Center for Neuroprosthetics

2015 annual report

Bertarelli
Foundation
Chair in Cognitive
Neuroprosthetics

Olaf Blanke

Fondation IRP
Chair in Spinal
Cord Repair

Grégoire Courtine

Medtronic
Chair in
Neuroengineering

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Welcome

In the field of neuroprosthetics, the well-established treatments of deep brain stimulation for Parkinson's disease, cochlear implants for hearing loss, virtual reality for neuropsychiatric rehabilitation, and brain-computer interfaces for movement restoration are merely four success stories. Much work lies ahead of us to enable novel neurotechnological breakthroughs and bring them to the rapidly expanding pool of neurological and psychiatric patients worldwide. With no effective pharmacological treatments in sight for major neuropsychiatric diseases such as spinal cord injury, stroke, or Alzheimer's disease (to name just three), researchers at the Center for Neuroprosthetics strive to develop the next generation of electroceutical and cogniceutical treatments in neuroprosthetics. With approximately one third of the population in Europe and the US afflicted by brain disorders, major advances in systems and cognitive neuroprosthetics are desperately needed to treat patients with motor, sensory, and cognitive deficits.

2015 was an outstanding scientific year for our Center, with a major breakthrough in bionic limb control and integrated limb sensations in amputee patients, with the discovery of highly flexible neuroprosthetic technology that is perfectly adapted to the nervous system, with revolutionary neurotechnology to treat spinal cord injury, and with the definition of new limits in human brain imaging. We are proud to guide the next generation of neuroprosthetics researchers as students from EPFL and abroad are drawn to our courses in Neuroprosthetics at EPFL, leading to a steady increase in enrollment in EPFL's specialization in Neuroprosthetics. We have also been joined by a new colleague and his laboratory's researchers, Dimitri Van de Ville, who carries out fascinating research in Bioengineering and Medical Informatics both at EPFL and the University of Geneva. Concerning Tech transfer I would like to highlight just two of our major success stories. G-therapeutics and Mindmaze were created by researchers from the Center for Neuroprosthetics and have secured significant funding to take their neurotechnologies to hospitals and to the homes of patients suffering from motor deficits.

I conclude by inviting you to visit us soon in the CNP's new home in Geneva's beautiful Campus Biotech. Stay tuned.

Olaf Blanke
Director of the Center for Neuroprosthetics
Swiss Federal Institute of Technology (EPFL)

Mission

The Center for Neuroprosthetics (CNP) capitalizes on its unique access to advanced engineering, computer science, signal analysis, and brain research at the Swiss Federal Institute of Technology (Ecole Polytechnique Fédérale de Lausanne, EPFL). We strive to translate these advances to novel treatments in neurological and psychiatric diseases by developing new technologies that support, repair, replace and enhance functions of the nervous system.

The development of such technologies and devices, called neuroprostheses, depends on engineering advances, on medical know-how, and on the understanding of the neurobiological mechanisms for sensory perception, cognitive operations, and movement. For the restoration of motor functions, we aim to record and process the dedicated signals and to translate them into data that can ultimately drive artificial limbs, bodies and robots. For the restoration of sensory and cognitive functions, we design devices that produce signals that selectively activate and control brain circuits involved in perception and different cognitive functions.

Pursuing strengths in education at EPFL with our research and clinical partners, we are shaping the next generation of researchers in neuroprosthetics and empower the technology transfer from laboratory-based neuroprosthetics to startup companies with impact in industry and society.
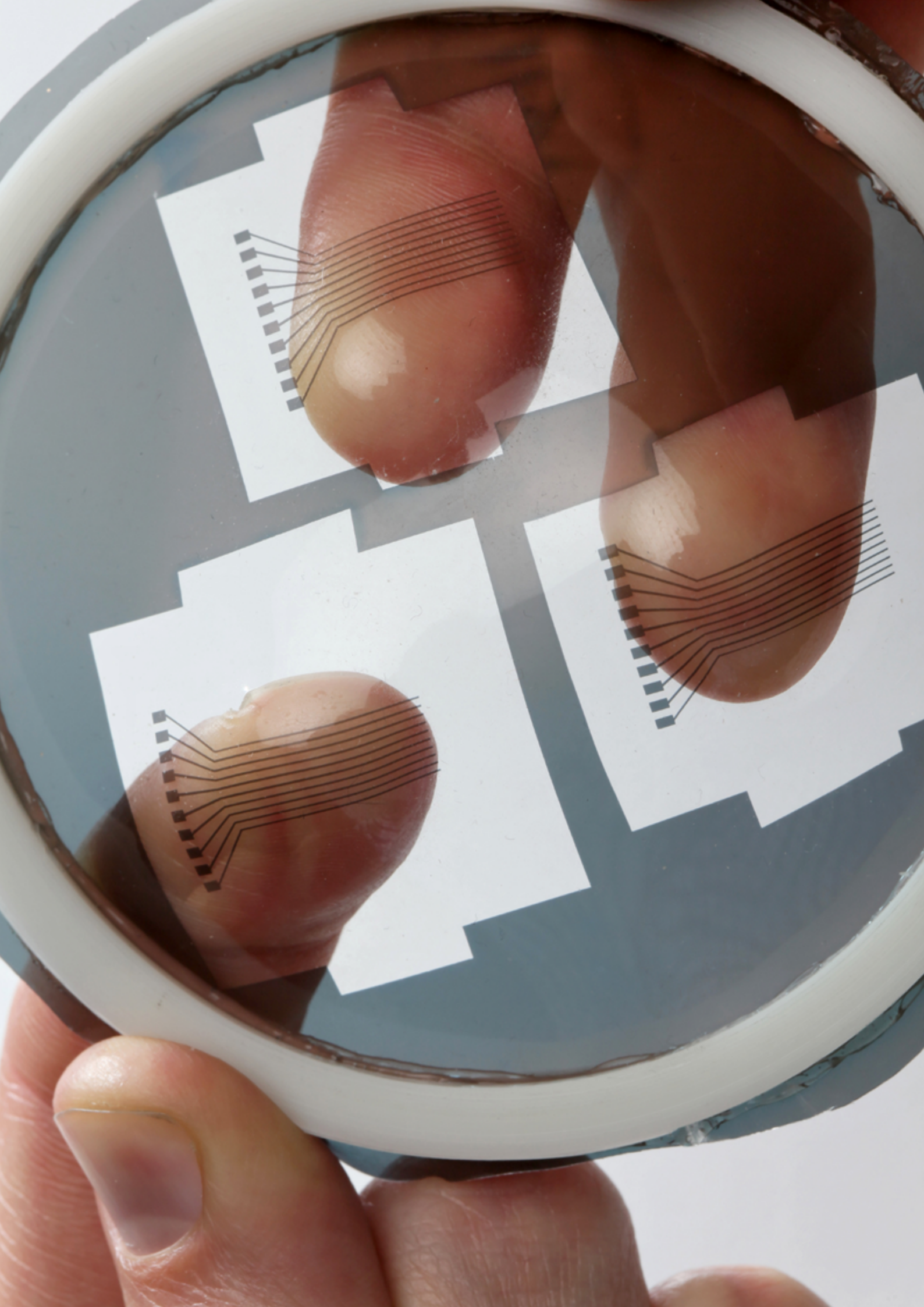
Projects

Walk again

Movement intentions of a paralyzed rodent with spinal cord injury are decoded from real-time recording of brain activity. This decoded information is directly fed into a brain-spinal interface computing optimal spinal cord stimulation to execute a desired movement. As a result, the animal is capable of locomotion and obstacle avoidance. This is achieved in spite of the spinal cord moto-neurons being physically separated from the brain.

Cognitive enhancement and repair

Major advances in cognitive neuroscience, robotics, haptics, virtual and augmented reality and wearable technology are exploited to develop new disruptive devices (cognetics) and treatments (cogniceuticals) for several application and medical conditions. Key conditions are chronic pain, schizophrenia, memory disorders, and retoraution of mobility and communication. We also pursue industry, gaming, and entertainment applications. This is achieved with robust real-time movement control of robots and wheelchair as well as pioneering work in virtual reality, augmented reality, robotics, haptics, wearables, and brain-machine interfaces.

Rehabilitation of upper limb sensorimotor loss

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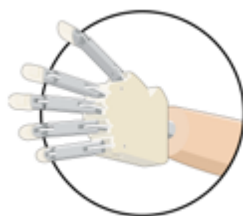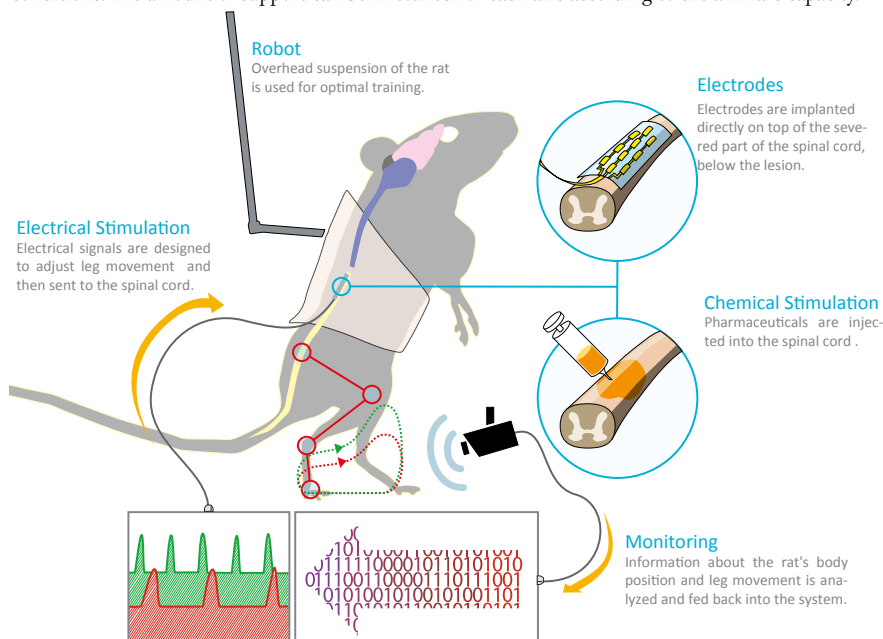
Bionic hand

Biocompatible flexible electrodes are implanted into different peripheral arm nerves of amputee patients. The patient's movement commands are decoded from signals in the implanted electrodes and transmitted to the prosthetic hand. These intentions are translated into movements of the prosthetic hand and fingers. In the same way, signals from different sensors in the prosthetic hand can also transmit via the implanted electrodes to the peripheral nerve and enable sensory functions such as the sense of touch and of finger positioning. Novel non-invasive stimulation also using virtual and augmented reality closed-loop protocols are developed to enable touch, embodiment and analgesia in chronic (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.

Robot
Overhead suspension of the rat is used for optimal training.

Electrodes
Electrodes are implanted directly on top of the severed part of the spinal cord, below the lesion.

Electrical Stimulation
Electrical signals are designed to adjust leg movement and then sent to the spinal cord.

Chemical Stimulation
Pharmaceuticals are injected into the spinal cord .

Monitoring
Information about the rat's body position and leg movement is analyzed and fed back into the system.

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).
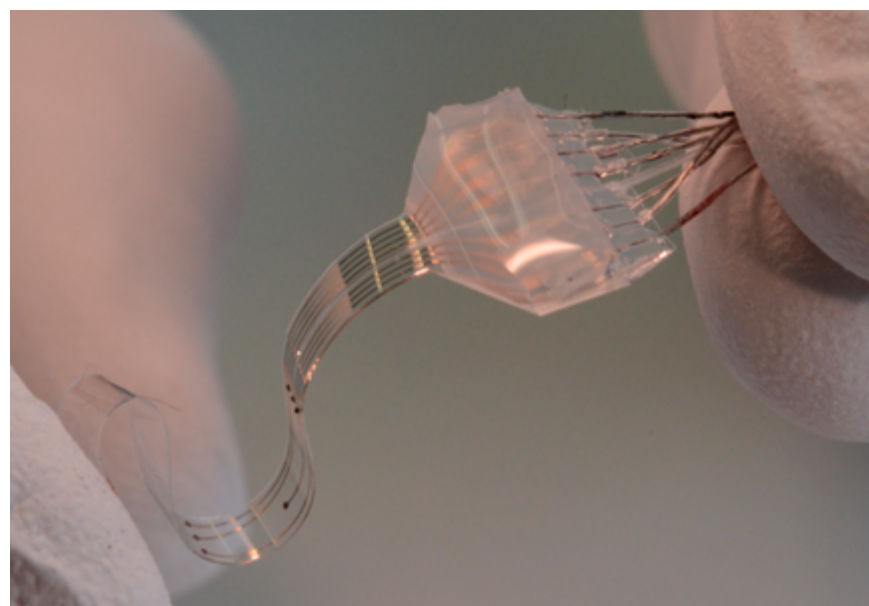
A Computational Model for Epidural Electrical Stimulation of Spinal Sensorimotor Circuits

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.
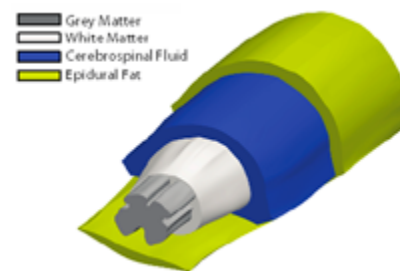
The computational model: the realistic finite element model

Cognitive enhancement and repair

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

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.
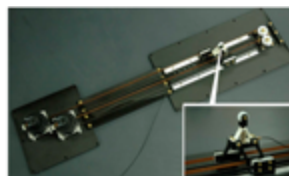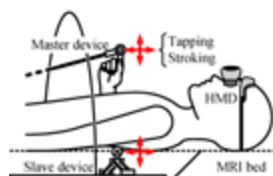

BrainTree, a motor imagery hybrid BCI speller.

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.
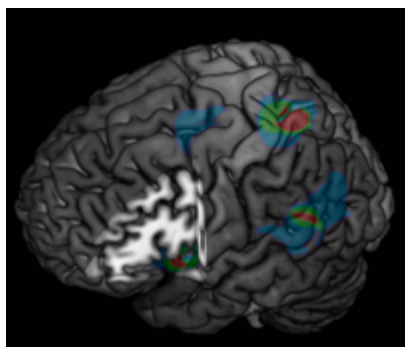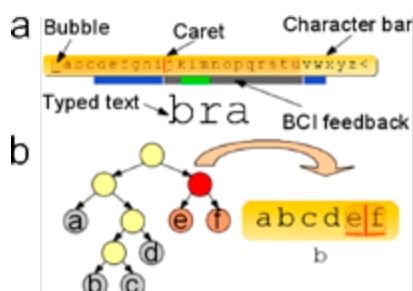
EEG correlates of upcoming driving actions.

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.


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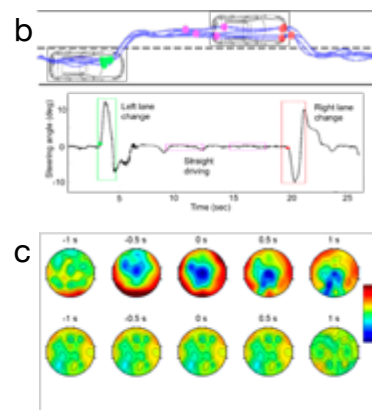
Rehabilitation of upper limb sensorimotor loss

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.
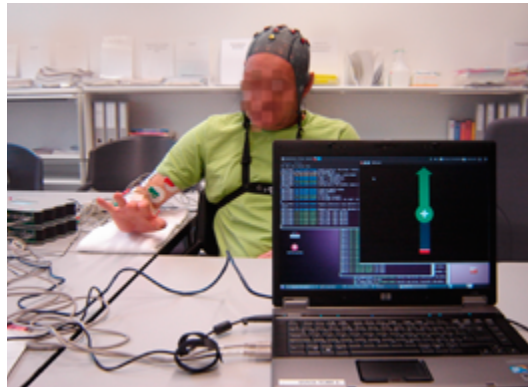
Robotic neurorehabilitation of upper limbs.

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

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.

Medial Distal
Medial Proximal
Thenars
Lateral Distal
Lateral Proximal
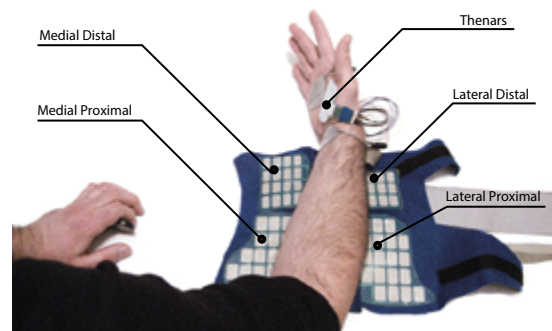
Virtual reality for treatment of pain and motor loss

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 will 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.
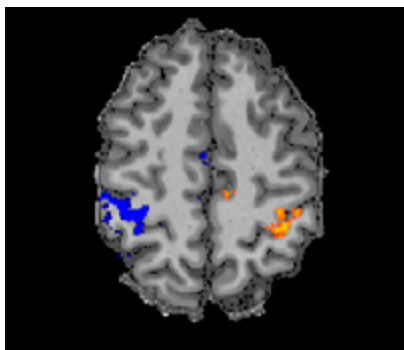

Neural representation of the phantom hand in a human amputee with targeted muscle reinnervation

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.
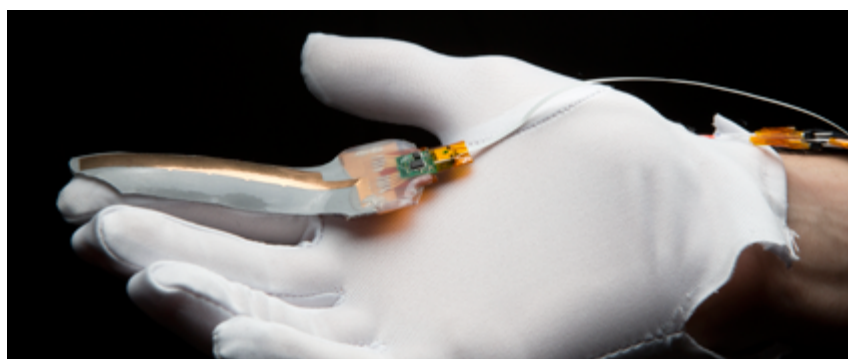
Generalization of BMI decoders across different protocols

(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.
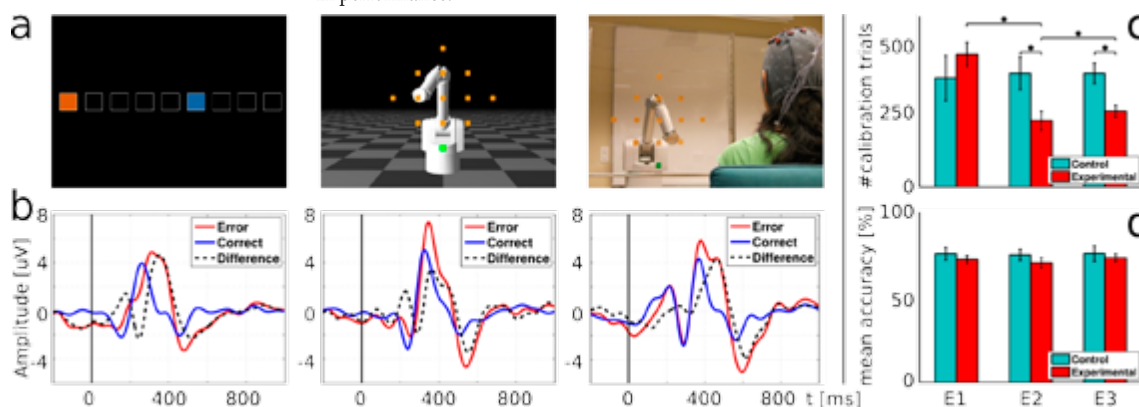
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The Blanke Lab (Bertarelli Chair in Cognitive Neuroprosthetics) has two missions – the scientific study of consciousness and the development of cognitive neuroprostheses. In neuroscience we investigate the brain mechanisms of body perception, body awareness and consciousness, combining psychophysical and cognitive paradigms, neuroimaging techniques (high resolution fMRI, intracranial and surface EEG, TMS). We have pioneered the use of engineering techniques such as robotics, haptics, and virtual reality and their full integration with behavioral and neuroscience technologies, leading to the new research field of cognetics.

In our clinical research projects we translate our cognetic insights to the development of new treatments for two major mental diseases with massive impact on public health: schizophrenia and chronic pain. In robotic psychiatry we are designing robotic technology, including wearable robotic solutions, to understand the brain mechanisms of schizophrenia; these insights from robotic psychiatry are used to control and treat major schizophrenic symptoms. In our chronic pain projects we integrate augmented reality with cognitive neuroscience and brain stimulation to induce technology-mediated analgesia in patients suffering from complex regional pain syndrome, phantom limb pain, and neuropathic leg pain.

Results Obtained in 2015

We proposed a powerful model about the multisensory mechanisms of consciousness, in particular bodily mechanisms of consciousness (Blanke, Slater, Serino, Neuron 2015). Recent achievements were the uncovering of the unisensory (Martuzzi et al., Social Cognitive Affective Neuroscience, 2015) and multisensory mechanisms of self-consciousness (namely, somatosensory, visual, auditory, vestibular and even interoceptive signals) (Serino et al., Scientific Reports 2015, Noel et al., Cognition, 2015, Pfeiffer et al., Neuroimage, 2016; Ronchi et al., Neuropsychologia, 2015; Gale et al., Journal of Neurophysiology, 2016). Another line of work concerned how manipulating multisensory bodily cues affects consciousness for external events, such as visual consciousness (Faivre et al., Current Opinion in Neurology, 2015), tactile perception (Salomon et al., Neuropsychologia, 2015), as well as semantic processing (Canzoneri et al., Cognition, in press) and memory (Peer et al., Proceedings of the National Academy of Science USA, 2015).

This knowledge has inspired novel neuroprosthetic approaches based on virtual reality and robotics (Rognini & Blanke, Trends in Cognitive Science, 2016) and has been translated to the clinic. In our translational project on chronic pain we developed virtual reality scenarios to study technologically-mediated analgesia induction (Romano et al., Journal of Pain, 2016). We have now successfully translated these findings to patients suffering chronic regional pain syndrome (Solca et al., in preparation), from neuropathic leg pain in spinal cord injury (Pozeg et al., in preparation), and phantom limb pain following amputation (Rognini et al., in preparation). 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 have recently applied this robotic psychiatry technology to the investigation of the brain mechanisms of hallucinations and first-rank symptoms in patients suffering from psychosis (Salomon et al., in preparation).

Keywords

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

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 neuroscience research is dedicated to the study of consciousness and how bodily processing encodes the self. He is also translating this scientific knowledge in neurorehabilitation and neuroprosthetics by pioneering new fields at the intersection of cognitive neuroscience, medicine and engineering: robotic psychiatry, cognetics, and cogniceuticals.

fb fondation bertarelli

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 in the participants an illusory feeling of another person standing behind them, i.e., feeling of a presence.
The sensory motor conflict and the induced experience activates a network of brain areas, including the sensory-motor cortices, the temporal parietal junction and the insular cortex, as shown by converging data from high-density EEG (shown in the picture), fMRI and lesion analysis

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Selected Publications

Rognini G, Blanke O. (2016). Cognetics: Robotic interfaces for the conscious mind. Trends Cogn Sci. 20(3):162-4.

Blanke O, Slater M, Serino A. (2015). Behavioral, neural, and computational principles of bodily self-consciousness. Neuron. 88(1):145-66.

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Ionta S, Heydrich L, Lenggenhager B, Mouthon M, Fornari E, Chapuis D, Gassert R, Blanke O. (2011). Multisensory mechanisms in temporo-parietal cortex support self-location and first-person perspective. Neuron. 70(2):363-74.

Courtine Lab

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The World Health Organization (WHO) estimates that as many as 500'000 people suffer from a spinal cord injury each year, with dramatic consequences for the quality of life of affected individuals. Over the past 15 years, Prof. Courtine and his team have developed an unconventional therapeutic strategy that reestablished voluntary control of leg movements in rats with a spinal cord injury leading to permanent paralysis. This strategy is shortly described as follows: when an injury occurs, the brain signals to the spinal cord are severely compromised. The neurons that control the muscles become dormant. To reawaken these neurons, we delivered combination of chemical and electrical stimulation to the spinal cord using innovative neural implants and sophisticated control algorithms. During training, the rats are placed in a cutting-edge robotic interface that supports their weight against gravity in a safe environment. This robot encourages the rat to volitionally move itself toward a food reward. This will-powered based training under highly functional states of motor circuits below the injury promotes the extensive and ubiquitous remodeling of residual neuronal connections in the brain and spinal cord. Even after a severe injury, the rats regain the ability to walk. 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 implemented a translational neuroprosthetic program that combines work in mice, rats, non-human primates, and human patients. Prof. Courtine also founded a start-up that develops all the technologies necessary to apply these therapeutic concepts in paraplegic people.

Results Obtained in 2015

Neuromodulation therapies *(Science Translational Medicine, 2014; Science 2015; Neuron 2016; Nature Medicine 2016):* We have identified the mechanisms underlying the facilitation of locomotion with electrical spinal cord stimulation. This conceptual framework guided the development of 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 paralyzed rats.

Mechanisms of recovery *(Science Translational Medicine, 2015):* We studied the reorganization and function of the corticospinal tract after spinal cord injury in rats, monkeys, and humans. In humans with lateralized injury, there was greater recovery in motor function than those with more symmetric injuries; this recovery was mirrored in monkeys with a similar injury, but not in rats. We showed that monkeys and humans have a great potential for synaptic reorganization above and below the lesion than rats, in particular the corticospinal tract. These results indicate that primate models should be considered more frequently for research aimed at spinal cord repair and therapeutics.

Gait rehabilitation platform: With the CHUV and the SUVA, we established a new Gait Platform that brings together innovative monitoring and rehabilitation technology. A clinical trial starting in 2016 will exploit this platform to evaluate the ability of our therapeutic intervention to improve motor function after spinal cord injury.

Keywords

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

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 to translate these medical and technological breakthroughs into treatments.

I R P

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Selected Publications

Wenger N., Martin Moraud E., Gandar J., Musienko P., Capogrosso M., Baud L., Le Goff C., Barraud Q., Pavlova N., Dominici N., Minev I.R., Asboth L., Hirsch A., Duis S., Kreider J., Mortera A., Haverbeck O., Kraus S., Schmitz F., DiGiovanna J., van den Brand R., Bloch J., Detemple P., Lacour S.P., Bézard E., Micera S., Courtine G. (2016). Spatiotemporal neuromodulation therapies engaging muscle synergies to improve motor control after spinal cord injury. Nature Medicine. 22(2):138-45.

Martin Moraud E., Capogrosso M., Formento E., Wenger N., DiGiovanna J., Micera S.* and Courtine G*. (2016). Mechanisms underlying the neuromodulation of spinal circuits for correcting gait and balance deficits after spinal cord injury. Neuron, Volume 89, Issue 4, Pages 814–828.

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Minev I. R., Musienko P., Hirsch A., Barraud Q., Wenger N., Moraud E. M., Gandar J., Capogrosso M., Milekovic T., Asboth L., Torres R. F., Vachicouras N., Liu Q., Pavlova N., Duis S., Larmagnac A., Voros J., Micera S., Suo Z., Lacour S. P. and Courtine G*., (2015). Biomaterials. Electronic dura mater for long-term multimodal neural interfaces. Science. Vol. 347, no. 6218, pp. 159–163.

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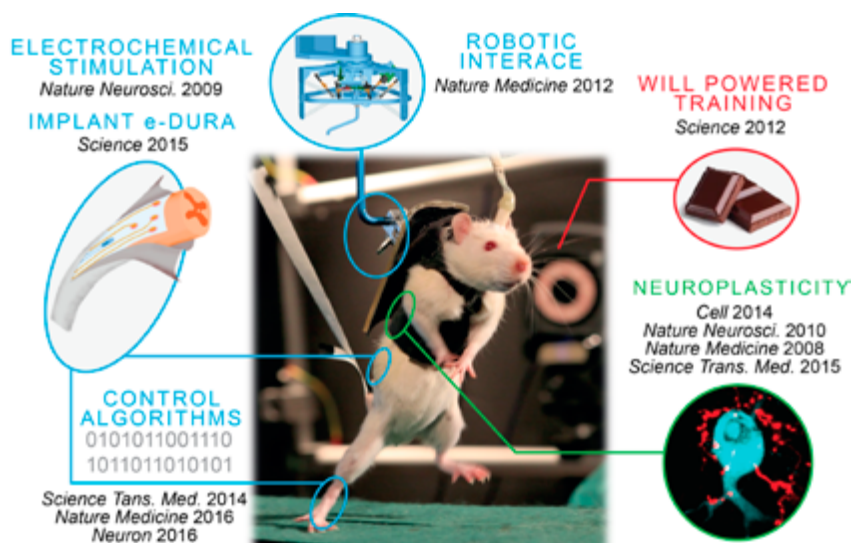
A decade of evidence-based science that led to the development of neuroprosthetic rehabilitation–an intervention that restored skilled descending motor control in rodent.

Ghezzi Lab

http://lne.epfl.ch

Worldwide the number of people visually impaired is 285 million, of whom 39 million are blind (WHO); in Europe, macular degeneration and glaucoma are considered the leading causes of blindness (16% and 12.2%, respectively). Moreover, other intractable causes (e.g. diabetic retinopathy, and optic nerve atrophy or trauma) worsen this picture. In addition, population aging is expected to raise this figure in the next decades. Despite various strategies, including pharmacology, gene therapy, stem-cell transplantation, optogenetics, and visual prostheses have been attempted so far, with encouraging results in animals and also in some human trials, there is no established method to prevent or cure blindness due to photoreceptor degeneration.

The mission of the laboratory is focused on the implementation of novel technological approaches for fighting blindness, providing a fundamental advancement towards sight restoration in patients affected by retinal dystrophies, and translating our research findings into clinical practice.

Currently the laboratory is active on 2 research lines: i) the development of an injectable, self-opening, and freestanding organic retinal prosthesis and ii) the development an intra-neural prosthesis for the direct stimulation of the optic nerve in blind patients

Results Obtained in 2015

In 2015 the activities has been focused mostly on the setting up of the laboratory arena. Moreover, our research effort has been dedicated in the design and fabrication of an injectable, self-opening, and freestanding organic retinal prosthesis. We are designing an injectable structure housing photovoltaic elements for the light stimulation of retinal cells. In parallel, we started working on the optimization of the photovoltaic elements for retinal stimulation.

Bio

Diego Ghezzi received his MSc in Biomedical Engineering (2004) and PhD in Bioengineering (2008) from Politecnico di Milano. He completed his postdoc at Istituto Italiano di Tecnologia (Neuroscience and Brain Technologies department), where he was promoted Researcher in 2013. In 2015, he was appointed PATT at EPFL, as member of the CNP.
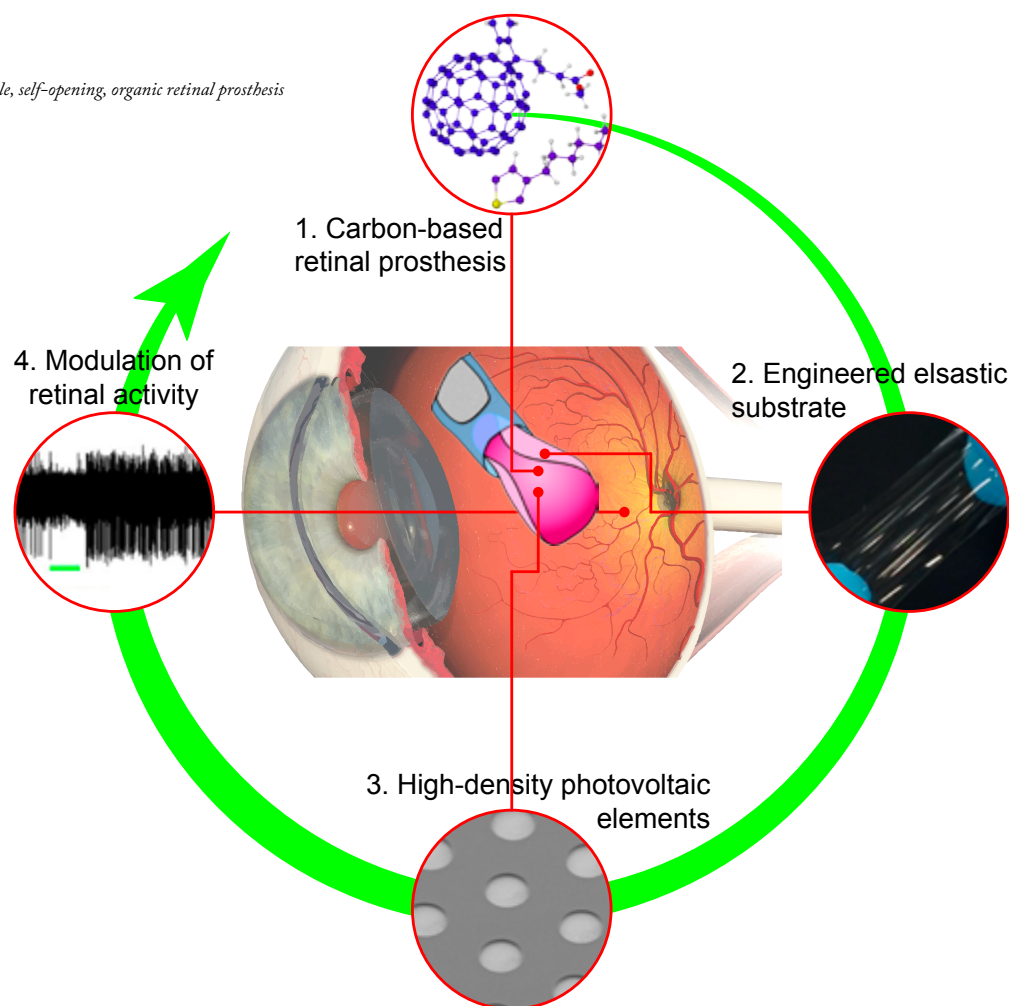
Keywords

Neuroprosthetics; Visual prostheses; Organic neuroprosthetics; Fighting blindness; Neuro-optoelectronic interfaces; Optical stimulation.

Design characteristics of an injectable, self-opening, organic retinal prosthesis

1. Carbon-based retinal prosthesis

4. Modulation of retinal activity

2. Engineered elsastic substrate

3. High-density photovoltaic elements

Team

Assistant Professor
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Postdoctoral fellows
Laura Ferlauto

PhD students
Marta JI Airaghi Leccardi
Paola Vagni

Master students
Kévin Si-Peng Meng
Floriana Guido
Matteo Salari

Administrative Assistant
Manuela da Silva

Selected Publications

Feyen, P., Colombo, E., Endeman, D., Nova, M., Laudato, L., Martino, N., Antognazza, M.R., Lanzani, G., Benfenati, F. and Ghezzi, D. (2016). Light-evoked hyperpolarization and silencing of neurons by conjugated polymers. Sci. Rep. 6:22718.

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Ghezzi, D., Antognazza, M.R., Maccarone, R., Bellani, S., Lanzarini, E., Martino, N., Mete, M., Pertile, G., Bisti, S., Lanzani G. and Benfenati, F. (2013). A polymer optoelectronic interface restores light sensitivity in blind rat retinas. Nat. Phot. 7(5):400-406.

dal Maschio, M., Ghezzi, D., Bony, G., Alabastri, A., Deidda, G., Brondi, M., Sulis Sato, S., Proietti Zaccaria, R., Di Fabrizio, E., Ratto, G.M. and Cancedda, L. (2012). High-performance and site-directed in utero electroporation by a triple-electrode probe. Nat. Comm. 3, 960.

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Lacour Lab

http://lsbi.epfl.ch

Bioelectronics integrates principles of electrical engineering to biology, medicine and ultimately health. EPFL LSBI challenges and seeks to advance our fundamental concepts in man-made electronic systems applied to biology. Specifically, the focus is on designing and manufacturing electronic devices with mechanical properties close to those of the host biological tissue so that long-term reliability and minimal perturbation are induced in vivo and/or truly wearable systems become possible.

We use fabrication methods borrowed from the MEMS and microelectronics industries and adapt them to soft substrates like elastomers. We develop novel characterization tools customized to mechanically compliant bioelectronic circuits. We evaluate in vitro, in animal models and ultimately on humans our soft bioelectronic interfaces.

In 2015, the first two PhD students graduated from the Lab.

Results Obtained in 2015

In 2015, our research contributed innovative technological developments for stretchable electronic devices and advanced implantable interfaces.

Intrinsically stretchable biphasic (liquid-solid) Ga-based thin metal films
We have designed and developed a new class of soft metallization based on biphasic (solid-liquid) thin metal films, compatible with large-area and standard thin-film technology that offers intrinsic stretchability and un-matched electromechanical performance. We have demonstrated that our soft metallization is compatible with multi-layer layouts with a 10 µm critical dimension, supports high currents and voltages for power applications, and facilitates truly wearable electronic skins [Adv. Mat. 2016].

Soft electronic dura
We have engineered a new class of soft multimodal neural implants that offer extraordinary resilience and unprecedented long-term bio-integration within the nervous system [Science 2015]. In 2015, we have pursued our e-dura developments in the context of restoring locomotion after spinal cord injury in two ways: (1) tailoring of the electrode design to improve the specificity of epidural spinal cord stimulation, (2) scaling of the technology for non-human primate models. The LSBI team works in close collaboration with the team of Prof. Courtine, EPFL, Center for Neuroprosthetics.

We also pursued our efforts in developing a range of soft, multimodal neural implants including auditory brainstem implants (ABI), electrocorticography implants (ECoG), peripheral nerve regenerative cuffs, and optoelectronic and optical nerve implants.

Bio

Prof. Stéphanie P. Lacour 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, a SNSF-ERC Consolidator Grant and was elected a 2015 Young Global Leader by the World Economic Forum.

fb fondation bertarelli

Keywords

Thin film electronics; soft materials; neural implants; artificial skin

Team

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Aaron Lee
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Selected Publications

Lantoine J, Grevesse T, Villers A, Delhaye G, Mestdagh C, Versaevel M, Mohammed D, Bruyère C, Alaimo L, Lacour SP, Ris L, Gabriele S (2016). Matrix stiffness modulates formation and activity of neuronal networks of controlled architectures. Biomaterials. 89:14-24.

Hirsch A*, Michaud HO*, Gerratt AP, de Mulatier S, Lacour SP (2016). Intrinsically stretchable biphasic (solid-liquid) thin metal films. Advanced Materials, on-line.

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Srinivasan A, Tipton J, Tahilramani M, Kharbouch A, Gaupp E, Song C, Venkataraman P, Falcone J, Lacour SP, Stanley GB, English AW, Bellamkonda RV (2015). A regenerative microchannel device for recording multiple single unit action potentials in awake, ambulatory animals. European J. of Neuroscience, 43(3): 474-485.

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Guex A, Vachicouras N, Hight AE, Brown MC, Lee DJ, Lacour SP (2015). Conducting polymer electrodes for auditory brainstem implants. Journal of Materials Chemistry B, 3(25):5021-5027

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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.

Picture of a biphasic gold-gallium film patterned by photolithography with critical dimension of 100µm on a 40µm thick PDMS elastomer membrane

Micera Lab

http://tne.epfl.ch
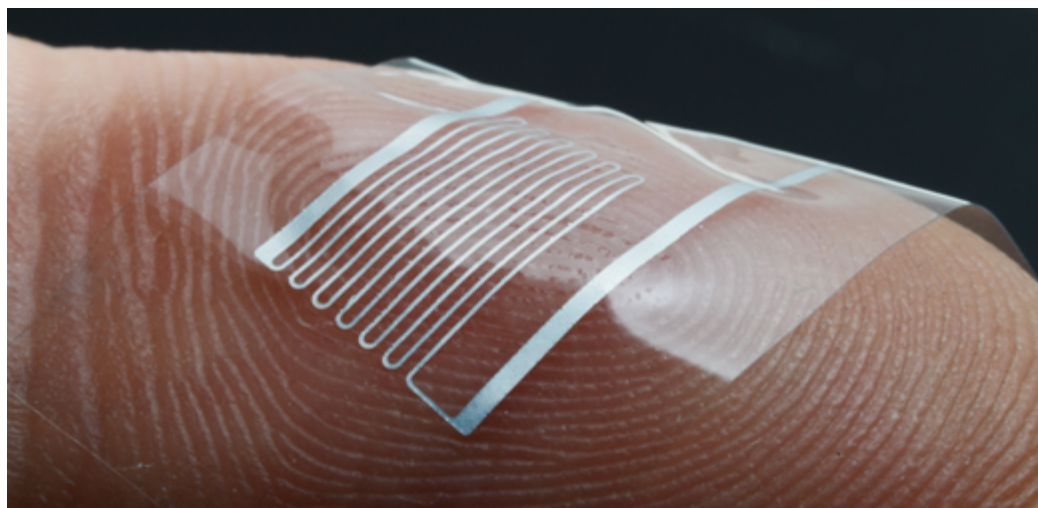
The main goal of our laboratory is to develop implantable neural interfaces and robotic systems aimed at restoring sensorimotor function in people with different kind of disabilities (spinal cord injury, stroke, amputation, etc...), starting from basic scientific knowledge in the field of neuroscience, neurology and geriatrics, and investigating further to gain new information by using advanced technologies and protocols.

For this reason our activities combine (i) technological developments (robotics, implantable neural interfaces, algorithms for closed-loop control and signal processing), (ii) experiments to understand the basic neuroscientific principles of motor control; (iii) integration and test of different types of hybrid neuro-prosthetic systems to restore sensory and motor functions.

Starting from a background on signal processing and closed-loop control, we have been able to enlarge the focus of his scientific activities and now our team has the ability to investigate all the different issues related to the development and test of effective neural and rehabilitation systems. We are one of the few groups in the world able to study all these issues in an integrated and harmonized manner.

Results Obtained in 2015

During 2015 we reached very important milestones on several important topics which are currently under investigation: (i) demonstration of the possibility to restore more sophisticated sensory feedback information in amputees using intraneural electrodes; (ii) development of novel approaches for epidural electrical stimulation to restore locomotion after spinal cord injury. These approaches are based on an increased understanding of the mechanisms underlying EES thanks to advanced computational models; (iii) technological development for a novel clinical study on robot-based neurorehabilitation; (iv) development of a novel self-opening neural interface (SELINE). This polyimide-based electrode has a three-dimensional structure that provides an anchorage system to the nerve and confers stability after implant. Results showed that SELINEs significantly improve mechanical anchorage to the nerve and could be an interesting solution for future translational applications.

Bio

Silvestro Micera is currently Associate Professor of Biomedical Engineering at the EPFL where he is holding the Bertarelli Foundation Chair in Translational NeuroEngineering. He is also Professor of Biomedical Engineering at the Scuola Superiore Sant'Anna (Italy). In 2009 he was the recipient of the "Early Career Achievement Award" of the IEEE Engineering in Medicine and Biology Society.

fb fondation bertarelli

Keywords

Neuroprosthetics, Bionics, Hand prosthesis, Modelling and control.

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Nicolas Menard
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Isabelle Pitteloud

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Anouk Hein

Selected Publications

Moraud E.M., Capogrosso M., Formento E., Wenger N., DiGiovanna J., Courtine G., Micera S. (2016). Mechanisms Underlying the Neuromodulation of Spinal Circuits for Correcting Gait and Balance Deficits after Spinal Cord Injury. Neuron. 17;89(4):814-28.

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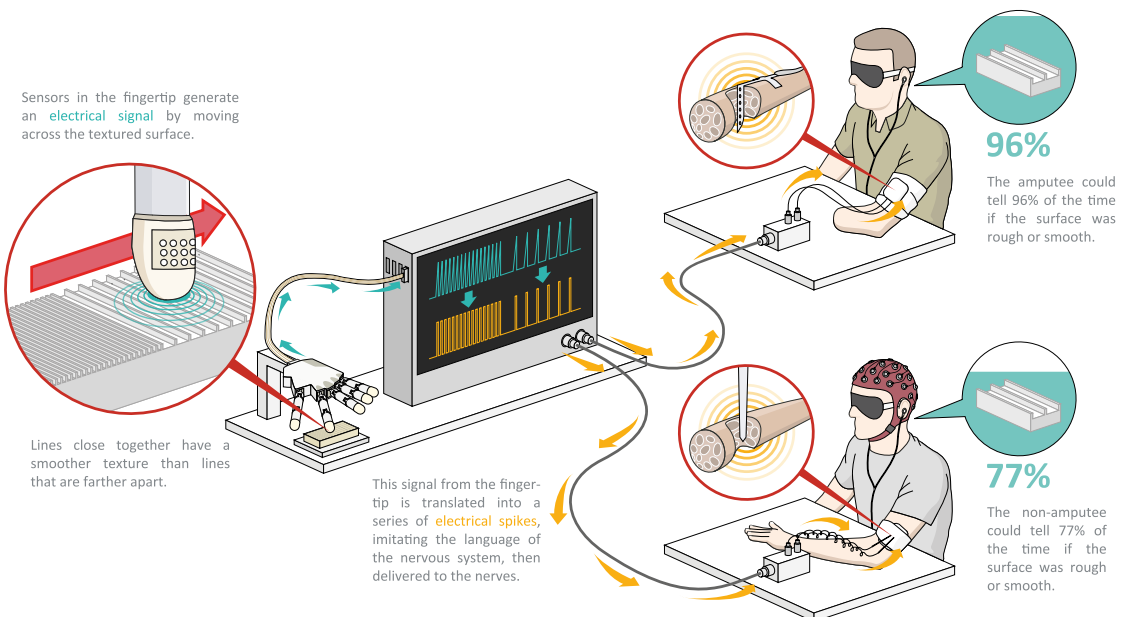
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Raspopovic S., Capogrosso M., Petrini F.M., Bonizzato M., Rigosa J., Di Pino G., Carpaneto J., Controzzi M., Boretius T., Fernandez E., Granata G., Oddo C.M., Citi L., Ciancio A.L., Cipriani C., Carrozza M.C., Jensen W., Guglielmelli E., Stieglitz T., Rossini P.M., Micera S. (2014) Restoring natural sensory feedback in real-time bidirectional hand prostheses. Science Translational Medicine. 5;6(222):222ra19.

van den Brand R., Heutschi L., Barraud Q., DiGiovanna J., Bartholdi K., Huerlimann M., Friedli L., Vollenweider I., Moraud E.M., Duis S., Dominici N., Micera S., Musienko P., Courtine G. (2012). Restoring voluntary control of locomotion after paralyzing spinal cord injury. Science, 336:1182-5.

Feeling Texture with a Bionic Fingertip

An amputee and non-amputees feel textural features in realtime from an artificial fingertip connected to nerves inthe arm.

Sensors in the fingertip generate an electrical signal by moving across the textured surface.

Lines close together have a smoother texture than lines that are farther apart.

This signal from the fingertip is translated into a series of electrical spikes, imitating the language of the nervous system, then delivered to the nerves.

96%
The amputee could tell 96% of the time if the surface was rough or smooth.

77%
The non-amputee could tell 77% of the time if the surface was rough or smooth.

Does the bionic fingertip really resemble the feeling of touch from a real finger ? Brain scans collected by an EEG cap placed on the subject's head revealed that activated regions in the brain were analogous.

ÉPFL
ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

Sant'Anna
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Restoration of texture discrimination in intact subjects and amputees

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.

Results Obtained in 2015

In 2015, we have focused our research on two different paths: translational work with end users and basic research on Brain-Machine Interfaces (BMI). Thus, we advanced our work on the development and test of different assistive devices. Recently, we demonstrated how nine subjects with severe motor disabilities were able to control a telepresence mobile robot successfully, and with results similar to those obtained by a control group of 10 healthy users (Leeb et al., 2015). We have also made progress on two other brain-controlled assistive robots, namely a lower-limb exoskeleton for locomotion and a hand orthosis.

Beyond disability, we reinforced our collaboration with the car manufacturer Nissan. Our work has mainly focused on predicting driver's actions before they occur (pressing brake/accelerator pedals, changing lanes) and detecting error brain signals whenever the driver does not agree with suggestions made by the intelligent car (Zhang et al., 2015b; Khaliliardali et al., 2015). Importantly, all these brain signals can robustly been decoded while the person undertakes natural actions (body movements) to drive the car.

We have also conducted basic BMI and neuroscientific studies aiming at understanding the underlying mechanisms of different signals, such as error-related brain signals (Zhang et al., 2015a); and discovering new neural imprints of different motor tasks, such as the decoding of grasping initiation or the motor task difficulty from EEG.

Publications in 2015 covered the following main research lines:
- Review, analysis and roadmap for future BMI applications.
- Translational work for physically disabled users for assistive and rehabilitation scenarios.
- Prediction of driving behaviors.
- Exploration of neural correlates of subject's cognitive processes during human-machine interaction and their exploitation to improve such an interaction.

Bio

Prof. José del R. Millán holds the Defitech Chair since 2009, where he designs neuroprostheses (brain-controlled devices like robots, exoskeletons and communication aids) for augmenting interaction experiences and restoring lost functions. His research on brain-machine interfaces has received a number of awards and recognitions.

Keywords

Brain-machine interfaces, Neuroprosthetics, Machine learning, Robotics, EEG.

Team

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Postdoctoral Fellows
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Maria Laura Blefari
Ricardo Chavarriaga
Iñaki Iturrate
Kyuhwa Lee
Robert Leeb
Andrea Maesani
Serafeim Perdikis
Aaron Schurger (with LNCO)
Aleksander Sobolewski

PhD students
Ruslan Aydarkhanov
Jaiber Cardona (visiting)
Tiffany Corbet
Lucian Gheorghe
Zahra Khaliliardali
Dong Liu (visiting)
Stéphanie Martin
Michael Pereira
Luca Randazzo
Sareh Saeedi
Christoph Schneider
Huaijian Zhang

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Géraud L'Eplattenier

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Xavier Mottart

Administrative Assistant
Christel Daidié

Selected Publications

Leeb R., Tonin L., Rohm M., Desideri L., Carlson T. and Millán J.d.R (2015). Towards Independence: A BCI Telepresence Robot for People with Severe Motor Disabilities. Proceedings of the IEEE, 103(6):969-982.

Iturrate I., Chavarriaga R., Montesano L., Minguez J. and Millán J.d.R. (2015). Teaching brain-machine interfaces as an alternative paradigm to neuroprosthetics control. Scientific Reports, 5:13893.

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Zhang H., Chavarriaga R., Khaliliardali Z., Gheorghe L.A., Iturrate I. and Millán J.d.R. (2015b). EEG-based decoding of error-related brain activity in a real-world driving task. Journal of Neural Engineering, 12(6):066028.

Khaliliardali Z., Chavarriaga R., Gheorghe L. A. and Millán J.d.R (2015). Action prediction based on anticipatory brain potentials during simulated driving. Journal of Neural Engineering, 12(6):066006.

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Courtine, G., Micera, S., DiGiovanna, J., and Millán, J.d.R. (2013). Brain-Machine Interface: Closer to Therapeutic Reality? The Lancet, 381(9866):515–517.

A BCI Telepresence Robot for People With Severe Motor Disabilities. (Left) End-user at a clinic while operating the BCI. (Right) Telepresence robot equipped with infrared sensors for obstacle detection and the Skype connection on top.

Van De Ville Lab

http://miplab.epfl.ch
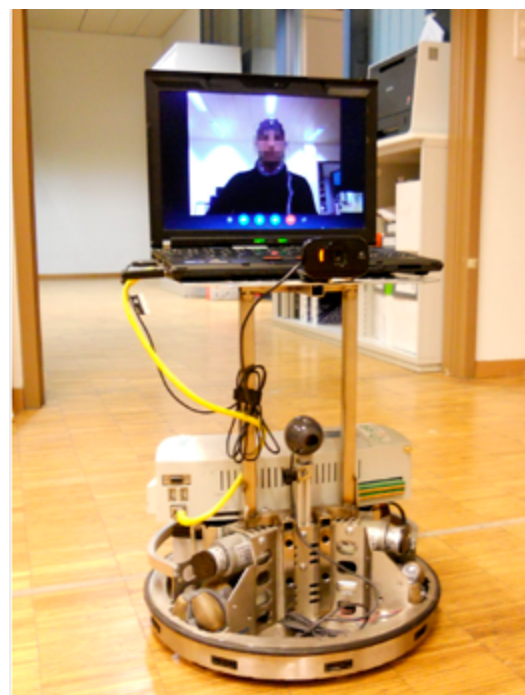
The Medical Image Processing Laboratory (MIP:lab) pursues the development and integration of innovative data-processing tools at various stages of the acquisition, analysis, and interpretation pipeline of neuroimaging data. We aim at obtaining new insights into brain function & dysfunction by approaches that are based on modeling the brain as a network and as a dynamical system. These new signatures of brain function are promising to interpret and predict cognitive and clinical conditions, and also provide avenues for neurofeedback based on real-time fMRI.

Results Obtained in 2015

The first highlight is on modeling of functional brain networks at the systems level; i.e., based on whole-brain functional magnetic resonance imaging (fMRI). Using graph theory, multiscale techniques, and pattern recognition we are able to identify and characterize brain networks in a meaningful way during cognitive tasks, as well as alterations by neurological conditions, which opens the potential for new imaging-based biomarkers that might for instance complement neuropsychological testing in prodromal stage of Alzheimer's Disease.

The second highlight is on temporal dynamics of these networks during spontaneous activity. We have pioneered subspace discovery methods for dynamic functional connectivity, which reveal meaningful interactions between large-scale distributed networks in terms of ongoing fluctuations. These techniques bring us closer to capturing the global brain state, which is essential for future development of invasive and non-invasive neuroprosthetics, such as neurofeedback based on real-time fMRI. Finally, we also relate the slow dynamics of fMRI back to fast millisecond-scale EEG signals.

Bio

M.S. and Ph.D. in Computer Sciences from Ghent University, Belgium (1998, 2002), Post-doctoral Fellow at EPFL (2002-2005), Junior Group Leader of the CIBM Signal Processing Unit at University of Geneva (2005-2009), awarded SNSF professorship (2009), Associate Professor of Bioengineering since 2015 jointly affiliated with University of Geneva (Department of Radiology & Medical Informatics).

Keywords

Computational neuroimaging, network science, brain dynamics, signal processing, functional magnetic resonance imaging, electroencephalography.

Team

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Thomas Bolton
Kirsten Emmert
Valeria Kebets
Rotem Kopel
Naghmeh Ghazaleh
David Nguyen
Daniela Zöller

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Umair Javaid
Martin Ndengera
Nemanja Masala
Antonios Poulakakis
Giorgio Policella
Anna Vybornova
Davide Zanchi

Administrative Assistant
Manuela Da Silva

Selected Publications

Karahanoglu, F. I., Van De Ville, D. (2015) Transient Brain Activity Disentangles fMRI Resting-date Dynamics in Terms of Spatially and Temporally Overlapping Networks. Nature Communications. 6:7751.

Behjat, H., Leonardi, N., Sörnmo, L., Van De Ville, D. (2015) Anatomically-Adapted Graph Wavelets for Improved Group-Level fMRI Activation Mapping. NeuroImage. 123:185-199.

Leonardi, N., Van De Ville, D. (2015) On Spurious and Real Fluctuations of Dynamic Functional Connectivity During Rest. NeuroImage.104:430-436.

Dogan, Z., Gilliam, C., Blu, T., Van De Ville, D. (2015) Reconstruction of Finite Rate of Innovation Signals with Model-Fitting Approach. IEEE Transactions on Signal Processing. 63:6024-6036.

Gschwind, M., Michel, C. M., Van De Ville, D. (2015) Long-Range Dependencies Make the Difference. NeuroImage. 117:449-455. *Featured on Cover Page*.

Leonardi, N., Shirer, W., Greicius, M., Van De Ville, D. (2014) Disentangling dynamic networks: separated and joint expressions of functional connectivity patterns in time. Human Brain Mapping. 35:5984-5995.

Richiardi, J. Achard, S., Bunke, H., Van De Ville, D. (2013) Machine learning with brain graphs. IEEE Signal Processing Magazine. 30: 58-70.

Leonardi, N., Richiardi, J., Gschwind, M., Simoni, S., Annoni, J.-M., Schluep, M., Vuilleumier, P., Van De Ville D. (2013) Principal components of functional connectivity: a new approach to study dynamic brain connectivity during rest. NeuroImage. 83:937-950.

Van De Ville, D., Jhooti, P., Haas, T., Kopel, R., Lovblad, K.-O., Haller, S. (2012) Recovery of the Default Mode Network After Demanding Neurofeedback Training Occurs in Spatio-Temporally Segregated Subnetworks. NeuroImage. 63:1775-1781.

Richiardi, J., Eryilmaz, H., Schwartz, S., Vuilleumier, P., Van De Ville, D. (2011) Decoding Brain States from fMRI Connectivity Graphs. NeuroImage. 56:616-626

Sequence of whole-brain cortical states that can be extracted from resting-state fMRI. Our computational methods allow identifying these states acknowledging for spatial and temporal overlap of these networks and their activity, respectively.
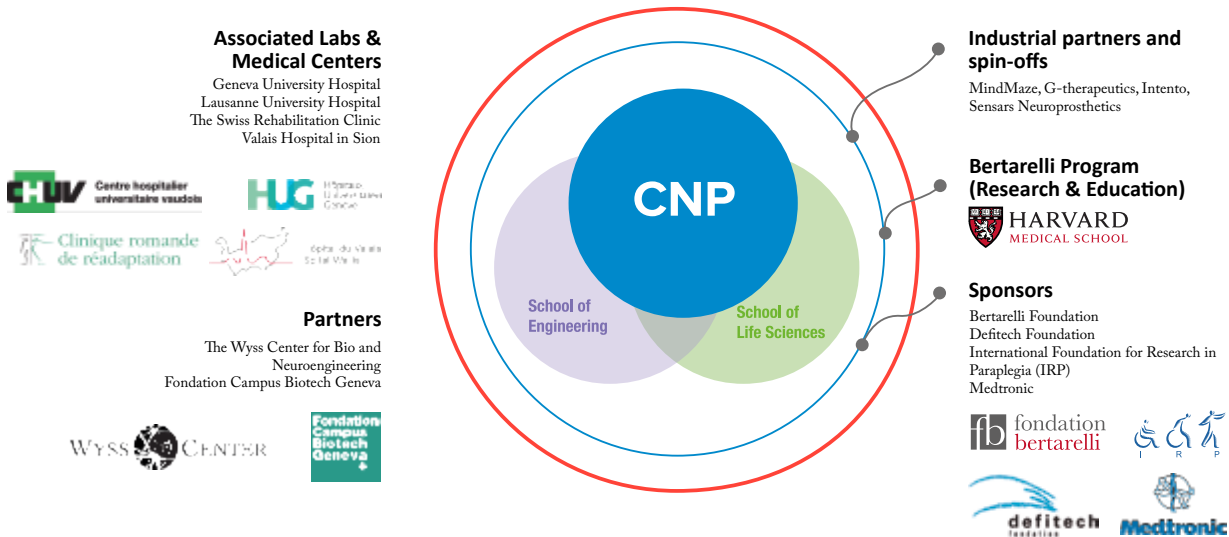
Research partners and activities

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 counts with 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, with the 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.

Associated Labs & Medical Centers
Geneva University Hospital
Lausanne University Hospital
The Swiss Rehabilitation Clinic
Valais Hospital in Sion

Partners
The Wyss Center for Bio and Neuroengineering
Fondation Campus Biotech Geneva

CNP

School of Engineering

School of Life Sciences

Industrial partners and spin-offs
MindMaze, G-therapeutics, Intento, Sensars Neuroprosthetics

Bertarelli Program (Research & Education)

Sponsors
Bertarelli Foundation
Defitech Foundation
International Foundation for Research in Paraplegia (IRP)
Medtronic

Associated laboratories

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.

EPFL

AMINIAN Kamiar, Laboratory of Movement Analysis and Measurement.

BLEULER Hannes, Robotic Systems Laboratory

BOULIC Ronan, Immersive Interaction Group

IJSPEERT Auke, Biorobotics Laboratory

PAIK Jamie, Reconfigurable Robotics Laboratory

Centre Hospitalier Vaudois (CHUV)

BLOCH Jocelyne, Stereotactic and Functional Neurosurgery Program, Department of Neurosurgery

**MURRAY** Micah, IONTA Silvio, Laboratory for Investigative Neurophysiology

RAFFOUL Wassim, Department of Plastic and Reconstructive Surgery

Hôpitaux Universitaires de Genève (HUG)

JANSSENS Jean-Paul, ADLER Dan, HERITIER BARRAS Anne-Chantal, IANCU FERFOGLIA Ruxandra, Department of Pneumology and Neurology

SCHNIDER Armin, GUGGISBERG Adrian, Cognitive Neuro-Rehabilitation Laboratory, Neurorehabilitation Clinic

SCHALLER Karl, MOMJIAN Shahan, Department of Neurosurgery
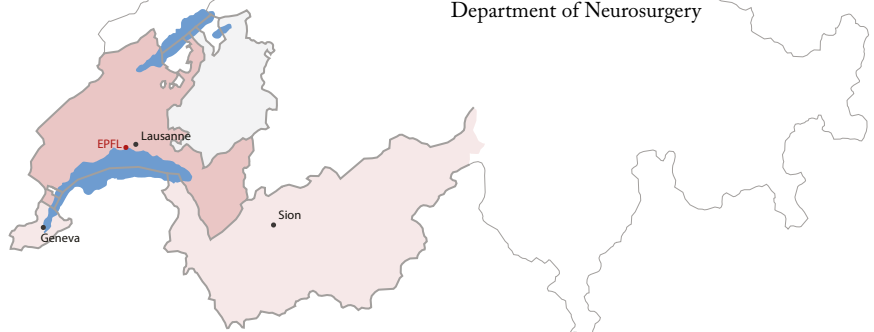
Partners and associated medical centers (continued)

The Wyss Center for Bio & Neuroengineering and the Center for Neuroprosthetics are collaborating in research projects and for the supervision of research platform at Campus Biotech.

The Wyss Center is an independent, not for profit, research organization that aims to transform neurotechnology research ideas into clinical solutions. The Center advances technology to the marketplace to help people with nervous system disorders live independent lives.

Established by a generous donation from the Swiss entrepreneur and philanthropist Hansjörg Wyss, and based at Campus Biotech in Geneva, the Wyss Center presents a new model in translational neurotechnology research.

Competitively awarded support is available for high risk, high reward research driven technology development projects that have the potential to make substantial clinical impact.

Over the course of the past year the Wyss Center has provided support and scientific, business and regulatory expertise to the CNP researchers.

Prof. John Donoghue is the founding Director of the Wyss Center for Bio and Neuroengineering, based at Campus Biotech in Geneva. He is Adjunct Professor at the Brain and Mind Institute of the Ecole Polytechnique Fédérale de Lausanne (EPFL). He is also visiting professor at the University of Geneva. He founded the Brown Institute of Brain Science at Brown University where he maintains a professorship. John Donoghue is a pioneer of the merger between neuroscience and cybernetics. He is best known for his work on human brain computer interfaces, brain function and plasticity and his work has been widely reported in the media.
http://www.wysscenter.ch/
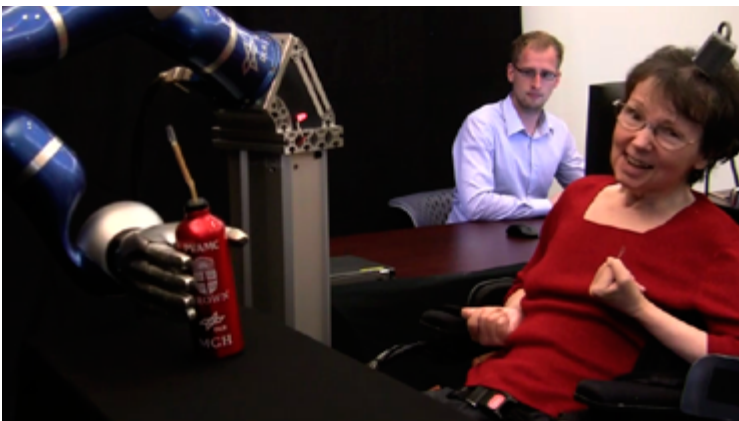
The ultimate goal of Professor Donoghue's research is to develop a device that would allow people to not only control robotic prostheses, as shown here, but directly trigger movement in paralyzed limbs through thought alone.

Wyss Center-supported CNP Projects

- Memory enhancement by amygdala stimulation
- Body illusions therapy for psychiatric disorders
- Restoration of leg movement after paralysis
- Restoring Sight with Self-Opening Intra-Neural Electrodes for Optic Nerve Stimulation
- Electronic dura mater systems: translation to clinical uses
- Personalised wearable robots to promote brain plasticity after stroke
- Restoring sensory and motor functions after arm or hand amputation
- Augmenting brain plasticity to enhance neurorehabilitation of arm movements after stroke
- Closed-loop and VR-enhanced real-time fMRI: Integrating machine learning, virtual reality, and real-time fMRI to develop new therapies for drug-resistant tinnitus and pain

Selected highlights 2015

January 2015

Neuroprosthetics for paralysis: a new implant on the spinal cord

New therapies are on the horizon for individuals paralyzed following spinal cord injury. The e-Dura implant developed by EPFL scientists can be applied directly to the spinal cord without causing damage and inflammation. The device is described in an article appearing online January 8, 2015, in Science.

e–Dura implant developed by Prof. Stéphanie Lacour

February 2015

The SUVA clinic in Sion inaugurates its extension

The new building of the Clinique Romande de Réadaptation counts 5 levels of clinical beds, and will host the offices and laboratories of the new EPFL-CNP chair in clinical neuroengineering.

April 2015

Stéphanie Lacour elected as Young Scientist by World Economic Forum

Congratulations to Professor Stéphanie Lacour, who has been elected as a Young Global Leader in the World Economic Forum (WEF).

Playing a video game using thoughts

The start-up MindMaze has opened a new dimension in the world of video games: moving with thoughts through a virtual environment or even directly interacting through certain emotions. Introduced at the Game Developers Conference in San Francisco, the MindLeap system is a big hit. The company has also just raised 8.5 million francs, and its CEO, Tej Tadi, was named among the Young Global Leaders at the World Economic Forum.

Intelligent Neuroprostheses mimic natural motor control

Prof. José del R. Millán gave an invited talk at the 22nd Annual Meeting of the Cognitive Neuroscience Society (CNS2015) held in San Francisco on March 28-31, 2015.

The CNP meets François Hollande and Simonetta Sommaruga

As part of the French Presidential visit in Switzerland (17.04.2015), the Center for Neuroprosthetics was honored by the EPFL presidency to represent the excellence of scientific and industrial innovation of EPFL to François Hollande and Simonetta Sommaruga. Professors Grégoire Courtine and Stéphanie Lacour presented their research in spinal cord repair and the E-Dura electrodes. The translation to clinical application through the G-Therapeutic startup was highlighted. Professor Olaf Blanke and Dr Bruno Herbelin demonstrated a virtual reality project with applications in cognitive neuropsychology and rehabilitation.

The French President François Hollande and the Swiss President Simonetta Sommaruga visiting EPFL on 17th April 2015.

Bertarelli Symposium on Translational Neurosciences and Neuroengineering

The symposium took place at the Campus Biotech in Geneva on April 17, 2015.

May 2015

CNP gets two Brain Forum 2015 Innovation Awards

The winners are Intento (Jury Award Winner) and SensArs Neuroprosthetics (Audience Award Winner).

Drs Raspopovic & Petrini from SensArs

Drs Maesani & Biasiucci from Intento

June 2015

Disabled people pilot a robot remotely with their thoughts

Using a telepresence system developed at EPFL, 19 people – including nine quadriplegics – were able to remotely control a robot located in one of the university laboratories. This multi-year research project aims to give a measure of independence to paralysed people. This technology has proven its efficacy, ease of use, and benefit for the patients.

July 2015

The Center for Neuroprosthetics has moved to Campus Biotech

End June 2015, the laboratories of Prof. Blanke, Prof. Millán and Prof. Van De Ville settled at Campus Biotech, in the building H4 dedicated to human neuroscience and neuroprosthetic research.

Observing brain network dynamics to diagnose Alzheimer's disease

By analyzing blood flow in the brain, a team of researchers was able to observe the moment-to-moment interactions between different regions in the brain. Their new imaging technique could help with the early detection of Alzheimer's disease.

August 2015

Paralysis: primates recover better than rodents

Monkeys and humans exhibit greater motor recovery than rats after similar spinal cord injury, according to a study conducted in Grégoire Courtine's lab at EPFL. The study results have been published in Science Translational Medicine.

September 2015

When the neuroprosthetics learn from the patient

While it takes a long time to learn to control neuroprostheses, José del R. Millán's research, published in Nature Scientific Reports, will enable the creation of a new generation of self-learning and easy to use devices.

Selected seminars in 2015

Multimodal neuromodulation of cortical circuits: from basic neurophysiology to clinical application, January 2015
Prof. Giacomo KOCH, Fondazione Santa Lucia IRCCS, Rome, Italy.

Physiology of Cognition and Behavior: The contribution of non-invasive Brain Stimulation, January 2015
Prof. Michael A. Nitsche, M.D., Georg-August-University,Goettingen, Germany.

Control of balance during human walking, January 2015
Prof. Art Kuo, University of Michigan, USA.

A learning-based approach to artificial proprioception, February 2015
Prof. Philip Sabes, University of California San Francisco, USA.

Interareal interactions in the sensorimotor network: from mechanisms to interventions, February 2015
Prof. Friedhelm C. Hummel, University Medical Center Hamburg-Eppendorf, Hamburg, Germany.

New ways of using neurotechnologies for modulating human brain activity and functions, February 2015
Prof. Gregor Thut, Institute of Neuroscience and Psychology, University of Glasgow, United Kingdom.

Pre-impact fall detection, February 2015
Dr Vito Monaco, Scuola Superiore Sant'Anna, Pisa, Italy.

The Positive Impact of Placebo Imaging Research on Clinical Care, February 2015
Prof. Randy L. Gollub, Athinoula A. Martinos Center for Biomedical Imaging and Massachussetts General Hospital, Boston, MA (USA).

Human-machine interaction and neurorehabilitation, March 2015
Etienne Burdet Ph.D., Chair in Human Robotics, Imperial College London, United Kingdom.

Eyes are Ears, Hands are Eyes: Understanding Multisensory Integration in the Brain via Neurocomputational Models, October 2015
Elisa Magosso, University of Bologna, Italy.

Flexible microfabricated electrode arrays for Deep Brain Stimulation, October 2015
Michel Decré, Medtronic Eidhoven Design Center, Eidhoven, The Netherlands.

Multiple testing procedures for large and complex dependent data to study human brain complex network properties, October 2015
Djalel Meskaldji, Swiss Federal Institute of Technology, Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland.

Revealing the neural representation of remembered real-life experiences, November 2015
Prof. Per B. Sederberg, Ohio State University, USA.

Deep Brain Stimulation: Modulation of neural networks for behavioral self regulation, November 2015
Prof. Ali Rezai, Ohio State University, USA.
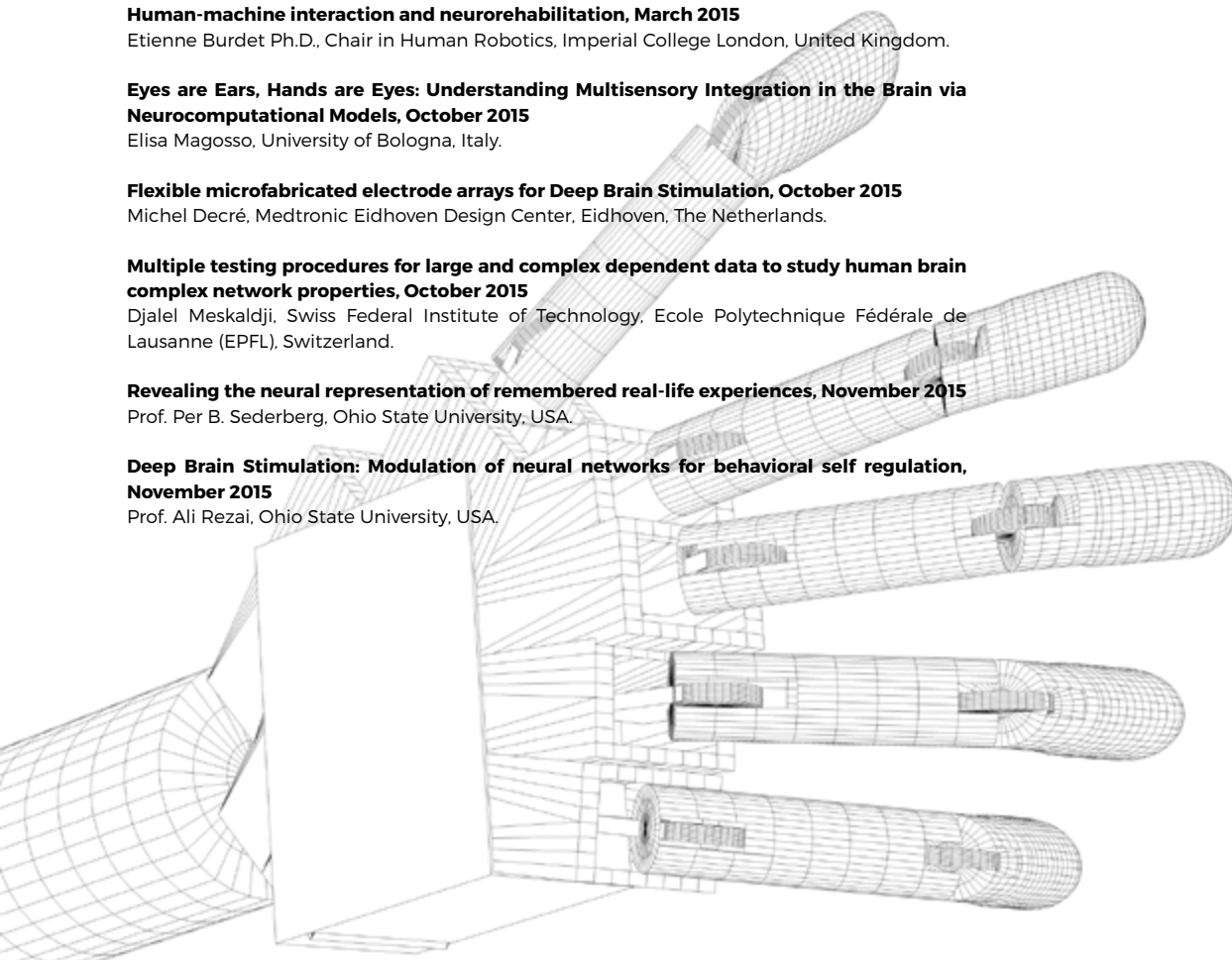
Teaching

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 neuro-scientists, 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.

Donatella and Ernesto Bertarelli meet the EPFL students of the HMS Fellowship program.

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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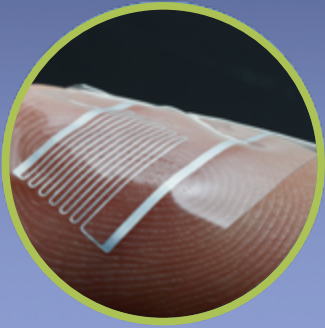
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