

IEEE SMC 2019



2019 International Conference on Systems, Man, and Cybernetics

Workshop on Brain-Machine Interface Systems

October 6 - 9, 2019

Bari, Italy

Sponsored by



*BR4N1O Brain-Computer Interface (BCI) Designer Hackathon free to all SMC2019 attendees - \$3,000 cash prizes to be won

Welcome Message from the BMI Workshop Organizers

The 2019 IEEE International Conference on Systems, Man, and Cybernetics (SMC 2019) will be held in Bari, Italy. SMC 2019 is the flagship conference of the IEEE Systems, Man, and Cybernetics Society. It provides an international forum for researchers and practitioners to report recent innovations and developments as well as exchange ideas and advances in all aspects of systems science and engineering, human machine systems, and cybernetics. Advances in systems science and engineering, human-machine systems, and cybernetics have increasing importance in the creation of intelligent environments involving technologies interacting with humans to provide an enriching experience and an improved quality of life.

The **IEEE SMC 2019 9th Workshop on Brain-Machine Interface (BMI) Systems** will be held on October 6–9, 2019 as part of the SMC 2019 program. The goal of the Workshop is to provide a forum to present research results and facilitate the interaction and intellectual exchange between researchers, developers, and consumers of BMI technology. Contributions report the latest advances, innovations, and applications in the field of BMI, including affective BMIs, hybrid BMIs, deep learning for BMIs, neurorehabilitation, BMIs and virtual/augmented reality, and other real-world applications. These topics represent both challenges to the field and a tremendous opportunity for collaborative and multidisciplinary research, thus requiring expertise in systems engineering, human-machine systems, cybernetics, neuroscience, medicine, robotics, and other disciplines. This year's theme is ***From Assistive Technologies to Affective Computing: What's Next for Neurotechnologies?*** Focus will be placed around how industry and industry-academia partnerships have been paving the road for next-generation developments. We welcome all SMC 2019 delegates who are involved or interested in learning more about the state-of-the-art and future industry challenges in BMI-related topics to attend this Workshop.

The BMI Workshop will feature the free BR41N.IO Brain-Computer Interface (BCI) Hackathon, a hands-on demo session, three keynote and four invited speakers, two panels, an industry-student mentorship session, a tutorial, a mini-workshop, contributed paper presentations, and a late-breaking research poster session. The Workshop is organized by the *IEEE SMC TC on BMI Systems* and is technically co-sponsored by the *IEEE Brain Initiative*.

Papers and Keynote Speakers

The goal of the Workshop is to provide a forum for researchers to present research results and facilitate the interaction and intellectual exchange between researchers, developers, and consumers of BMI and brain-research technology. This year, we have **87 full papers** accepted after careful peer-review by at least three experts in BMI-related fields and will be presented across **13 oral sessions** and **one poster session**. We also have **13 accepted late-breaking research abstracts**. The oral sessions will cover topics related to: BMI tools, techniques and metrics; artifact correction and channel selection for BMIs; neurotechnologies in the clinic; deep and transfer learning for BMIs; advances in steady-state visually evoked potential BMIs; BMIs enabled by shared control; BMIs for immersive environments; neurorehabilitation applications of BMIs; brain-inspired cognitive systems; passive BMIs; multimodal BMIs “in-the-wild”; real-world BMI applications; and brain state decoding.

We are pleased to have three outstanding BMI keynote speakers:

- **Maria Chiara Carrozza** (Professor, Biorobotics Institute, Scuola Superiore Sant'Anna, Italy): *Human-Robot Integration for Rehabilitation and Personal Assistance* (Monday, October 7, 2:00 pm – 3:00 pm, Room 3)
- **Febo Cincotti** (Professor at the Sapienza University of Rome, Italy): *Design and use of brain computer interfaces in neurorehabilitation* (Tuesday, October 8, 10:30 am – 11:15 am, Room 3)
- **Amy Kruse** (CSO, Platypus Institute, USA): *Human 2.0: Neurotechnology-enabled performance enhancement* (Wednesday, October 9, 10:30 am – 11:30 am, Room 3)

We also have five excellent BMI invited speakers giving six invited talks (Location: Room 3):

- **Christoph Guger** (CEO, g.tec, Austria): (1) *Current and future BCI applications*, (2) *Running real-time BCIs*; Sunday, October 6, 10:30 am – 11:30 am.
- **Martin Walchshofer** (Developer, g.tec GmbH, Austria): *Unicorn brain interface demonstration*, Sunday, October 6, 11:30 am – 12:00 pm.
- **Rossella Spataro** (Neurologist at Università degli Studi di Palermo, Italy): *BCIs for Assessment of Patients*, Sunday, October 6, 3:00 pm – 3:45 pm.
- **José M. Azorin** (Director of BMILab and Professor at Universidad Miguel Hernández de Elche, Spain): *BCIs for interacting with robots*, Monday, October 7, 12:00 pm – 12:45 pm.
- **Alfred Emondi** (Program Manager, DARPA Biological Technology Office, USA): *An overview of select DARPA programs advancing neural interfaces for functional recovery*, Tuesday, October 8, 11:15 am – 11:45 am.

BR41N.IO Brain-Computer-Interface Hackathon and Hands-on Demo Session

Hackathons are two-day brainstorming and collaborative marathons that create an environment supporting the rapid production of working prototypes. Registered SMC 2019 attendees interested in BCI/BMI and related technologies may participate in the **free Brain Computer Interface Hackathon** organized by the BMI Workshop to be held on Sunday, October 6 and Monday, October 7, 2019. **There are \$3,000 in cash prizes to be won.** Register at <https://www.br41n.io/Bari-2019> or email Christoph Guger at <guger@gttec.at> if you have questions.

Right after the Hackathon is over and prizes have been awarded, come experience real-time BMI applications in our **hands-on demo session**, including BMI virtual reality headsets, BMI spellers, and neuro-prostheses.

Panels and Industry-Student Mentorship Session

This year, we will feature two panels. The first panel is around the theme of **AI, BMIs, and human-in-the-loop autonomous agents: co-existence or self-destruction?** (Tuesday, October 8, 11:45 am – 12:30 pm, Room 3). Panelists will include experts in AI, autonomous agents, BMIs and their use (and potential drawbacks) in human-machine interactions. The second is an **industry panel** (Tuesday, October 8, 1:45 pm – 3:00 pm, Room 3) featuring 11 industry leaders who will share their insights about how industry and industry/academia partnerships have helped advance neurotechnology. Panelists will cover all aspects of the BMI chain, including sensors and software; applications in clinical, human enhancement, and entertainment; funding; and standardization.

Following the industry panel, interested students will be able to meet with the panelists in a “speed dating” style **mentorship session** (Tuesday, October 8, 3:00 pm – 4:00 pm, Room 3) to obtain advice on how to pursue successful careers or be an entrepreneur in the current and emergent neurotechnology markets.

Late-Breaking Research Posters

Want to hear about the latest innovations in neurotechnologies? The late-breaking research abstract session will showcase 13 posters with corporate, academic, and industry-academia partnership research. Titles include:

- MEG-based brain-geminioid interface using bilateral motor imagery characteristics
- Towards understanding the neural mechanisms of haptic communication
- An investigation of computer-based brain training on the cognitive and EEG performance of employees
- Adaptive modulation filtering for motor imagery classification enhancement
- A business proof-of-concept of a brain-computer interface for cognitive enhancement
- What is minimal EEG? User centered and reliable EEG headsets for real-world applications
- On modern neurofeedback solutions based on BCIs in uncontrolled real-world settings
- DEEPER: Online portal to improve reproducibility and accelerate deep learning research for EEG analysis
- Large-scale analysis of canonical cortical network dynamics across five visual target detection tasks
- Exploring predictive models of Alzheimer's disease severity based on resting state EEG and MRI features
- Multimodal database for mental workload, stress, and fatigue assessment of ambulant first responders
- Fusion of motif and EEG spectral features for improved automated emotion recognition
- Decoding intended saccade targets from lateral prefrontal cortex neuronal spiking rates using DNNs

IEEE Brain Initiative Best Paper Award

The IEEE Brain Initiative has sponsored a BMI Best Paper Award. The six finalists are:

- Inferring the temporal structure of directed functional connectivity in neural systems: some extensions to Granger causality (Paper 439)
- Classification of healthy, Alzheimer's disease, and Parkinson's disease individuals using single resting state EEG markers (Paper 604)
- Salience vs. affect in implicit cursor control: first indications of separate cortical processes (Paper 621)
- Augmented reality interface for smart home control using SSVEP-BCI and eye gaze (Paper 766)
- A pBCI to predict attentional error before it happens in real flight conditions (Paper 979)
- Optimizing input layers improves CNN generalization and transfer learning for imagined speech decoding from EEG (Paper 1082)

Tutorial and Mini-Workshop

A tutorial on *Introduction to the Lab Streaming Layer (LSL)* open-source software framework (Sunday, October 6, 2:00 pm - 6:30 pm, Room 11) and a mini-workshop on *Standardization of Neural Interface Research to Accelerate Interoperability, Clinical Integration, and Commercialization of Neurotechnologies* (Sunday, October 6, 11:00 am – 1:00 pm, Room 14) have been organized.

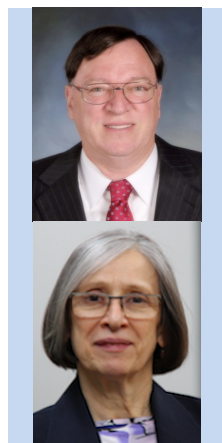
Closing Reception

We will close the Workshop with a reception sponsored by Intheon and Neocortex Ventures at a local nearby pub. More details will be posted on the announcement boards during the Workshop.

Organization Committee and Supporters

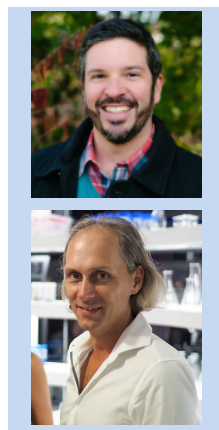
We would like to thank the many organizations and individuals who worked hard in organizing the Workshop, including the Technical Program Co-Chairs: *Ricardo Chavarriaga, Daniela de Venuto, and Yingxu Wang*; Special Session Co-Chairs: *Iñaki Iturrate, Christian Kothe, Tim Mullen, and Tadahiko Murata*; Industry Co-Chairs: *Ferdinand Ephrem and Javier Minguez*; Publicity Chair: *Ervin Sejdic*; Media Relations Chair: *Sarah Breinbauer*, and Webmaster: *Liviu Ivanescu*, as well as Brain Hackathon Chair and Co-Chairs: *Christoph Guger, Tiago H. Falk, José M. Azorín, Tim Mullen, Rossella Spataro, Salvatore Tramonte, and Daniela de Venuto*. Special thanks to all Special Session organizers: *Felix Putze, Dean Krusienski, Sergi Bermúdez i Badia, Alexander Heilingner, Christoph Guger, Ivan Volosyuk, Tim Mullen, Stefan Haufe, Mark Parent, Tiago H. Falk, Ning Jiang, Yiwen Wang, Yingxu Wang, Henry Leung, Thorsten Zander, Laurens Krol, Dongrui Wu, Yufei Huang, Christian Kothe, Francisco Fraga, Claudio Babiloni, Luca Tonin, Serafeim Perdakis, Tzyy-Ping Jung, Iñaki Iturrate, and Ricardo Chavarriaga*. We also thank the BMI Workshop supporters for their generous funding: IEEE Brain, g.tec, Intheon, Bitbrain, NIRx, Brain Products, BeamMeUp NeuroVR Labs, Advanced Brain Monitoring, and Neocortex Ventures.

We look forward to meeting you in Bari!



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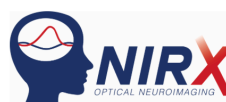


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Expert Panel: Recent Neurotechnology Innovations and Applications in Industry

(Room 3, Tuesday, October 8, 1:45 pm – 3:00 pm)



Tim Mullen, Moderator

Dr. Mullen obtained his Ph.D. from the Dept. of Cognitive Science at UC San Diego. He is founder/CEO of Intheon, a San Diego neurotechnology company serving industry, clinical, and scientific communities with state-of-the-art statistical machine learning, signal processing and cloud computing infrastructure for bio/neural state decoding. He also directs Intheon's R&D division to advance applied and basic scientific research in neurotechnology.



Amy Kruse, Panelist

Dr. Kruse is CSO of the Platypus Institute, an applied neuroscience research organization that translates neuroscience discoveries into practical tools and programs to enhance the human experience. She is involved with project “Human 2.0” – an initiative that helps individuals and teams leverage neurotechnology to generate meaningful competitive advantages. Her ultimate goal with the project is to create a vibrant, widespread neurotechnology industry that allows humanity to upgrade the human brain and, thereby, the human condition.



Amir Meghdadi, Panelist

Dr. Meghdadi is the Director of Research at Advanced Brain Monitoring (ABM) in Carlsbad, California, USA. He received his Ph.D. in Electrical Eng. from the University of Manitoba, Canada and worked as a post-doctoral fellow at the Psychological and Brain Sciences Department at UC Santa Barbara. He and his team at ABM work on developing electroencephalography-based biomarkers associated with central nervous system disorders, such as neuro-degenerative diseases or mood disorders.



Emil Hewage, Panelist

Dr. Emil Hewage is Co-Founder and CEO at BIOS, a leading neural engineering startup. Emil undertook Ph.D. research in computational neuroscience and machine learning at the University of Cambridge and has used this knowledge to pioneer the use of artificial intelligence for interpreting neural data. He began working in startups at age 17 and held engineering and leadership roles across a range of industries from clean energy to advanced medical technologies. He was recently named to Forbes 30 Under 30.



Alex Bates, Panelist

Alex works on bringing artificial intelligence (AI) and machine learning to the forefront of the industrial market. He led DARPA funded research in neural networks, applied analytics for the world's largest data warehouses at Teradata, and created Mtell, a machine learning company acquired by Aspentech, he believes the coming wave of human-centered AI has the potential to make us superhuman and create a world of abundance. He is author of the book *Augmented Mind* which explores the potential of combining AI with human intelligence.

**Christopher Guger, Panelist**

Christoph Guger is the founder and CEO of g.tec medical engineering GmbH. He studied Biomedical Engineering at the Technical University of Graz, Austria and at the John Hopkins University in Baltimore, USA. During his studies, he concentrated on BCI systems and developed many of the early foundations for bio-signal acquisition and processing in real-time. G.tec produces and develops BCIs that help disabled people communicate or control their environments by their thoughts and regain motor functions after a stroke.

**Lamija Pašalić, Panelist**

Lamija Pašalić has over a decade of experience designing neuroimaging technology and supporting neuroscientists. She completed her B.Sc. and M.Sc. in Biomedical Eng. at Politecnico di Milano, focusing on biomedical signal processing. She is an expert in fNIRS, the Head of Project Management at NIRx GmbH, Berlin, and NIRx's primary scientific consultant for fNIRS analysis. She oversees their industry leading efforts and customer partnerships.

**Alfred Emondi, Panelist**

Dr. Emondi is Program Manager of DARPA's Biological Technologies Office where his focus is on the exploration and use of bidirectional central and peripheral nervous system interfaces for functional restoration, and the transformation and advancement of human-machine interaction. He was formerly with Naval Information Warfare Center (NIWC) where he was the CTO for the Atlantic region. In this role, he led the Science & Technology competency, focusing on basic and applied sciences, technology transition, and technology transfer.

**Javier Minguez, Panelist**

Dr. Minguez is co-founder of BitBrain Technologies, a neurotechnology company for health, market research, and entertainment applications. He is Professor of Computer Science and Lecturer in the Neuroscience, Biomedical and Engineering School at University of Zaragoza (Spain). He has 110+ research publications and 5 patents in the areas of neuroscience, neural engineering, BMIs, cognitive and motor neurorehabilitation, and market research. He has received numerous international awards for innovation and entrepreneurship.

**Marc Saab, Panelist**

Marc Saab is Founder and Managing Director of BML Technology, a biomedical engineering firm specializing in medical device, consumer wearables, and digital health. He is an expert in BCI/HCI and his corporate work on medical device and wearable product development has ranged from conception R&D to launch and commercialization for international markets. He holds a B.A.Sc. from University of Waterloo in Electrical Engineering (minor in Biology), and a M.Sc. in Biomedical Engineering from McGill University (Montreal Neurological Institute).

**Zach McKinney, Panelist**

Dr. McKinney is a post-doc researcher at the BioRobotics Institute, Scuola Superiore Sant'Anna (Pisa), where he manages the development and clinical evaluation of exoskeletal robotic systems for applications in industry and neural rehabilitation. He chairs IEEE Working Group P2794 developing a Reporting Standard for in vivo Neural Interface Research. He also leads the user needs focus area of the IEEE Industry Connections Activity on Neuro-technologies for BMIs. He was previously co-founder and CSO at Spinal Singularity.

Expert Panel

AI, BMIs and human-in-the-loop autonomous agents: co-existence or self-destruction?

Tuesday, October 8, 11:45 am – 12:30 pm, Room 3

Abstract

Artificial intelligence (AI) is advancing at light speeds and methods such as transfer learning, deep learning and reinforcement learning are enabling tools and technologies we couldn't dream of in a near past. These advances have pushed the performance envelope of autonomous agents, such as self-driving cars and robots, to name a few. The use of autonomous agents, however, in situations where the consequences of failure can be significant has been the subject of major debate, and new *human-in-the-loop* systems are emerging. With the advances witnessed recently in body/brain-machine interfaces, the question arises: can the triad: AI, human-in-the-loop control systems, and BMIs co-exist? Are we ready for such integration or will this be the beginning of the end? This panel will explore the potential of this triad in near- and far-future applications.

Moderator

José M. Azorin (Director, Brain-Machine Interface Systems Lab, Universidad Miguel Hernández de Elche): *BMIs for neurorehabilitation robotics.*

Panelists

- *Febo Cincotti* (Professor at the Sapienza University of Rome, Italy): *Use of direct BMIs for assistive and rehabilitation purposes.*
- *Edward Tunstel* (Associate Director of Robotics, United Technologies Research Center, USA; president of the IEEE SMC Society): *Human-collaborative robotics and autonomous systems.*
- *Dimitar Filev* (Henry Ford Technical Fellow, Ford Research & Innovation Center, USA): *AI and intelligent control for robotics and autonomous vehicle applications.*
- *Chadwick Boulay* (Senior Research Associate, Ottawa Hospital Research Institute, Canada): *Invasive BMIs and AI for assistive communication and to induce and guide adaptive plasticity.*
- *Luca Tonin* (Senior Researcher, Intelligent Autonomous System Lab, University of Padova, Italy): *Advanced techniques for BMI-driven robotics. Member of the 2016 BCI Cybathlon winning team.*
- *Emanuele Menegatti* (Professor, School of Engineering, University of Padova, Italy): *Humanoid robot perception and neurorobotics.*

Brain Hackathon: Room 3

Sunday, October 6, 8:00 am – Monday, October 7, 6:00 pm

A gathering such as IEEE SMC 2019 brings together great minds. We invite you to be a part of the **free** IEEE SMC 2019 Brain-Computer Interface (BCI) Designer Hackathon, where participants are engaged in a brainstorming and collaborative round-the-clock marathon, designed to rapidly produce working prototypes. The event is organized by the BR41N.IO BCI Designer Hackathon series and IEEE SMC. The goal is to stretch the boundaries of BCI technology, to put creative minds from many disciplines together, and to provide an environment for innovation, entrepreneurship, and creation of applications/products that have great commercialization potential. **There are \$3,000 in cash prizes to be won.** Individual or team participants (each up to 5 persons) are welcome, with a limitation of 100 individuals/20 teams. Coffee, food and more will be provided.

What's a Hackathon and Why? IEEE SMC BMI Hackathons are free-to-attend brainstorming and collaborative marathons designed to rapidly produce working prototypes. Conventional hackathons typically bring developers and technologists together over 24 hours to cram and build solutions that they can present. By putting creative minds from multiple disciplines together for a short period of time, we have the opportunity to discover and uncover possibilities for using BCI-related hardware and software not readily thought of. Hacks and innovation developed from hackathons have great potential for commercialization and are great events for networking.

Who Can Participate and How? Anyone, regardless of background. In the past, attendees with interests in BMI, cloud technologies, IoT, robotics, AR, VR, machine learning, sensors, 3D printing and design, fashion design, human-machine interfaces, control, signal processing, big data, haptics, and rehabilitation, have participated. You do not have to be a BCI expert to participate on a team! Interdisciplinary teams with a combination of BCI and non-BCI skills are often successful in building solutions and producing working prototypes. You can register at www.br41n.io. Register as soon as possible to select your favorite project and to find other team members.

Hackathon Program

Sunday, October 6, 2019, Location: Room 3 (Session Chair: Christoph Guger)

9:00–10:00	BR41N.IO press conference
10:00–10:30	Welcome
10:30–11:00	Current and future applications of brain-computer interfaces (Speaker: Christoph Guger)
11:00–11:30	How to run a real-time BCI application (Speaker: Christoph Guger)
11:30–12:00	Unicorn brain interface demonstration (Speaker: Martin Walchshofer)
12:00–13:00	Group formation
13:00	Start BR41N.IO hackathon
15:00–15:45	BCI for assessment of patients (Speaker: Rossella Spataro)
24:00	BR41N.IO night break

Monday, October 9, 2018, Location: Room 3 (Session Chair: Christoph Guger)

6:00	Start BR41N.IO
12:00–12:45	BCI for interacting with robots (Speaker: José M. Azorin)
14:00	End BR41N.IO
15:00–17:00	Project presentations
17:00–17:30	Meeting of the hackathon jury
17:30–18:00	BR41N.IO prize ceremony (Ljiljana Trajković, IEEE Division X Director and SMCS Awards Chair)
19:00–21:00	BR41N.IO winner presentations during hands-on demo session

Sponsors and Supporters



Tutorial and Mini-Workshop

Sunday, October 6, 2019

TUTORIAL: Introduction to the Lab Streaming Layer (LSL)

Organizers: Tim Mullen and Christian Kothe (Intheon Labs)

Presenters: Christian Kothe, Tim Mullen, David Medine, and Chadwick Boulay

Location and time: Room 11, 2:00 pm – 6:30 pm

This tutorial will provide an introduction to Lab Streaming Layer (LSL), an open source software framework for standardized, time-synchronized, acquisition and streaming of multimodal time-series data from a wide range of hardware devices, including neural sensors (EEG, iEEG, etc), eye trackers, ECG/PPG sensors, video cameras, and more. The tutorial will provide an overview of the LSL project, hands-on tutorials, and round-table discussion / Q&A, and will feature lectures from key developers in the LSL community. We will also discuss the closely related Extensible Data Format (XDF) and Attuned Container Format (ANSI/CTA 2060 standard) for storage of EEG and multimodal data and metadata.

MINI-WORKSHOP: Neural Interface Research Standardization to Accelerate Interoperability, Clinical Integration, and Commercialization of Neurotechnologies

Organizers: Zach McKinney (Scuola Superiore Sant'Anna), Luigi Bianchi (University of Rome Tor Vergata), and Dennis McBride (Source America, NeuroRx)

Location and time: Room 14, 11:00 am – 1:00 pm

Continued progress in the fields of neurotechnology and neurorehabilitation demand increasing functional integration between a broad spectrum of human-machine interfacing technologies, neural interfaces chief among them. However, the current lack of broad interoperability between various neural interfacing systems and the multitude of peripheral devices with which they are intended to interact poses an ongoing barrier to research, clinical, and commercial objectives alike. This Mini-Workshop will highlight a suite of current IEEE Standards Working Groups as a strategic means of aligning incentives and overcoming barriers to neurotechnology integration and development across a range of neurotechnology stakeholders, including researchers, commercial technology developers, medical device regulators, and public funding agencies. In particular, presentations will include detailed overviews of IEEE Working Groups P2794 (Reporting Standards for in vivo Neural Interface Research) and P2731 (Unified Terminology for Brain-Machine Interfaces), including the WG objectives, scope of work, preliminary structure of our standard, and current activities. In addition, the workshop will feature a brief overview of IEEE the Standardization process (including how to participate), as well as presentations of several research projects highlighting critical challenges and strategies for system and data integration in multi-modal neural interface systems and studies.

IEEE SMC 2019 Workshop on Brain-Machine Interface Systems - Program Summary											
Monday, October 7			Tuesday, October 8			Wednesday, October 9					
	Room 7	Room 8	Room 3 (BR41N.IO Brain-Computer Interface Designer Hackathon*)	Room 7	Room 8	Cassiopea (Poster) Room	Room 3	Room 7	Room 8	Room 3	
6:00			Start BR41N.IO BCI Designer Hackathon								poster setup
9:00-10:00	BR41N.IO BCI Designer Hackathon Press Conference										
10:00-10:30	Welcome										
10:30-11:00	Current and future applications of brain-computer interfaces (Christoph Guger)						BMI keynote #2 (Febo Cincotti, "Design and use of brain computer interfaces in neurorehabilitation") 10:30am-11:15am				BMI Industry keynote (Amy Kruse, "Human 2.0: Neurotechnology Enabled Performance Enhancement")
11:00-11:15											
11:15-11:30	How to run a real-time BCI application (Christoph Guger)										
11:30-11:45	Unicon Brain Interface Demonstration (Martin Walchshofer)	BMI Session #1 BCI tools, techniques and metrics (Chair: Ivan Volosyak) Papers: 519-555-600-700-1061-1258 (10:45-12:45)	BMI Session #2 Brain-Inspired Cognitive Systems (Chairs: Yingxun Wang and Henry Leung) Papers: 215-692-721-879-1001-1050 (10:45-12:45)			HUMAN-MACHINE SYSTEMS - BMI Papers: 837-838-881-978-998-1086-1088-1189-1287	An overview of select DARPA programs advancing neural interfaces for functional recovery (Alfred Emond) 11:15am - 11:45am				Late-breaking poster session
11:45-12:00							Expert Panel: AI, BMIs and human-in-the-loop autonomous agents: co-existence or self destruction? 11:45am - 12:30pm				
12:00-12:30	Group formation		BCI for Interacting with Robots (José M. Azorín) 12:00-12:45								
12:30-13:00											
13:00-13:30	Start BR41N.IO BCI Designer Hackathon		Hacking								
13:30-14:00			End BR41N.IO BCI Designer Hackathon								
14:00-14:30			BMI Keynote #1 (Maria Chiara Carrozza, Human-Robot Integration for Rehabilitation and Personal Assistance)				Expert panel: Recent Neurotechnology Innovations and Applications in Industry (1:45pm - 3:00pm)	BMI Session #8 Neurorehabilitation Applications of Brain-Machine Interfaces (Chair: Grijesh Prasad) Papers: 177-624-664-1340-1114-1051 (13:45-15:45)	BMI Session #9 Artifact correction and channel selection for BCI's (Chairs: Martin Bleichner and Raymundo Cassani) Papers: 248-381-403-610-939-1133 (13:45-15:45)	BMI Session #10 Neuroadaptive Technologies and Passive BCIS (Chairs: Thorsten Zander, Laurens Krol, and Tim Mullen) Papers: 621-729-1136-578-345-1252 (13:45-15:45)	
14:30-15:00							Industry-student mentorship session				
15:00-15:30	BCI for Assessment of Patients (Rossella Spataro) 15:00-15:45		Project Presentations								
15:30-16:00											
16:00-16:30											
16:30-17:00											
17:00-17:30		BMI Session #3 Neurotechnologies in the Clinic: Tools, Technologies and Machine Interface Applications (Chairs: Francisco Fraga, Tiago H. Falk, and Claudio Babiloni) Papers: 334-554-604-710-772-1081-1193	BMI Session #4 Deep Learning for Brain-Machine Interface (Chairs: Tim Mullen, Dongrui Wu, Yufei Huang, and Christian Kothe) Papers: 1228-591-1247-1082-1007-861-671	BMI Session #5 Recent advances in SSVEP based BCI systems (Chair: Ivan Volosyak) Papers: 409-470-582-722-797-1168 (16:15-18:15)	BMI Session #6 BMIs enabled by shared control: principles and applications (Chairs: Luca Tonin and Serafeim Perdikis) Papers: 155-330-514-515-563-942-1127-1232 (16:15-19:00)	BMI Session #7 BCI's for Immersive Environments: Augmented Reality, Virtual Reality and more (Chairs: Felix Putze, Dean Krusienski, and Sergi Bermúdez L Badia) Papers: 583-766-1211-556-1256-941 (16:15-18:15)	BMI Session #11 Multimodal Brain/Body-Machine Interfaces for "In-the-Wild" Experiments (Chairs: Mark Parent and Tiago H. Falk) Papers: 227-479-495-787-979-1259 (16:15-18:15)	BMI Session #12 Real-world applications of BCI systems (Chairs: Alexander Heiligenberger, Christoph Guger, and Ivan Volosyak) Papers: 756-454-662-411-1088-1198 (16:15-18:15)	BMI Session #13 Brain connectivity and neuronal system identification: theory and applications to brain state decoding (Chairs: Tim Mullen and Stefan Haufe) Papers: 170-439-473-852-1325 (16:15-18:15)		
18:30-19:00											Intheon Farewell Happy Hour
19:00-21:00			Hands-on BCI demo session								
24:00:00	BCI Hackathon Night Break				hackathon panel					keynote	invited speaker
	special event										
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