanding of the neurobiological mechanisms of the functions that should be replaced or repaired, for example sensory perception, cognitive operations or movement. It also requires technological capabilities to design novel devices, to record and process signals and to translate them into outputs that can command artificial limbs, bodies and robots, for motor function, or produce signals to activate the brain, in the case of sensory and cognitive prostheses.
The well-established treatments of deep brain stimulation for Parkinson's disease, of cochlear implants for hearing loss, and of virtual reality for neuropsychiatric rehabilitation are just three of the success stories in this area. Clearly, much work lies ahead of us while we strive to provide enabling neurotechnological treatments to neurological and psychiatric patients. Such electroceutical and cogniceutical treatments are desperately needed with approximately a third of the population in Europe and the US afflicted by brain disorders. Major advances in systems and cognitive neuroprosthetics are necessary for treating patients with motor and sensory loss as well as cognitive deficits such as those caused by Alzheimer's disease and vascular stroke.

Projects

Walk again

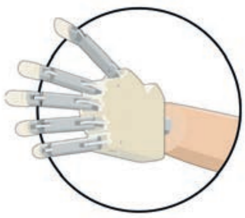
Movement intentions of a paralyzed rodent with spinal cord injury are decoded from real-time recording of brain activity. Decoded information is directly fed into a brain-spinal interface that computes optimal spinal cord stimulation patterns to execute the desired movement. As a result the animal is capable of locomotion and obstacle avoidance, even though the spinal cord motoneurons are physically separated from the brain.

Cognitive enhancement and repair

Robust real-time movement control of wheelchairs and robots, pioneering work in virtual reality, augmented reality, wearable robotics, and brain-machine interfaces, and major advances in cognitive neuroscience and wearable technology are exploited to develop new devices and treatments for mobility restoration, chronic pain, schizophrenia, communication, neuroscience research, and entertainment.

Rehabilitation of upper limb sensorimotor loss

Merging insights from robotics and neuroengineering, our devices enable novel neurorehabilitation training for patients suffering from sensorimotor loss of the upper extremity. These tools are complemented by techniques from brain-machine interfaces and virtual reality to further enhance rehabilitation outcomes for patients with sensorimotor loss, chronic pain and cognitive deficits.



Bionic hand

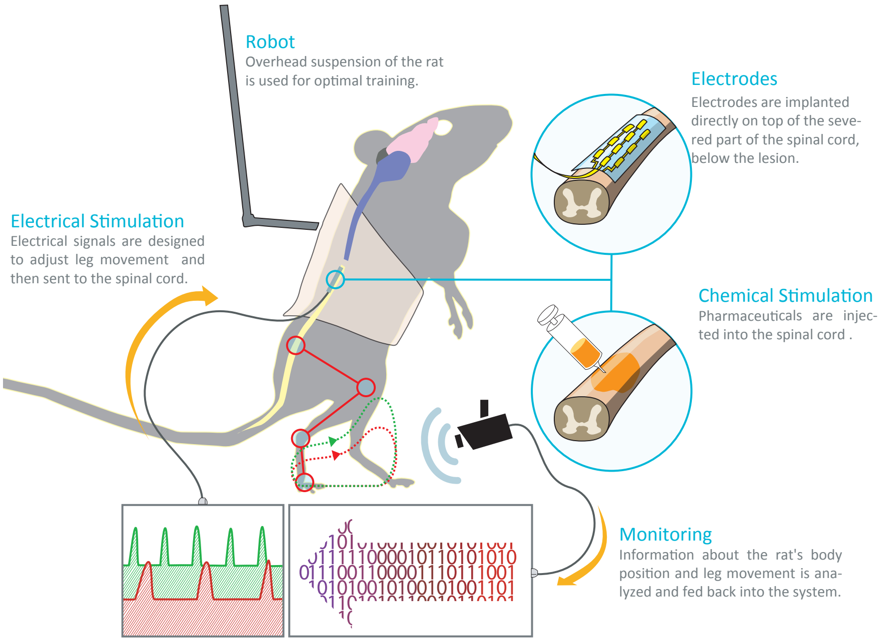
Biocompatible flexible electrodes are implanted into peripheral arm nerves of amputee patients. Movement commands of the amputee patient are decoded from signals in the implanted electrodes and transmitted to the prosthetic hand, where they are translated into movements of the prosthetic hand and fingers. Signals from different sensors in the prosthetic hand can also be transmitted via the implanted electrodes to the peripheral nerve to enable sensory functions such as the sense of touch and of finger position. Novel non-invasive stimulation protocols are developed to enable touch and decrease phantom limb pain.

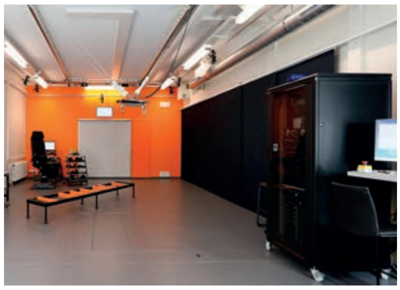
Walk again

Restoring sensorimotor functions after spinal cord injury

Robotic postural neuroprosthesis

Novel robotic postural neuroprosthesis to evaluate, enable, and train locomotion under natural walking conditions. The amount of support can be finetuned for each axis according to the animal's capacity.

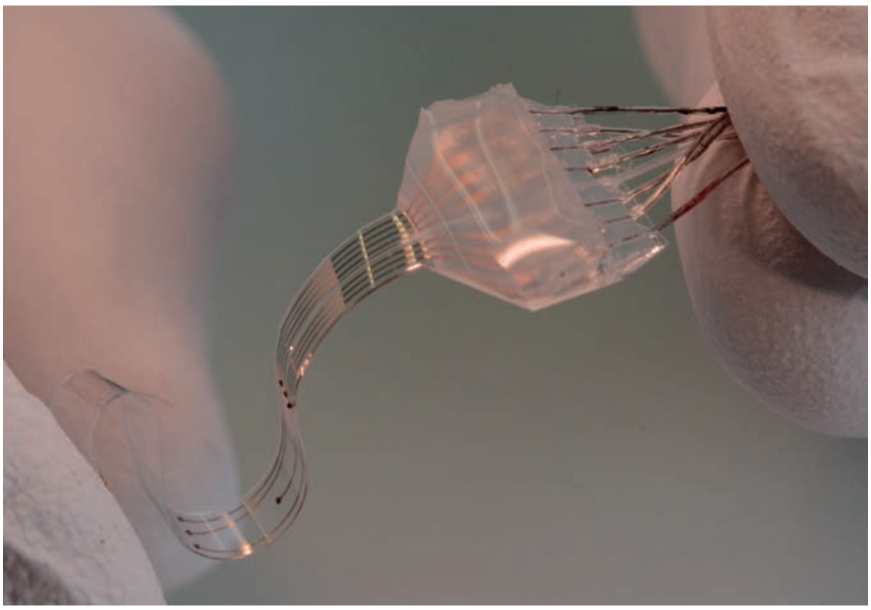




Together with the neurosurgery department at CHUV, the Courtine Lab designed an advanced gait rehabilitation platform. A room located in the neurorehabilitation unit at the Nestlé Rehabilitation Hospital has been entirely renovated to integrate the most advanced technologies for the recordings and rehabilitation of people with locomotor impairments.

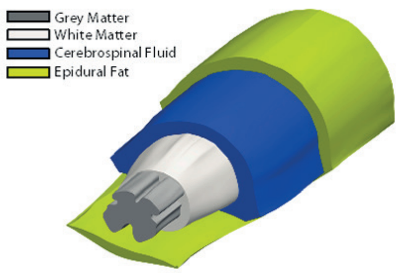
Electronic dura mater (e-dura)

The soft elastomeric implant is prepared with silicone rubber, stretchable thin-gold film interconnects, platinum-silicone composite electrode coating, and hosts a silicone microfluidic channel for in situ drug delivery. This surface electrode implant can be inserted below the natural dura mater to conform to the surface of the brain or the spinal cord (Minev et al., Science 2015).



A Computational Model for Epidural Electrical Stimulation of Spinal Sensorimotor Circuits

Spinal neuroprosthetics and in particular epidural electrical stimulation (EES) of lumbosacral segments can restore a range of movements after spinal cord injury. However, the mechanisms and neural structures through which EES facilitates movement execution remain unclear. Researchers from the CNP developed a realistic finite element computer model of rat lumbosacral segments to identify the currents generated by EES and coupled this model with an anatomically realistic biophysical model of sensorimotor circuits.
Our computational model, which we validated with actual measurements from the animal, offers an alternative to classical experimental approaches to optimize quickly and precisely the position, size, and configuration of EES electrodes.



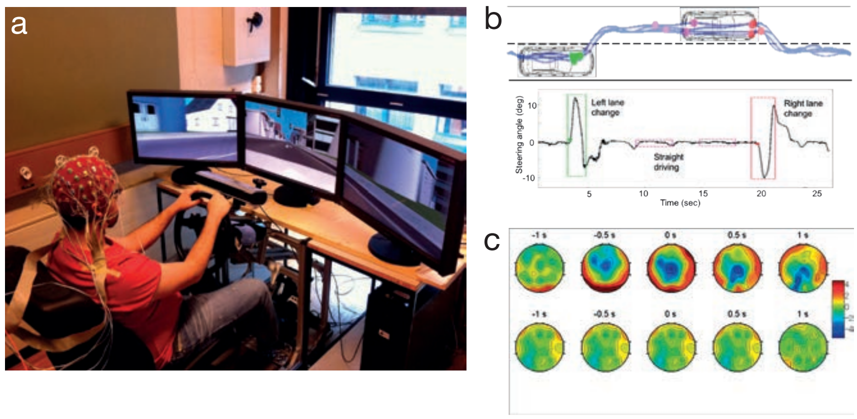
The computational model: the realistic finite element model

Cognitive enhancement and repair

Restoring and enhancing sensorimotor integration and cognition through brain-computer interfaces and neuroscience robotics

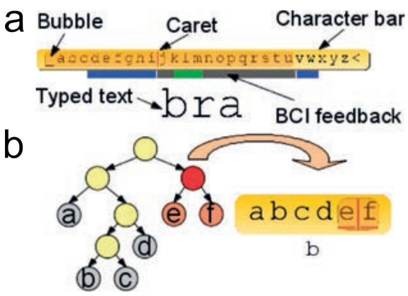
EEG correlates of upcoming driving actions.

The decoding of brain activity during car driving identifies and can even anticipate the changing of lane on a highway. (a) Car driving simulator used in the experiments, including a real car seat and steering wheel, and 3D monitors. b) Car trajectories and steering angles during lane changes. (c) Grand average ERP during lane changes (top) and straight driving periods (bottom). Topographical activity represented by a top view of the scalp (nose up). t=0 corresponds to the moment of steering.



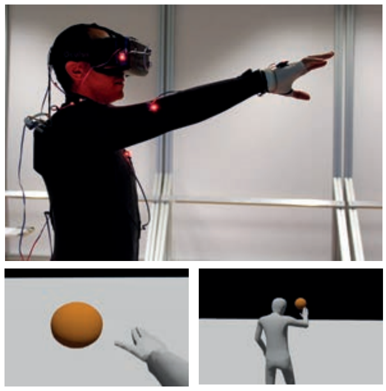
BrainTree, a motor imagery hybrid BCI speller.

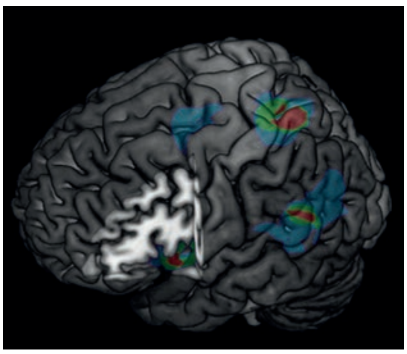
Using a new graphical user interface and an underlying binary tree structure, the hybrid BCI (hBCI) can be used in combination with context awareness to improve flawless spelling task completion.



Avatar embodiment for immersive interaction.

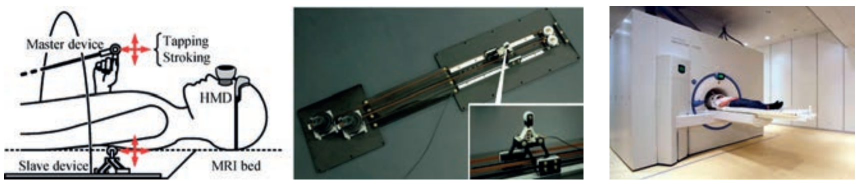
Users control a 3D avatar to interact with virtual objects and other virtual humans based on full body motion capture and virtual reality technology. These technologies are tailored and personalized for patients suffering from chronic pain and motor disorders.





Neuroscience robotics and robotic psychiatry

We have developed several new robotic devices that allow us to study the brain mechanisms of psychosis-like mental states (first-rank symptoms of schizophrenia; i.e. passivity feelings) in healthy subjects. These data are compared with data in neurological patients (left). Moreover, we recently designed a new MRI-compatible robot allowing to determine the detailed brain mechanisms of psychosis-like states in healthy subjects and patients with psychosis.

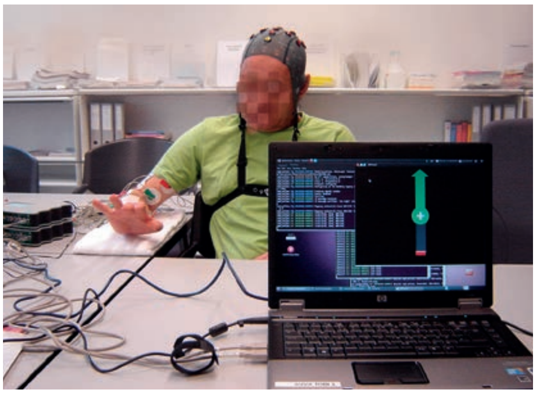


Rehabilitation of upper limb sensorimotor loss

Providing neurotechnological tools for cerebral stroke rehabilitation

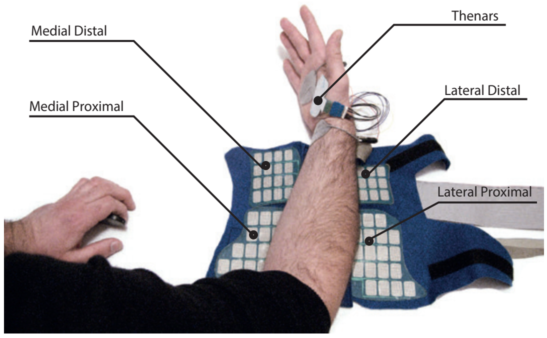
Brain-computer interfaces and rehabilitation

Brain-computer interfaces (BCI) can help stroke patients to regain motor control of their paralyzed hand. The BCI detects the patient's intent to execute a hand extension movement and activates appropriate functional electrical stimulation patterns to activate the hand muscles and execute the desired action. The BCI also checks that intent is encoded in physiologically relevant cortical areas and frequencies.



Precise neuro-muscular electrical stimulation of hand and fingers

Our electrode arrays facilitate specific flexion and extension of the fingers and also control the wrist.



Robotic neurorehabilitation of upper limbs.

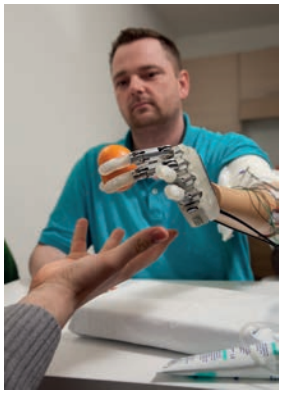
CNP develops personalized approaches for robot-based post-stroke neurorehabiltiation using novel upper limb exoskeletons and virtual reality.

Virtual reality for treatment of pain and motor loss

We developed a new line of systems merging insights from neuroscience of bodily self-consciousness and augmented reality for chronic pain patients... (amputation, cerebral stroke or orthopedic disorders).

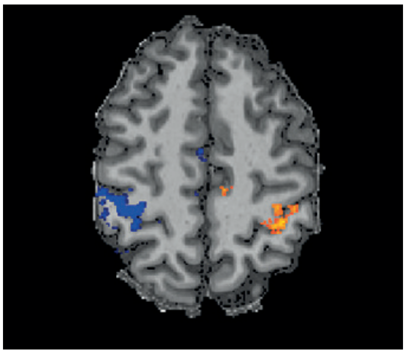
Bionic hand

Restoring sensory and motor functions after arm or hand amputation



Restoring natural sensory feedback for real-time bidirectional robotic arm control in a human amputee

The ideal bidirectional hand prosthesis should involve both a reliable decoding of the user's intentions and the delivery of sensory feedback through the remnant afferent pathways simultaneously and in real time. We showed that, by stimulating peripheral nerves using intraneural electrodes, natural sensory information can be provided to an amputee during the real time control of a hand prosthesis. This feedback enabled the participant to effectively modulate the grasping force of the prosthesis without any visual or auditory feedback.
Results also show that by restoring dynamic sensory information derived from specific hand locations, a higher complexity of perception can be obtained, allowing the subject to identify the compliance and shape of different objects.

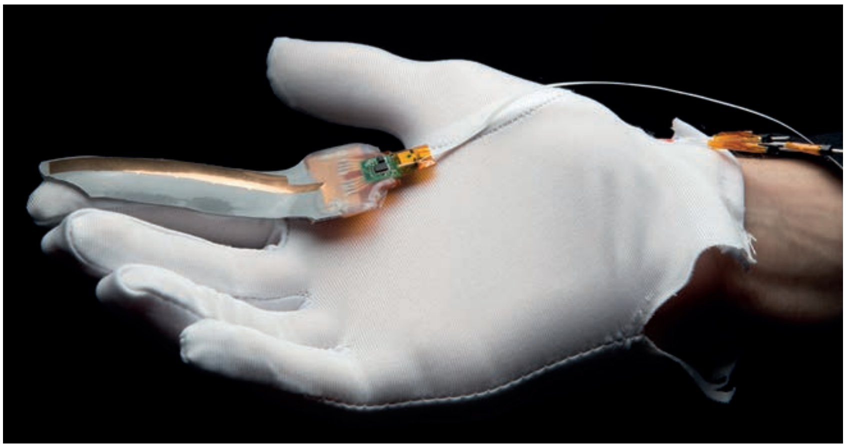


Neural representation of the phantom hand in a human amputee with targeted muscle reinnervation

Targeted muscle reinnervation (TMR) interfaces persisting nerves from the amputated limb with another muscle of the amputee (here the chest muscle) allowing the control of a robotic or prosthetic limb. We used ultra-high resolution imaging at 7 tesla fMRI and showed that the cortical hand motor centers in such TMR patients were restored to the location of the hand motor centers controlling the non-amputated hand. This differs from the location of motor centers in amputee patients without TMR and will benefit the design of future neuroprostheses.

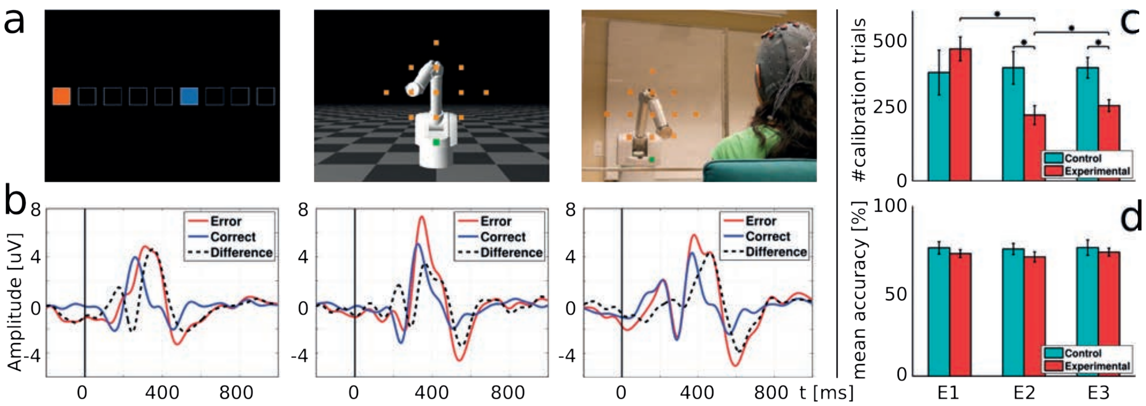
Electronic artificial skin, or e-skin

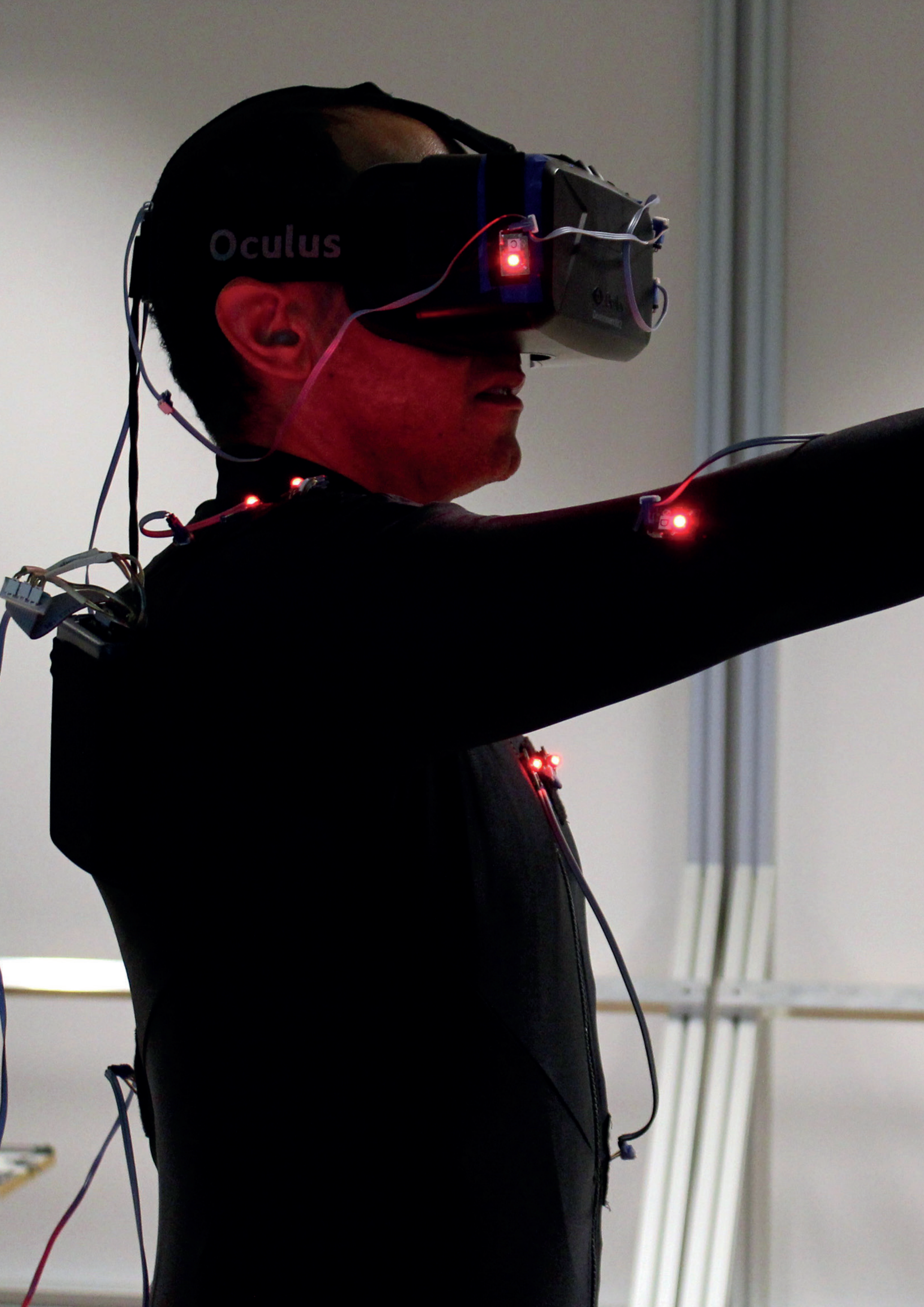
Our multimodal electronic skin covers the dorsal and palmar sides of the fingers. This wearable elastomer-based e-skin includes resistive sensors for monitoring finger articulation and capacitive tactile pressure sensors that register distributed pressure along the entire length of the finger. Future prosthesis may be covered with artificial skin. Our artificial skin can sustain crumpling as well as sharp indentation while the gold film coating remains intact.



Generalization of BMI decoders across different protocols

(a) Experimental protocol. (b) EEG error related potentials (ErrP) in each experimental protocol. (c-d) ErrP decoders can generalize across protocols with reduced calibration time without decrease in performance.




Oculus

Laboratories

Bertarelli Foundation Chair in Cognitive Neuroprosthetics
Blanke Lab

http://lnco.epfl.ch

IRP Foundation Chair in Spinal Cord Repair
Courtine Lab

http://courtine-lab.epfl.ch

Medtronic Chair in Neuroengineering
Ghezzi Lab

http://cnp.epfl.ch/Ghezzilab

Bertarelli Foundation Chair in Neuroprosthetic Technology
Lacour Lab

http://lsbi.epfl.ch

Translational Neural Engineering Laboratory
Micera Lab

http://tne.epfl.ch

Defitech Foundation Chair in Brain-Machine Interface
Millán Lab

http://cnbi.epfl.ch

Bertarelli Foundation Chair in Cognitive Neuroprosthetics

Blanke Lab

http://lnco.epfl.ch

The Blanke Lab (Bertarelli Chair in Cognitive Neuroprosthetics) targets the brain mechanisms of body perception, body awareness and consciousness. Neuroscience projects rely on the investigation of healthy subjects, neurological, psychiatric, orthopedic patients by combining psychophysical and cognitive paradigms, neuroimaging techniques (high resolution fMRI, intracranial and surface EEG, TMS), and engineering-based approaches (virtual reality, robotics, vestibular stimulation). In neuroprosthetics, we pursue an active line of research on sensory substitution, neurorehabilitation, and human enhancement. Pioneering the field of cognitive neuroprosthetics, we have integrated several engineering techniques such as robotics, haptics, and virtual reality with a broad range of behavioral and neuroscience technologies. Most recently we have pursued the development of the field of robotic psychiatry (robotics to understand the brain mechanisms of psychiatric symptoms) and cogniceuticals (the application of robotics and augmented reality to enhance and alter mind, cognition, and consciousness).

Results Obtained in 2014

In robotic psychiatry, a major achievement was the design and application of a master-slave robotic system (Hara et al., Journal of Neuroscience Methods, 2014) that manipulates sensorimotor signals in a fine-grained way and is able to induce altered bodily experience and psychosis-like states in healthy participants (Blanke et al., Current Biology 2014). We also studied the same states and the involved brain circuits in a large group of neurological patients. Most recently, we have started to investigate the involved brain circuits in healthy participants by using another robotic system that is fully compatible with brain imaging using magnetic resonance imaging. In cogniceuticals, we have launched a major effort in treating patients with chronic pain (of neurological and orthopedic origin) using a new integrated virtual reality platform with our clinical partners in the rehabilitation clinics in Sion and Geneva (research is ongoing). Our neuroscience research targeted the brain regions underlying body perception and consciousness in healthy participants (Ionta et al., Social Cognitive and Affective Neuroscience 2014) and neurological patients (Heydrich & Blanke, Brain 2013; Serino et al., Epilepsy and Behavior 2014; Heydrich et al., Journal of Neurology, Neurosurgery and Psychiatry 2015; Ronchi et al., Neuropsychologia, 2015) including processing of bodily sounds (Van Elk et al., Biological Psychology, 2014a, 2014b) and pain (Romano et al., Behavioral Brain Research 2014), and visual consciousness (Faivre et al., Current Opinion in Neurology, 2015).

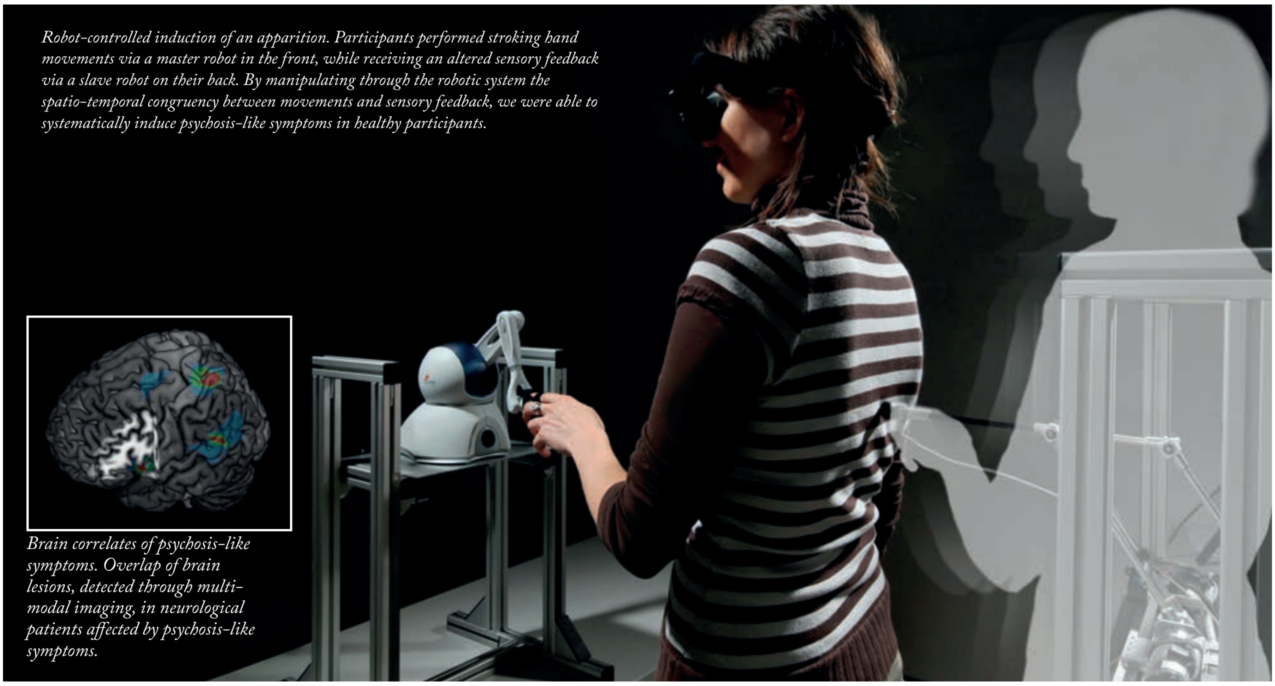
Bio

Olaf Blanke is founding Director of the Center for Neuroprosthetics and holds the Bertarelli Foundation Chair in Cognitive Neuroprosthetics at the Ecole Polytechnique Fédérale de Lausanne (EPFL). He also directs the Laboratory of Cognitive Neuroscience at EPFL and is Professor of Neurology at the Department of Neurology at the University Hospital of Geneva. Blanke's human neuroscience research is dedicated to the understanding of how the brain represents our body and the neuroscientific study of consciousness. In neuroprosthetics he develops the fields of robotic psychiatry, cognetics, and cogniceuticals.

fondation bertarelli

Keywords

Multisensory and sensorimotor processing, consciousness, neuroscience, robotics, virtual and augmented reality, neuroimaging, fMRI, EEG, neurology, psychiatry.



Robot-controlled induction of an apparition. Participants performed stroking hand movements via a master robot in the front, while receiving an altered sensory feedback via a slave robot on their back. By manipulating through the robotic system the spatio-temporal congruency between movements and sensory feedback, we were able to systematically induce psychosis-like symptoms in healthy participants.

Brain correlates of psychosis-like symptoms. Overlap of brain lesions, detected through multi-modal imaging, in neurological patients affected by psychosis-like symptoms.

Team

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Sonia Neffati-Laifi

Selected Publications

Ronchi R, Bello-Ruiz J, Lukowska M, Herbelin B, Cabrilo I, Schaller K, Blanke O. 2015. Right insular damage decreases heartbeat awareness and alters cardio-visual effects on bodily self-consciousness. Neuropsychologia 70:11-20.

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van Elk M, Salomon R, Kannape O, Blanke O. 2014. Suppression of the N1 auditory evoked potential for sounds generated by the upper and lower limbs. Biological Psychology 102:108-17.

van Elk M, Lenggenhager B, Heydrich L, Blanke O. 2014. Suppression of the auditory N1-component for heartbeat-related sounds reflects interoceptive predictive coding. Biological Psychology 99:172-82.

Serino A, Heydrich L, Kurian M, Spinelli L, Seeck M, Blanke O. 2014. Auditory verbal hallucinations of epileptic origin. Epilepsy and Behavior 31:181-6.

Romano D, Pfeiffer C, Maravita A, Blanke O. 2014. Illusory self-identification with an avatar reduces arousal responses to painful stimuli. Behavioral Brain Research 15;261:275-81.

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Heydrich L, Blanke O. 2013. Distinct illusory own-body perceptions caused by damage to posterior insula and extrastriate cortex. Brain 136 (3):790-803.

Kannape OA and Blanke O. 2013. Self in motion: sensorimotor and cognitive mechanisms in gait agency. Journal of Neurophysiology 110(8):1837-47.

Foundation IRP Chair in Spinal Cord Repair

Courtine Lab

http://courtine-lab.epfl.ch

The World Health Organization (WHO) estimates that as many as 500'000 people suffer from a spinal cord injury each year. Over the past decade, we implemented an unconventional research program with the aim to develop radically new treatment paradigms to improve functional recovery after spinal cord injury. We have progressively conceived a treatment that integrates a serotonergic replacement therapy (Nature Neuroscience, 2009), electrical spinal cord stimulation (Science Translational Medicine, 2014; Science, 2015), next-generation weight-supporting robotic systems (Nature Medicine, 2012) and novel will-powered training regimes (Science, 2012). We have shown that this combinatorial treatment restored refined locomotion after severe spinal cord injury in rodent models. Recovery occurs through the extensive and ubiquitous remodeling of residual neuronal connections in the brain and spinal cord. The goal of the laboratory is to translate this treatment into a medical practice for improving functional recovery after spinal cord injury in humans. To this aim, we have structured a translational, neuroprosthetic program that combines work in mice, rats, non-human primates, and humans. Specifically, our objective is to (i) identify the mechanisms underlying the immediate and long-term effects of our treatment in genetically modified mice using virus-mediated experimental manipulations, calcium imaging and optogenetics; (ii) refine all our methods and procedures in rat models of spinal cord injury; (iii) optimize and validate our new neurotechnologies and therapeutic concepts in non-human primate models; and (iv) deploy clinical studies that progressively integrate the different components of our interventions.

Bio

Grégoire Courtine was trained in Mathematics, Physics, and Neurosciences in France and Italy. After a Postdoc in Los Angeles (UCLA), he established his laboratory at the University of Zurich. In 2012, he was appointed the International Paraplegic Foundation Chair in Spinal Cord Repair at the Center for Neuroprosthetics at EPFL. His research program aims to develop neuroprosthetic treatments to improve recovery after spinal cord injury—an endeavor that has been reported in high-profile publications, and has extensively been covered in the media. His startup, G-Therapeutics SA, aims at translating these medical and technological breakthroughs into treatments.

Results Obtained in 2014

Mechanisms of recovery after spinal cord injury (Cell 2014): We had previously demonstrated that recovery after spinal cord injury relies on novel detour connections that bypass the injury. However, the circuit-level mechanism behind this process was not elucidated. We found that muscle spindles and associated circuits promote the establishment of these detour connections. These findings may contribute to improving our treatment strategies.

Neuromodulation therapies (Science Translational Medicine, 2014; Science 2015): We have identified the mechanisms underlying the facilitation of locomotion with electrical spinal cord stimulation. This conceptual framework guided the development of innovative hardware and software to improve our neuromodulation therapies. We designed the first entirely stretchable, multimodal implants that exhibit unprecedented bio-integration in the central nervous system. This implant, developed in collaboration with Prof. Lacour, can deliver both electrical and chemical stimulations over the brain and spinal cord. In parallel, we collaborated with Prof. Micera to develop a control platform through which neuromodulation parameters can be adjusted in real-time, based on movement feedback. Using this hardware and software, we designed control algorithms that achieve precise adjustment of leg movements in animal models of neurological disorders.

Wireless neurosensor (Neuron, 2014): Neuroscience research has been constrained by cables required to connect brain sensors to computers. In collaboration with Brown University, we developed and validated a wireless brain-sensing system that allows recordings of high-fidelity neural data during unconstrained behavior in primates.

Gait rehabilitation platform: In collaboration with the CHUV, the SUVA and the Canton of Valais, we established a new Gait Platform that brings together innovative monitoring and rehabilitation technology. We will exploit this Gait Platform to evaluate the ability of our electrical stimulation protocols and robot-assisted training procedures to improve motor function after spinal cord injury.

Keywords

Spinal cord injury, neural repair, neurorehabilitation, neuroprosthetics, brain-machine interface, robotics, neuronal recordings, optogenetics, EMG, kinematics, locomotion, neuromorphology, mice, rats, monkeys, humans.

Team

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Rafael Fajardo
Michel Fanny
Sam Ghazanfari
Nili Halimi
Audrey Nguyen
Jean Pie
Solange Richter
Romain Sagean
Giorgio Ulrich
Marie-Claire Ung

Selected Publications

Minev IR, Musienko P, Hirsch A, Barraud Q, Wenger N, Moraud EM, Gandar J, Capogrosso M, Milekovic T, Asboth L, Torres RF, Vachicouras N, Liu Q, Pavlova N, Duis S, Larmagnac A, Vörös J, Micera S, Suo Z, Courtine G and Lacour SP. 2015. Biomaterials. Electronic dura mater for long-term multimodal neural interfaces. Science, 347(6218):159-63.

Takeoka A, Vollenweider I, Courtine G and Arber S. 2014. Muscle spindle feedback directs locomotor recovery and circuit reorganization after spinal cord injury, Cell, 159(7): 1626-39.

Yin M, Borton DA, Komar J, Agha N, Lu Y, Li H, Laurens J, Lang Y, Li Q, Bull C, Larson L, Rosler D, Bezard E, Courtine G and Nurmikko AV. 2014. Wireless Neurosensor for Full-Spectrum Electrophysiology Recordings during Free Behavior, Neuron, 84(6): 1170-82.

Wenger N, Martin Moraud E, Raspopovic S, Bonizzato M, DiGiovanna J, Musienko P, Morari M, Micera S and Courtine G. 2014. Closed-loop neuromodulation of spinal sensorimotor circuits controls refined locomotion after complete spinal cord injury, Science Translational Medicine, 6(255):255ra133.

Borton D, Micera S, Millán J d R and Courtine G. 2013. Personalized neuroprosthetics, Science Translational Medicine, 5(210):210rv2.

Capogrosso M, Wenger N, Raspopovic S, Musienko P, Beauparlant J, Bassi Luciani L, Courtine G and Micera S. 2013. A Computational Model for Epidural Electrical Stimulation of Spinal Sensorimotor Circuits, Journal of Neuroscience, 33(49): 19326-40.

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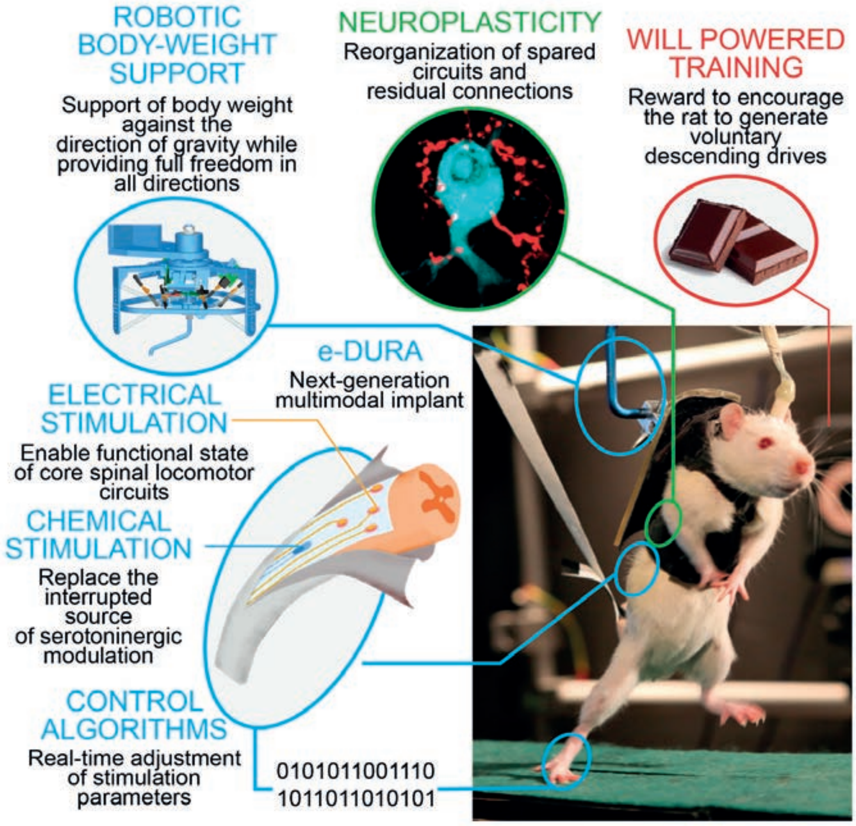


A completely paralyzed rat can be made to walk over obstacles and up stairs by electrically stimulating the severed part of the spinal cord.

Medtronic
Chair in
Neuroengineeing

Ghezzi Lab

http://cnp.epfl.ch/Ghezzilab

Our laboratory represents a bridge among research on material science, engineering, and life science, with the mission of exploring novel interfaces for light modulation of neurons. The primary exploitation of these technologies is represented by restoration of sight. The degeneration of the retinal outer nuclear layer represents one of the major causes of adult blindness in industrialized countries. Despite the enormous effort and advances in the clinical treatment of eye diseases, there is no established method to prevent or cure such causes of blindness. Research at the Ghezzi Lab will combine engineering and biotechnological tool in order to provide novel solutions for photoreceptor restoration or replacement.

Results Obtained in 2014

In 2014, I started setting up my research activities at the Center for Neuroprosthetics. I was selected from the Global Ophthalmology Awards Program from Bayer HealthCare to lead a research project dedicated to the restoration of sight, by implementing new biotechnological techniques, such as Genome Editing. I also started a new project aiming at combining far infrared illumination with optogenetics for the restoration of vision, in collaboration with Teresa Pellegrino at Istituto Italiano di Tecnologia (IIT). The research on the development of an organic retinal prosthesis reaches the stage of in-vivo validation in a rat model of Retinitis pigmentosa. Preliminary results demonstrated the capability of the prosthesis to rescue light sensitivity in-vivo.

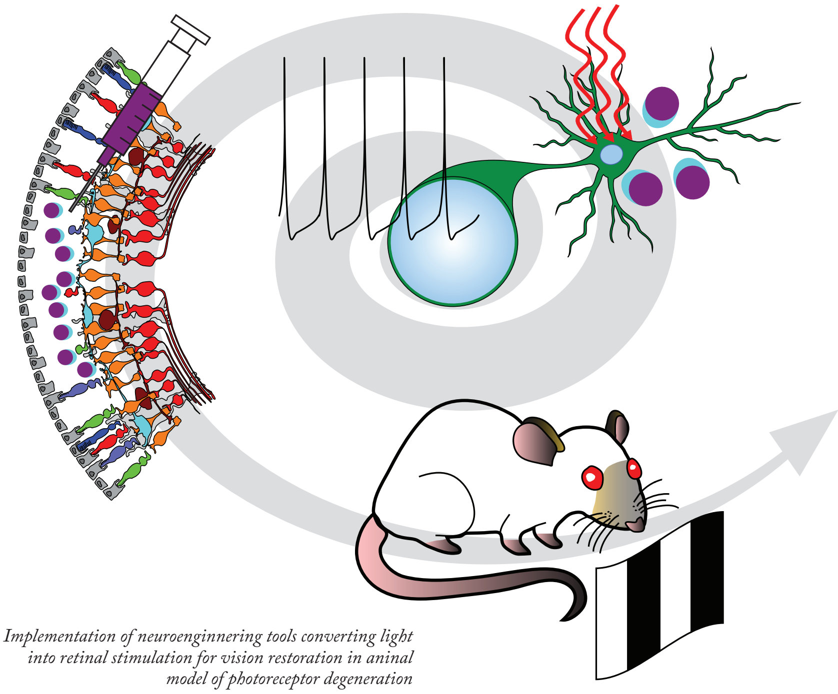
Bio

Prof. Diego Ghezzi holds the Medtronic Chair in Neuroengineering at the School of Engineering at the Ecole Polytechnique Fédérale de Lausanne. He received his M.Sc. in Biomedical Engineering (2004) and his Ph.D. in Bioengineering (2008) from Politecnico di Milano. From 2008 to 2013, he completed his postdoctoral training at Istituto Italiano di Tecnologia in Genova at the department of Neuroscience and Brain Technologies where he was promoted to Researcher in 2013. In 2015, he was appointed as Tenure Track Assistant Professor of Bioengineering in the EPFL Center for Neuroprosthetics. His research activities are primarily focused on the implementation of novel technological approaches for sight restoration, and in general the development of neuro-artificial interfaces and tools for the non-invasive stimulation of the brain with light.

Medtronic

Keywords

Neuro-optoelectronic interfaces, visual prosthesis, optical stimulation, nanofabrication, polymers, neuroprosthetics, biocompatibility, visual system, sight restoration, sensory perception, artificial photoreceptors.



Implementation of neuroenginnering tools converting light into retinal stimulation for vision restoration in aninal model of photoreceptor degeneration

Team

Assistant Professor
Diego Ghezzi

Selected Publications

Endeman D, Feyen P, Ghezzi D, Antognazza MR, Martino N, Colombo E, Lanzani G and Benfenati F. 2014. The use of light sensitive organic semiconductors to manipulate neuronal activity. In Novel Approaches for Single Molecule Activation and Detection, 189-202, Springer.

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Contestabile A, Greco B, Ghezzi D, Tucci V, Benfenati F, Gasparini L. 2013. Lithium rescues synaptic plasticity and memory in Down syndrome mice. The Journal of Clinical Investigation 123(1):348-361.

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Szczurkowska J, Dal Maschio M, Cwetsch AW, Ghezzi D, Bony G, Alabastri A, Zaccaria RP, Di Fabrizio E, Ratto GM, Cancedda L. 2013. Increased performance in genetic manipulation by modeling the dielectric properties of the rodent brain. Proceedings of 35th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, Osaka 2013.

Ghezzi D, Antognazza MR, Mete M, Pertile G, Lanzani G, Benfenati F. 2013. A polymer-based interface restores light sensitivity in rat blind retinas. Abstracts of the 43th Society for Neuroscience Annual Meeting, October 9-13 2013, San Diego, California, United States of America, 373.13

Mete M, Ghezzi D, Antognazza MR, MaccaroneR, Lanzarini E, MartinoN, Pertile G, Bisti S, Lanzani G, Benfenati F. 2013. A polymer-based interface restores light sensitivity in rat blind retinas. Abstracts of the ARVO 2013 Annual Meeting, Life-Changing Research, May 5-9 2013, Seattle, Washington, United States of America.

Bertarelli Foundation Chair in Neuroprosthetic Technology

Lacour Lab

http://lsbi.epfl.ch

Bioelectronics integrates principles of electrical engineering to biology, medicine and ultimately health. The Laboratory for Soft Bioelectronics Interfaces (LSBI) challenges and seeks to advance our fundamental concepts in man-made electronic interfaces applied to biological systems. Specifically, the focus is on designing and manufacturing electronic devices with mechanical properties close to that of the host biological tissues so that long-term reliability and minimal perturbation are induced in vivo and/or truly wearable systems become possible. Applications include assistive technologies for patients with impaired neurological functions in the form of soft implantable electrodes, and wearable interfaces in skin-like formats for prosthetic tactile skins.

We use fabrication methods borrowed from the MEMS industry and adapt them to soft substrates like elastomers. We develop novel characterization tools adapted to mechanically compliant bioelectronic circuits. Moving soft bio-electronics forward requires innovation in the fields of materials science, fabrication, engineering and biocompatibility and a multidisciplinary mindset.

Results Obtained in 2014

In 2014, our research has focused on the integration and characterization of soft bioelectronic devices, designed for sensory skins and compliant neural interfaces.

Electronic Dura Mater

We have demonstrated a new class of soft multimodal neural implants that offer extraordinary resilience and unprecedented long-term bio-integration within the central nervous system. The soft neural implants, which we called e-dura because they display nearly identical mechanical behavior to the natural dura mater, are entirely made of stretchable materials. The electrodes are coated with a soft,
engineered platinum-silicone composite with high electrical efficiency.

In collaboration with CNP labs of Prof. Grégoire Courtine and Prof. Silvestro Micera, we have implemented the soft neuroprosthesis to restore locomotion in paralyzed rats who had suffered a near complete spinal cord injury, over extended periods of time. Using a similar implant, placed on the surface of the motor cortex, we were able to record cortical states associated with locomotion in freely behaving rodents. This new technological platform is highly versatile and will lead to a broad range of applications for basic research and translational medicine. (Minev*, Musienko* et al. Science 2015).

We are pursuing the development of a range compliant electrode implants including flexible auditory brainstem implants and peripheral nerve interfaces based on soft conduit coatings and microchannel electrodes.

Tactile sensory skin

The sensing capability of human skin is remarkable; it is able to measure physical stimuli such as shear and normal pressures, temperature, and vibration at a thickness of only 1 mm, and can do so while undergoing large deformations and extensions. Electronic artificial skin, or e-skin, represents a powerful tool for applications such as prosthetics, robotics, and wearable electronics. In 2014, the LSBI has optimized and implemented a multimodal electronic skin covering the dorsal and palmar sides of the fingers. The wearable elastomer-based electronic skin includes resistive sensors for monitoring finger articulation and capacitive tactile pressure sensors that register distributed pressure along the entire length of the finger.

We are also pursuing our efforts in manufacturing high-performance thin-film transistors (TFTs) based on Indium Gallium Zinc Oxide (IGZO) semiconductor channel on compliant substrates. Such devices are essential elements to scale up our sensory skin to large area and high-density sensor arrays.

Bio

Prof. Stéphanie P. Lacour holds the Bertarelli Foundation Chair in Neuroprosthetic Technology at the School of Engineering at the Ecole Polytechnique Fédérale de Lausanne. She received her PhD in Electrical Engineering from INSA de Lyon, France, and completed postdoctoral research at Princeton University (USA) and the University of Cambridge (UK). She is the recipient of the 2006 MIT TR35, a University Research Fellowship from the Royal Society (UK), a European Research Council ERC Starting Grant, the 2011 Zonta award and the 2014 World Economic Forum Young Scientist award.

Her laboratory explores materials, technology and integration of soft bioelectronic interfaces, with particular applications in soft robotics and long-term active neuroprosthesis.

fondation bertarelli

Keywords

Microfabrication, soft bioelectronics, implantable electrodes, elastomer, electronic skin

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Selected Publications

Minev IR*, Musienko P*, Hirsch A, Barraud Q, Wenger N, Moraud EM, Gandar J, Capogrosso M, Milekovic T, Asboth L, Torres RF, Vachicouras N, Liu Q, Pavlova N, Duis S, Larmagnac A, Voros J, Micera S, Z. Suo, Courtine G*, and Lacour SP*. 2015. Electronic dura mater for long-term multimodal neural interfaces. Science, 347(6218): 159-63.

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Musick KM, Chew DJ , Fawcett JW, and Lacour SP. 2013. PDMS Microchannel Regenerative Peripheral Nerve Interface, 2013 6th International IEEE/EMBS Conference on Neural Engineering (NER), pp. 649-652.

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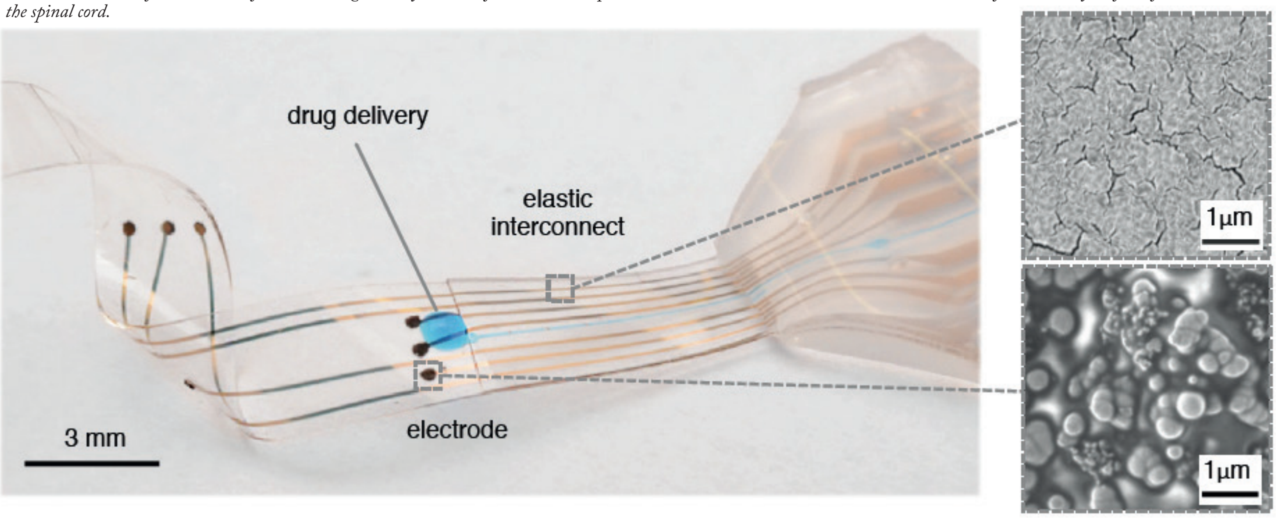
Dobrzynski MK, Vanderparre H, Pericet-Camara R, L'Eplattenier G, Lacour SP, Floreano D. 2013. Hyper-flexible 1D shape sensor, The 17th International Conference on Solid-State Sensors, Actuators and Microsystems (IEEE Transducers & Eurosensors XXVII), 2013, 1899-1902.

Electronic dura mater. The soft elastomeric implant is prepared with silicone rubber, stretchable thin-gold film interconnects, platinum-silicone composite electrode coating, and hosts a silicone microfluidic channel for in situ drug delivery. This surface electrode implant can be inserted below the natural dura mater to conform the very surface of the brain or the spinal cord.



Bertarelli Foundation Chair in Translational Neuroengineering

Micera Lab

http://tne.epfl.ch

The goal of the Translational Neural Engineering (TNE) Laboratory is to develop implantable neural interfaces and robotic systems to restore sensorimotor function in people with different kinds of disabilities (spinal cord injury, stroke, amputation, etc.). In particular, the TNE lab aim is to be a technological bridge between basic science and the clinical environment. Therefore, TNE novel technologies and approaches are designed and developed, starting from basic scientific knowledge in the field of neuroscience, neurology and geriatrics, with the idea that better understanding means better development of clinical solutions.

Results Obtained in 2014

In 2014, we published the first example of a bidirectional arm neuroprosthesis in humans. We showed, for the first time, the possibility to develop a real-time bidirectional control of hand prostheses using intraneural peripheral electrodes.

We were also deeply involved in the activities led by Professor Courtine's team to develop a novel neuroprosthesis to restore locomotion using epidural electrical stimulation (EES). These activities produced, among others, a publication in Science Translational Medicine showing novel control strategies to improve the performance of EES real time control of gait parameters.

We participated at the development of the e-dura technology from Prof. Stéphanie Lacour's lab, recently published in Science.

We are also currently working with the University Hospital of Geneva (Prof. Guyot) to develop and validate a novel neuroprosthesis to restore vestibular functions in disabled subjects. The TNE is responsible for the integration of the device, and the development of novel approaches to assess the performance of this device and collaborates on the clinical and neurophysiological characterization together with HUG clinical team. We are also starting a new industrial collaboration on this topic.

Finally, we develop a wearable system for functional electrical stimulation to restore grasping in highly disabled subjects. The system is currently in clinical testing in Italy.

Bio

Silvestro Micera is Director of the Translational Neural Engineering Laboratory and holds the Bertarelli Foundation Chair in Translational Neuroengineering at the Center for Neuroprosthetics and the Institute of Bioengineering. He received the University degree (Laurea) in Electrical Engineering from the University of Pisa in 1996, and the Ph.D. degree in Biomedical Engineering from the Scuola Superiore Sant'Anna in 2000. In 2009 he was the recipient of the "Early Career Achievement Award" of the IEEE Engineering in Medicine and Biology Society. Prof. Micera's research interests include the development of neuroprostheses based on the use of implantable neural interfaces with the central and peripheral nervous systems to restore sensory and motor function in disabled persons.

fondation bertarelli

Keywords

Implantable neuroprostheses, rehabilitation robotics, wearable devices, neuro-controlled artificial limbs, reaching and grasping, locomotion, functional electrical stimulation.

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Georgia Sousouri
Aurelie Staphan

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Anouk Hein

Selected Publications

Minev IR, Musienko P, Hirsch A, Barraud Q, Wenger N, Moraud EM, Gandar J, Capogrosso M, Milekovic T, Asboth L, Torres RF, Vachicouras N, Liu Q, Pavlova N, Duis S, Larmagnac A, Vörös J, Micera S, Suo Z, Courtine G, Lacour SP. 2015. Biomaterials. Electronic dura mater for long-term multimodal neural interfaces. Science, 347(6218):159-63.

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Wenger N, Moraud EM, Raspopovic S, Bonizzato M, DiGiovanna J, Musienko P, Morari M, Micera S, Courtine G. 2014. Closed-loop neuromodulation of spinal sensorimotor circuits controls refined locomotion after complete spinal cord injury. Science Translational Medicine: 6(255):255ra133.

Poppendieck W, Sossalla A, Krob MO, Welsch C, Nguyen TA, Gong W, DiGiovanna J, Micera S, Merfeld DM, Hoffmann KP.2014. Development, manufacturing and application of double-sided flexible implantable microelectrodes. Biomedical Microdevices. 16(6):837-50.

Nguyen TA, Ranieri M, DiGiovanna J, Peter O, Genovese V, Perez Fornos A, Micera S. 2014. A real-time research platform to study vestibular implants with gyroscopic inputs in vestibular deficient subjects.IEEE Transaction on Biomedical Circuits and Systems. 8(4):474-84.

Perez Fornos A, Guinand N, van de Berg R, Stokroos R, Micera S, Kingma H, Pelizzone M, Guyot JP. 2014. Artificial balance: restoration of the vestibulo-ocular reflex in humans with a prototype vestibular neuroprosthesis. Frontiers in Neurology. 5(66).

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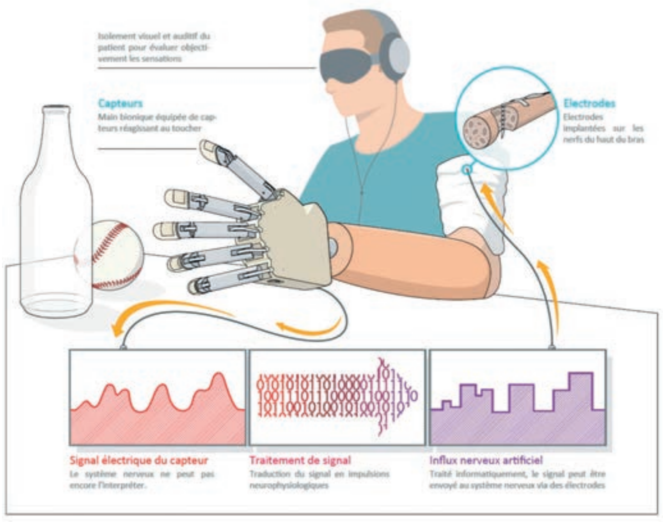
Raspopovic S, Capogrosso M, Petrini FM, Bonizzato M, Rigosa J, Di Pino G, Carpaneto J, Controzzi M, Boretius T, Fernandez E, Granata G, Oddo CM, Citi L, Ciancio AL, Cipriani C, Carrozza MC, Jensen W, Guglielmelli E, Stieglitz T, Rossini PM, Micera S. 1024. Restoring natural sensory feedback in real-time bidirectional hand prostheses. Science Translational Medicine. 6(222):222ra19.

Spalletti C, Lai S, Mainardi M, Panarese A, Ghionzoli A, Alia C, Gianfranceschi L, Chisari C, Micera S, Caleo M. 2014. A robotic system for quantitative assessment and poststroke training of forelimb retraction in mice. Neurorehabilitation and Neural Repair. 28(2):188-96.

Capogrosso M, Wenger N, Raspopovic S, Musienko P, Beauparlant J, Bassi Luciani L, Courtine G, Micera S. 2013. A computational model for epidural electrical stimulation of spinal sensorimotor circuits. Journal of Neuroscience. 33(49):19326-40.

Borton D, Micera S, Millán J del R, Courtine G. 2013. Personalized neuroprosthetics. Science Translational Medicine. 5(210):210rv2.

Hand loss is a highly disabling event that markedly affects the quality of life. To achieve a close to natural replacement for the lost hand, the user should be provided with the rich sensations that we naturally perceive when grasping or manipulating an object. Ideal bidirectional hand prostheses should involve both a reliable decoding of the user's intentions and the delivery of nearly "natural" sensory feedback through remnant afferent pathways, simultaneously and in real time. However, current hand prostheses fail to achieve these requirements, particularly because they lack any sensory feedback. The TNE lab showed that by stimulating the median and ulnar nerve fascicles using transversal multichannel intrafascicular electrodes, according to the information provided by the artificial sensors from a hand prosthesis, physiologically appropriate (near-natural) sensory information can be provided to an amputee during the real-time decoding of different grasping tasks to control a dexterous hand prosthesis. This feedback enables the user to effectively modulate the grasping force and feel the shape of grasped objects. This approach could improve the efficacy and "life-like" quality of hand prostheses, resulting in a keystone strategy for the near-natural replacement of missing hands.



Defitech Foundation Chair in Brain-machine Interface

Millán Lab

http://cnbi.epfl.ch

The Chair in Brain-Machine Interface laboratory (CNBI) carries out research on the direct use of human brain signals to control devices and interact with our environment. In this multidisciplinary research, we are bringing together our pioneering work on the two fields of brain-machine interfaces and adaptive intelligent robotics. Our approach to design intelligent neuroprostheses balances the development of prototypes, where robust real-time operation is critical, and the exploration of new interaction principles and their associated brain correlates. A key element at each stage is the design of efficient machine learning algorithms for real-time analysis of brain activity that allow users to convey their intents rapidly, on the order of hundred milliseconds. Our neuroprostheses are explored in cooperation with clinical partners and disabled volunteers for the purpose of motor restoration, communication, entertainment and rehabilitation

Bio

Prof. José del R. Millán holds the Defitech Chair at the École Polytechnique Fédérale de Lausanne (EPFL) where he explores the use of brain signals for multimodal interaction and, in particular, the development of non-invasive brain-controlled robots and neuroprostheses. In this multidisciplinary research effort, Prof. Millán is bringing together his pioneering work on the two fields of brain-computer interfaces and adaptive intelligent robotics. His research on brain-computer interfaces was nominated finalist of the European Descartes Prize 2001 and he has been named Research Leader 2004 by the journal Scientific American for his work on brain-controlled robots. He is the recipient of the IEEE Nobert Wiener Award 2011 for his seminal and pioneering contributions to non-invasive brain-computer interfaces. The journal Science has reviewed his work as one of the world's key researchers in the field of brain-computer interfaces. Prof. Millán has been the coordinator of a number of European projects on brain-computer interfaces and also is a frequent keynote speaker at international meetings. His work on brain-computer interfaces has received wide scientific and media coverage around the world.

Results Obtained in 2014

In the previous year we put strong focus on further evaluation of brain-machine interfaces (BMI) by their intended end-users. This year we have continued our translational efforts with a comprehensive assessment of BMI systems. Taking into account that these systems should closely interact with their users, this evaluation has covered not only traditional performance metrics (i.e., decoding accuracy) but also psychosocial and human factors (Gruebler et al., 2014; Rupp et al, 2014). Regarding these factors, our research has highlighted how adopting a user-centered approach leads to successful design of BMI systems (Perdikis et al., 2014a, 2014b).

The second main axis of our research is focused on the decoding of cognitive-related signals that are naturally elicited during motor actions and interaction. Examples of cognitive signals we have been successfully characterized reflect user's awareness of errors in the interaction (Chavarriaga et al., 2014; Iturrate et al., 2014), as well as EEG signatures of visual attention in real applications (Renold et al., 2014). We have also extended previous work on the decoding of cortical activity that conveys information about intended actions to the analysis of intracranial signals (Bloch et al, 2014; Borton et al., 2014) and the decoding of reaching directions (Lew et al., 2014).

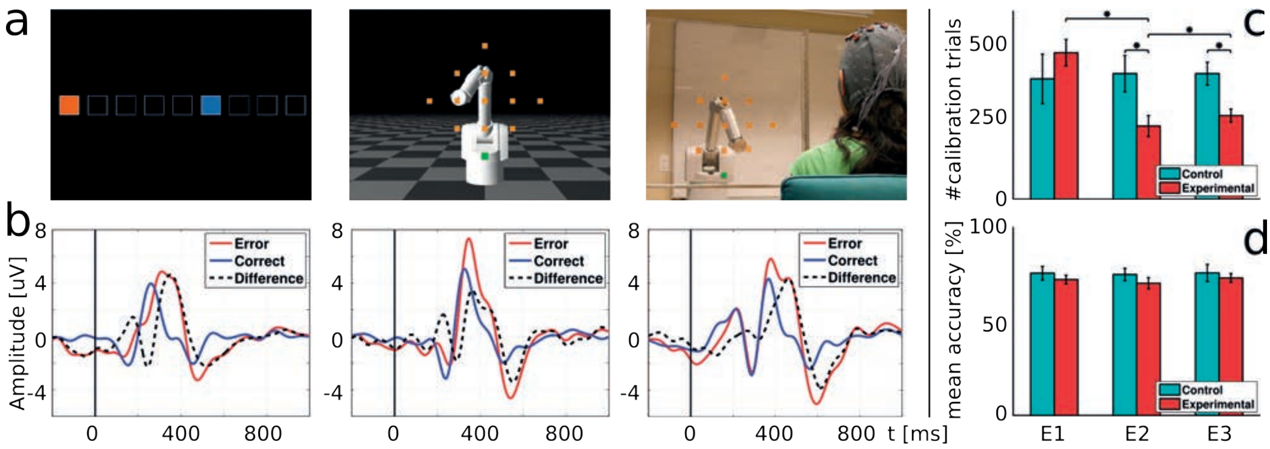
It is also important to evaluate effective means to provide the user with information about the state of the BMI system and the devices we want to control. Traditionally, BMI systems have strongly relied on visual feedback while other modalities have been seldom considered. To overcome this limitations we have studied means to better characterize multitasking capabilities during BMI operation and strategies to reduce the visual load induced by the interface (Leeb et al, 2014; Kwak et al., 2014).

The achievements described above rely strongly on comprehensive development of advanced methods for decoding brain signals and for providing effective human machine interaction. For example, we developed means to evaluate the reliability of the recorded signals (Sagha et al., 2014), methods to improve the classification accuracy (Iturrate et al, 2014; Tzovara et al., 2014; Zhang et al, 2014), as well as support for shared control approaches able to provide timely and suitable assistance to the users (Saeedi et al., 2014).

defitech fondation

Keywords

Brain-computer interfaces, neuroprosthetics, statistical machine learning, human-robot interaction, adaptive robotics, neuroscience, EEG, local field potentials.



Generalization of BMI decoders across different protocols (a) Experimental protocol. (b) EEG error related potentials (ErrP) in each experimental protocol. (c-d) ErrP decoders can generalize across protocols with reduced calibration time without decrease in performance.

Team

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Selected Publications

Bloch J, Chavarriaga R, Sobolewski A, Leeb R, Pralong E and del R Millán J. 2014. Reliable control of a brain-machine interface using epidural electrocorticography. 21st Congress European Society of Stereotactic and Functional Neurosurgery (ESSFN), Maastricht, NL.

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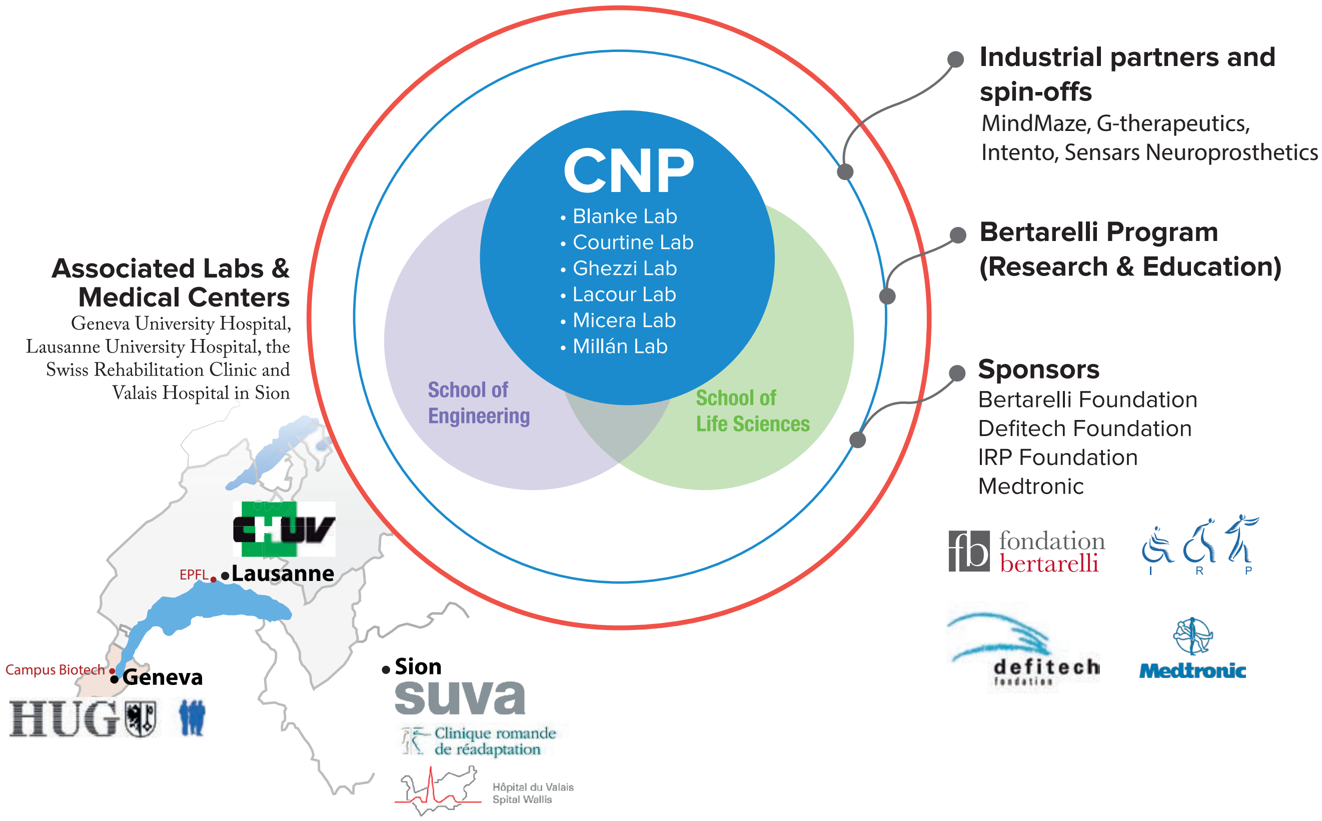
Research partners and activities

The Center for Neuroprosthetics draws upon EPFL's expertise in biology, neuroscience, brain imaging, and genetics as well as biomedical, electrical, mechanical engineering, micro- and nanotechnology. The Center also draws upon EPFL's cutting edge research in signal analysis, theoretical and computational neuroscience. CNP faculty pursues ambitious research projects within Europe's flagship Human Brain Project (www.humanbrainproject.eu) and two Swiss National Centers of Competence in Research, the NCCR in Robotics (www.nccr-robotics.ch) and the NCCR Synapsy in Psychiatric disease (www.nccr-synapsy.ch).

Partners and associated medical centers

The Center for Neuroprosthetics is part of the School of Life Sciences and the School of Engineering. In addition, through support from the Bertarelli foundation, a new research collaboration - dedicated to translational neuroscience and neuroengineering has been created between Harvard Medical School, EPFL's Institutes of Bioengineering and Neuroscience, and the Center for Neuroprosthetics.
The Center has strategic partnerships with Geneva University Hospital (Hôpitaux Universitaires de Genève, HUG), Lausanne University Hospital (Centre Hospitalier Universitaire Vaudois, CHUV), and the Swiss Rehabilitation Clinic in Sion (Clinique Romande de Réadaptation, CRR), as well as with the regional biomedical industry.



Associated laboratories

AMINIAN Kamiar, Laboratory of Movement Analysis and Measurement (EPFL)

BLEULER Hannes, Robotic Systems Laboratory (EPFL)

BLOCH Jocelyne, Stereotactic and Functional Neurosurgery Program, Department of Neurosurgery (CHUV)

BOULIC Ronan, Immersive Interaction Group (EPFL)

DERIAZ Olivier, Rehabilitation & Readaptation Research Institute (Sion)

ADLER Dan, Center for amyotrophic lateral sclerosis, Department of Pneumology and Neurology (HUG)

LEBLEBICI Yusuf, SCHMID Alexandre, Microelectronic Systems Laboratory

MURRAY Micah, IONTA Silvio, Laboratory for Investigative Neurophysiology (CHUV)

PAIK Jamie, Reconfigurable Robotics Laboratory (EPFL)

RAFFOUL Wassim, Department of Plastic and Reconstructive Surgery (CHUV)

SCHNIDER Armin, GUGGISBERG Adrian, PTAK Radek, Cognitive Neuro-Rehabilitation Laboratory, Neurorehabilitation Clinic (HUG)

SEECK Margitta, EEG and Epilepsy unit, Department of Neurology (HUG)

SCHALLER Karl, MOMJIAN Shahan, Department of Neurosurgery (HUG)

VAN DE VILLE Dimitri, Medical Image Processing Laboratory (EPFL)

VUADENS Philippe, RIVIER Gilles, Clinique romande de réadaptation (CRR SuvaCare)

Intraneural electrodes for sensorized hand prosthesis

Prof W. Raffoul (Department of Plastic, Reconstructive and Hand Surgery, CHUV) collaborates with Prof S. Micera to implant intraneural electrodes into the upper limb peripheral nerves to develop a "bionic" hand prosthesis for amputees. The possibility of restoring tactile information in amputees while using a sensorized hand prosthesis will be investigated in long-term experiments.

Peripheral nerve repair

Prof W. Raffoul (Department of Plastic, Reconstructive and Hand Surgery, CHUV) and Prof S. P. Lacour work together on improving functional recovery after peripheral nerve injury. The project exploits neural engineering tools including cellular therapy and chronic electrodes to test novel nerve conduits for improved peripheral nerve regeneration.

Psychosis in schizophrenia and its relation to sensorimotor processing

Prof P. Conus and Prof. K. Do Cuenod (Department of Psychiatry, CHUV) are conducting research with Prof O. Blanke to study schizophrenia using a robotic platform to study the brain mechanisms of altered sensorimotor processing in psychotic patients suffering from schizophrenia.

ECoG-based control of devices

Dr. J. Bloch (Department of Clinical Neurosciences,CHUV) collaborates with Prof J. del R. Millán on the decoding of different parameters of patient's motor intent from implanted epidural electrodes.

Robot-assisted gait rehabilitation with electrical spinal cord stimulation

In collaboration with pivotal players in the Department of Clinical Neurosciences at the CHUV, in particular the functional neurosurgeon Dr J. Bloch, CNP is preparing a clinical trial to evaluate the efficacy of robot-assisted rehabilitation enabled by electrical spinal cord stimulation to improve the recovery of locomotion in people with spinal cord injury. This collaboration will foster further interactions with the CHUV and the hospitals in Sion to achieve the translation of EPFL technologies into neuroprosthetic treatments to improve the quality of life of people with neurological disorders.

Functional reorganization of the primary somatosensory cortex after amputation

Dr O. Borens (Service of Orthopaedics and Traumatology, CHUV), Dr F. Luthi and Dr M. Iakova (Department for Musculoskeletal Rehabilitation, CRR SuvaCare) are working together with Prof O. Blanke on a project exploiting the high spatial resolution provided by ultra-high field fMRI to better characterize the cortical reorganization following the amputation of a limb.

Vestibular neuroprosthetics

Prof J. P. Guyot (Service of Otorhinolaryngology and Head and Neck Surgery, Department of Clinical Neurosciences, HUG) collaborates with Prof S. Micera to develop an implantable vestibular neuroprosthesis to replace the missing function in patients with bilateral vestibular Loss.

Personalized robotic neurorehabilitation

Prof A. Schnider and Dr A.G. Guggisberg (Laboratory of Cognitive Neurorehabilitation, UniGE Medical School & Department of Clinical Neurosciences, HUG) started a collaboration with Prof S. Micera on the development of personalized approaches for robot-based neurorehabiltiation using a novel upper limb exoskeleton.

Virtual and augmented reality in chronic pain

Dr. J-Y Beaulieu (Hand Surgery Department, HUG), Prof A. Schnider and Dr A.G. Guggisberg (Department of Clinical Neurosciences, HUG) together with Dr. François Luthi (Department for Musculoskeletal Rehabilitation, CRR SuvaCare) and Prof O. Blanke are leading a project aiming at the development of a wearable noninvasive technology alleviating chronic arm-related pain.

BCI for stroke rehabilitation

Prof A. Schnider and Dr A.G. Guggisberg (Department of Clinical Neurosciences, HUG), Dr P. Vuadens (Department of Neurorehabilitation, CRR SuvaCare) are collaborating with Prof J. del R. Millán to conduct clinical studies on the use of BCI-based approaches to post-stroke motor rehabilitation that decode the patient's intent to execute a movement of their paretic hand. The clinical trial involves chronic patients. A clinical trial to evaluate the efficacy of this BCI-based approach to post-stroke motor rehabilitation with acute patients was launched with Prof. H.-J. Heinze (University of Magdeburg, Germany).

Virtual and augmented reality in patients suffering from spinal cord injury

Reducing pain during illusory own body perception using virtual reality in patients with spinal cord injury - Prof A. Schnider and Dr A. Kassouha (Department of Clinical Neurosciences, HUG), Dr P. Vuadens, (CRR SuvaCare), Dr X. Jordan (Department of Paraplegia, CRR SuvaCare) and Prof O. Blanke are conducting a project investigating whether persistent analgesia and embodiment can be induced in patients with spinal cord injury.

Unilateral spatial neglect and the illusion of ownership of a virtual body

Dr P. Vuadens (Department of Neurorehabilitation, CRR SuvaCare) and Prof J-A. Ghika (Department of Neurology, Valais Hospital) colla borate with Prof O. Blanke on a project investigating how right-brain-damaged patients with and without spatial neglect integrate multisensory interoceptive and exteroceptive information.

Selected highlights 2014

February 2014

CNP Researchers on Swiss national TV TSR1

The medical documentary 36.9° presented the work of Prof. S. P. Lacour on artificial skin ("La main dans tous ses états") and of Dr. A. Serino on brain damage and its impact on body perception and their neurological impact on the body schema ("Lésions cérébrales : comment récupérer son GPS interne").

Prof. Stéphanie Lacour and Dr. Andrea Serino in the «36.9» medical documentaries (Swiss national TV).

May 2014

Green light for Campus Biotech!

The former Merck Serono site, located in the centre of Geneva, Switzerland, has been bought by the Campus Biotech consortium: the Ecole Polytechnique Fédérale de Lausanne, the University of Geneva, the Wyss Foundation and the Bertarelli Foundation.

G-Therapeutics wins Hello Tomorrow grand prize

After being among the 25 semifinalists from over 1200 candidates, G-Therapeutics is the grand prize winner of 100 000 € of the European competition Hello Tomorrow, a non-profit organization which aims at creating bridges between scientists, investors and entrepreneurs in all major technological fields.

August 2014

Workshop on Biomedical microelectronic translational systems

Research in bio-electronics has recently moved its focus from the pure interface towards full systems, potentially operating in closed-loop with some specific parts of the human nervous system. This workshop gathered experts from the National Chiao Tung and National Cheng Kung Universities, Taiwan, experts from Switzerland and more specifically participants of the nano-tera.ch program and from CNP and EPFL.

Prof. Grégoire Courtine's 2014 year again was full in new accomplishements, G-Therapeutics being the grand prize winner of the European competition Hello Tomorrow and the project NEUWalk being closer to clinical trials.

September 2014

From Rats to Humans: Project NEUWalk Closer to Clinical Trials

A completely paralyzed rat can be made to walk over obstacles and stairs by electrically stimulating the severed part of the spinal cord. The EPFL scientists discovered how to control in real-time how the rat moves forward and how high it lifts its limbs. In collaboration with the CHUV, the SUVA and the Canton of Valais this technology will be extended to human patients using an innovative Gait Platform, bringing the European Project NEUWalk closer to clinical trials.

John P. Donoghue is taking the Lead of the Wyss Center

EPFL and the University of Geneva (UNIGE) are pleased to announce the appointment of John P. Donoghue. The world renown neuroscientist is a pioneer in neuroprosthetics and neuroengineering and will head the Wyss Center at Campus Biotech in Geneva.

John P. Donoghue is taking the Lead of the Wyss Center at Campus Biotech.

Stéphanie Lacour selected as Young Scientist by World Economic Forum

Prof Stéphanie Lacour has been selected as one of the "40 extraordinary scientists under the age of 40" in the 2014 World Economic Forum.

November 2014

Defitech foundation supports new EPFL chair

The Defitech Foundation, created in 2001 by Sylviane and Daniel Borel, has made a commitment that will enable the creation of a new CNP laboratory. The "Research Chair in Clinical Neuroengineering and Human-Machine Interactions" will be established in Sion, as part of EPFL Valais Wallis, within the auspices of the Clinique Romande de Réadaptation (SuvaCare). This Chair, like the first Defitech Chair established in 2008, will be affiliated with EPFL's Center for Neuroprosthetics.

Pro Infirmis - Interdisciplinary Conference: From the repaired Human to the enhanced human: what kind of impacts on individual and society ?

Suported by EPFL and CNP, this public conference organized by Pro Infirmis openned the debate between the public, patients and scientists to discuss the acceptance and the future of prosthetic technologies. Prof. G. Courtine presented his work in neuroprosthetics and spinal cord repair in particular.

December 2014

Appointment of Diego Ghezzi to direct the EPFL Medtronic Chair in Neuroengineering.

Dr Diego Ghezzi, of the Italian Institute of Technology (IIT), is joining the EPFL's Center for Neuroprosthetics with support from Medtronic, world leader in advanced medical technologies. Ghezzi is a specialist in biocompatible implants and will set up his laboratory at Campus Biotech in Geneva.

Robotic Psychiatry awaken ghosts hidden in our Cortex

Ghosts only exist in our minds. Yet, patients suffering from neurological or psychiatric conditions have often reported a strange "feeling of a presence". Researchers from the Blanke Lab have now succeeded in recreating this illusion in the laboratory leading the way in robotic understanding of psychosis and its treatment.

The Human-Brain Project moved to Campus Biotech

Operational center and research teams of the HBP settled in their new offices. Transformation of buildings for the installation of laboratories hosting the Wyss Center and the Center for Neuroprosthetics is planned to be accomplished for several CNP laboratories in 2015.

Selected seminars in 2014

Neurotechnology: from curing the brain to understanding the mind, January 2014
Prof. John Donoghue, Director of the Brown Institute for Brain Science, Brown University

"Seeing" and reading with the ears, hands and bionic eyes: from basic research to visual rehabilitation, January 2014
Prof. Amir Amedi. Institute for Medical Research Israel-Canada (IMRIC), Edmond and Lily Safra Center for Brain Sciences (ELSC), Hebrew University of Jerusalem, Israel.

FES neuroprosthesis for the restoration of grasp function in a monkey model of spinal cord injury, June 2014
Dr Christian Ethier, Northwestern University, Chicago USA.

Brain-machine interfaces, microstimulation, and movement primitives, June 2014
Dr Simon Overduin, University of California, Berkeley USA

Neuroengineering approaches applied to the investigation of photoreceptor degeneration and to the restoration of sight, June 2014
Dr Diego Ghezzi, Fondazione Istituto Italiano di Tecnologia, Genova IT.

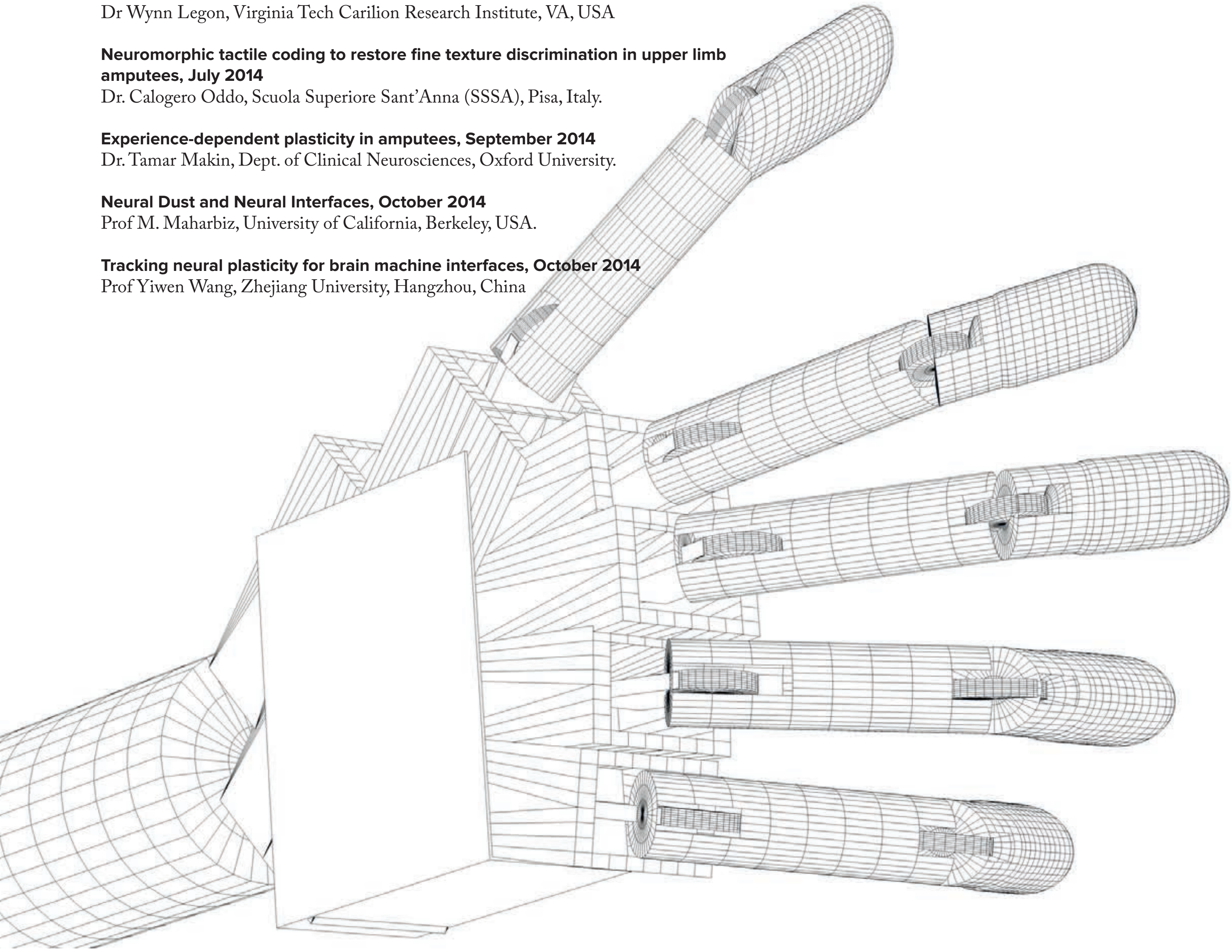
High resolution modulation of human brain circuits using transcranial focused ultrasound, June 2014
Dr Wynn Legon, Virginia Tech Carilion Research Institute, VA, USA

Neuromorphic tactile coding to restore fine texture discrimination in upper limb amputees, July 2014
Dr. Calogero Oddo, Scuola Superiore Sant'Anna (SSSA), Pisa, Italy.

Experience-dependent plasticity in amputees, September 2014
Dr. Tamar Makin, Dept. of Clinical Neurosciences, Oxford University.

Neural Dust and Neural Interfaces, October 2014
Prof M. Maharbiz, University of California, Berkeley, USA.

Tracking neural plasticity for brain machine interfaces, October 2014
Prof Yiwen Wang, Zhejiang University, Hangzhou, China



Teaching

Students enrolled in a master program at EPFL have the possibility to obtain an inter-faculty specialization in neuroprosthetics. This "Mineur" in neuroprosthetics covers the essential courses in neurosciences and neuroengineering in the field of neuroprosthetics, including medical applications. The programme is coordinated by Prof. José del R. Millán (School of Engineering, STI) and Prof Olaf Blanke (School of Life Sciences, SV).

http://cnp.epfl.ch/teaching

Bertarelli Program in Translational Neuroscience and Neuroengineering

The goal of the Bertarelli Program in Translational Neuroscience and Neuroengineering is to facilitate basic discoveries in neuroscience towards translation by creating stronger ties between basic neuroscientists, engineers and clinicians. The Program bridges two of the world's great universities, namely Harvard University's Medical School (HMS), with more than two centuries of leadership in alleviating human suffering caused by disease, and the Ecole Polytechnique Fédérale de Lausanne (EPFL), with special strength in engineering and technology. Prof. Blanke is co-Director of the Program on the EPFL side, together with Dean of Engineering Prof. Demetri Psaltis.

Léonie Asboth and Amélie Guex (at the center of the picture below) have benefitted from this fellowship and are now back at the EPFL as doctoral students in the Lacour and Courtine Labs.

The Bertarelli Research Grants fund EPFL-HMS collaborative projects over a period of three years. The program additionally funds EPFL Master students to study at HMS and HMS medical students to study at EPFL.

http://ptnn.epfl.ch/

Credits

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