IEEE SMC 2017

2017 International Conference on Systems, Man, and Cybernetics

Workshop on Brain-Machine Interface Systems

October 5 - 8, 2017
Banff, Canada

Sponsored by

IEEE SMC
Systems, Man, and Cybernetics

Welcome Message from the BMI Workshop Organizers

The 2017 IEEE International Conference on Systems, Man, and Cybernetics (SMC 2017) will be held in Banff Centre in Banff, Canada—one of the most modern conference facility in North America, with majestic mountain views from every presentation room. SMC 2017 is the flagship conference of the IEEE Systems, Man, and Cybernetics Society. It provides an international forum for researchers and practitioners to report up-to-the-minute innovations and developments, summarize state-of-the-art, and 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 2017 7th Workshop on Brain-Machine Interface Systems (BMI) will be held on October 5-8, 2017 at the Banff Centre as part of the SMC 2017 program. The goal of the Workshop is to provide a forum for researchers to present research results and facilitate the interaction and intellectual exchange between all researchers, developers, and consumers of BMI technology. We invite contributions reporting the latest advances, innovations, and applications in the field of BMI.

We would like to welcome all SMC 2017 delegates who are involved or interested in learning more about the state of the art and future challenges in BMI-related topics including sensor technologies, machine learning, big data, neurorehabilitation, and standards to attend this Workshop.

The Workshop is organized by the IEEE SMC Technical Committee on Brain-Machine Interfaces Systems and is technically co-sponsored by the *IEEE Brain Initiative, IEEE Consumer Electronic Society, IEEE Computational Intelligence Society, IEEE Magnetics Society,* and the *IEEE Systems Council*. Participation is free to all registered SMC 2017 attendees.

The theme of this year's workshop, ***From Lab to Life: BMI Systems in the Coming Decade***, addresses the range and sophistication of future BMI Systems that will achieve what seems impossible today: Intelligent neuromimetic prosthetics that function as a seamless extension of the brain; biocompatible nanotechnology that reside within the brain to read and write neural states without requiring a power supply; sensorimotor and cognitive BMI systems that restore lost or compromised vision, hearing, memory, and mobility; and artificially intelligent cloud-based systems that seamlessly augment our cognitive capabilities. In the coming decade, we will see progress being made towards these goals.

Papers

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 technology. We invite contributions reporting the latest advances, innovations, and applications in the field of BMI. Also of interest will be the report and evaluation of complete systems considering aspects such as multidimensional performance metrics reflecting decoding accuracy, task performance, human factors, decoding algorithms, and feedback. These and other topics represent both challenges to the field and a tremendous opportunity for collaborative and multidisciplinary research, involving not only peers with expertise in the field of BMI but also those with expertise in systems engineering, human-machine systems, cybernetics, and/or other disciplines. The four-day Workshop will feature tutorials, panels, a brain hackathon, a number of prominent invited speakers from industry and academia, and presentations of contributed papers.

We are also pleased to have two outstanding invited speakers on Saturday, October 7, and Sunday, October 8 2017:

- Christoph Guger (CEO, g.tec Technologies)
- Paul Sajda (Chair, IEEE Brain Initiative, Columbia University)

Brain Computer Interface Hackathon

Hackathons are two-day brainstorming and collaborative marathons that create an environment supporting the rapid production of working prototypes. SMC 2017 attendees and non-SMC 2017 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 Saturday, October 7, and Sunday, October 8, 2017. There are over $7,000 in cash and hardware prizes donated by the sponsors and organizers. Register at the 2017 IEEE SMC Brain Hackathon website or email Michael Smith at m.h.smith@ieee.org if you have questions.

Another highlight of the Workshop is a special session on Standards for Brain-Machine Interfacing. As BMI systems begin to leave the laboratory and transition to the development of both consumer and clinical products, multiple challenges need to be overcome. This situation requires researchers, manufacturers, and regulatory agencies to ensure that these devices comply with well-defined criteria regarding their safety and effectiveness. The special session is organized by the "IEEE Industry Connection Group on Neurotechnologies," whose goal is to evaluate the current state of standards in this field, identify existing gaps, and promote active participation of all stakeholders, including academy, industry, and regulatory agencies. The outcome of this session will be used to prepare a vision paper on standards for neurotechnologies and recommendations on future actions (expected release date: Spring 2018).

Two tutorials are held on the afternoon of Thursday, October 5, 2017:

- Designing Brain-Computer Interfaces for Users with Motor and Cognitive Disabilities
- Brain-Machine Interface Systems—Overview, Applications, and Research Challenges

The Workshop also features two panel sessions on Friday, October 6, and Saturday, October 7, 2017 moderated by Jack Gallant (UC Berkeley):

- Merging minds and machines: Using BMI to meld human minds with AI—Science fiction or inevitable future?
- Important topics in designing and building real world BMI systems: What is new?

This year, we also have 34 contributed papers that were accepted after being carefully peer-reviewed by at least two experts and will be published in the conference proceedings. Furthermore, all papers presented at the Workshop will be eligible for the SMC Franklin V. Taylor Memorial Award and the Best Student Paper Award. Contributions will be presented in technical sessions addressing a variety of topics including:

- Machine learning and signal processing for brain and neural computer interfaces;
- Neuro-interfacing wearable robots: Current state and future steps;
- Wearable BMI technology for thought identification and other high information content applications;
- Brain-computer interfaces for users with motor and cognitive disabilities;
- Real world applications of brain computer Interface systems.

Finally, we would like to thank the organizations and individuals who worked hard in organizing this Workshop, including the organizers of the Brain Hackathon: Christoph Guger, Tiago Falk, Tim Mullen, and Margaret Thompson. We also thank the BMI Workshop and Brain Hackathon sponsors and supporters for their generous funding and support: IEEE SMC Society, IEEE Brain Initiative, g.tec, Qusp, OpenBCI, NIRx, Smartstones, Interaxon, and Thalmic Myo. These include over $7,000 in cash and hardware prizes, including $1,000 IEEE SMC Society Brain Hackathon Prize, $1,000 IEEE Brain Initiative Brain Hackathon Prize, $1,000 Qusp Prize, $1,000 BR41N.IO Prize, $1,000 OpenBCI Prize, $1,000 Smartstones Prize, a $500 NIRx prize, and hardware prizes from Interaxon and Thalmic Myo.

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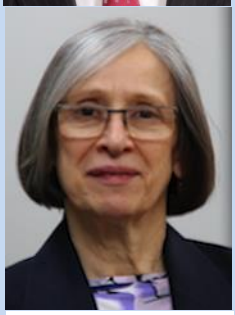

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BMI Workshop At-a-Glance

Open to all SMC2017 attendees:

Brain Hackathon – Free, all are invited to participate, $7,000+ in prizes
Saturday, October 7, 8:00 AM to 3:00 PM Sunday, October 8, Rm: MB252

IEEE Standards Meeting

Friday, October 6, 1:00-5:00 PM, Rm: MB252
Special Session on BMI Standards:
Meeting of the IEEE Industry Connection Group on Neuro-Technologies for Brain-Machine Interfacing
IEEE Standards Association

Invited Talks

Saturday, October 7, 8:30-9:15 AM Rm: MB252
Current and future brain-computer interface applications
Christoph Guger, CEO g.tec medical engineering GmbH, Austria

Saturday, October 7, 9:15-9:45 AM Rm: MB252
How to successfully run a real-time BCI application
Christoph Guger, CEO g.tec Medical Engineering GmbH, Austria

Sunday, October 8, 9:30-10:20 AM, Rm: MB252
Integrating brain-computer interface technology with augmented and virtual reality
Paul Sajda, Columbia University, USA

Panels

Friday October 6, 8:00-9:30 AM, Rm: MB252
Merging minds and machines: Using BMI to meld human minds with AI; Science fiction or inevitable future?
Moderator: Jack Gallant, UC Berkeley
Panelists: Randy Goebel, Univ. Alberta; Yingxu Wang, Univ. Calgary; Ricardo Chavarriaga, EPFL; Jianbo Lu, Ford Research

Saturday, October 7, 1:20-2:10 PM, Rm: MB252
Important topics in designing and building real world BMI systems: What is new?
Moderator: Jack Gallant, UC Berkeley
Panelists: Tiago Falk, INRS-EMT; Conor Russomanno, OpenBCI; Tom Ladd, Smartstones; Tim Mullen, Qusp; Irene Mikawoz, Natural Sciences and Engineering Research Council of Canada

Tutorials

Thursday, October 5, 8:30-11:30 AM, Rm: TBD
Designing brain-computer interfaces for users motor and cognitive disabilities
Organizers: R. Chavarriaga (EPFL, Switzerland), M. Grosse-Wentrup (MPI Tuebingen, Germany)

Thursday, October 5, 1:30-5:00 PM, Rm: TBD
Brain-machine interface systems - overview, applications and research challenges
Organizers: N. Robinson, K. Thomas (NTU, Singapore)

Special Sessions

See SMC2017 program guide for dates, times

Machine learning and signal processing for brain and neural computer interfaces
Organizer: Dongrui Wu (DataNova, USA), R. Chavarriaga (EPFL, Switzerland)

Neuro-interfacing wearable robots: Current state and future steps
Organizer: Jose L. Contreras-Vidal (U. Houston, USA), J. M. Azorin (Miguel Hernández University, Spain)

Wearable BMI Technology for thought identification and other high information content
Applications. Organizer: J. Libove (Furaxa Inc., USA)

Brain-computer interfaces for users with motor and cognitive disabilities
Organizers: R. Chavarriaga (EPFL, Switzerland), M. Grosse-Wentrup (MPI Tuebingen, Germany)

Real world applications of brain computer interface systems
Organizer: V.A. Prasad, S. Kavallur (NTU, Singapore)

You can still register for the free Brain Hackathon at SMC 2017 (if space is available). Email Michael Smith at m.h.smith@ieee.org, or register at room Max Bell MB 252 on Friday and Saturday at 8 AM. (Further details are available in the **Brain Computer Interface Hackathon 2017** section.)

	Saturday October 7	**Sunday October 8**
8:00-8:30 AM	Michael H. Smith Welcome Remarks, **Why IEEE Brain Hackathons?** Tiago Falk: **Welcome to the 1st Canadian Brain Hackathon** Christoph Guger: Logistic information	Hacking
8:30-9:15 AM	**Current and Future Applications of Brain-Computer Interfaces** Christoph Guger, g.tec	Hacking
	9:15-9:45 AM **How to Run a Real-Time BCI Application Successfully** Christoph Guger, g,tec	9:30-10:20 AM **Integrating Brain-Computer Interface Technology with Augmented and Virtual Reality** Paul Sajda, Columbia University
9:45-1:00 PM	Hacker Groups, Mentoring, Hacking	Hacking, Project Presentation Preparations
1:20-2:10 PM	BCI Panel (same room): **Important Topics in Designing and Building Real World BMI Systems: What is New?** Moderator: Jack Galant, UC Berkeley	Hackathon Project Presentations
2:10-6:00 PM	Hacking	Hackathon Project Presentation, Jury Meeting, Closing SMC Ceremony, Hackathon Awards
6:00 PM-2:00 AM	Hacking and Pizzas	

Meeting of the IEEE Industry Connection Group on Neuro-Technologies for Brain-Machine Interfacing
Special Session on BMI-related Standards
SMC 2017 BMI Workshop

Friday, October 6th, 2017, 13:00 – 17:00

Max Bell Building MB 252, Banff Center, Canada

Increased attention to Neuro-Technologies has triggered great expectations on the benefit they can bring both in consumer applications. Research on brain-machine interfaces starts to leave the laboratory and efforts are put on transitioning to the development of both consumer and clinical products. This transition entails multiple challenges since it requires researchers, manufacturers, and regulatory agencies to ensure these devices comply with well-defined criteria on their safety and effectiveness.

The IEEE Industry Connections Activity on Neuro Technologies for Brain-Machine Interfacing was established in May 2017 to evaluate the current state of standards in this field, identify existing gaps and promote active participation of all stakeholders. It currently gathers more than 30 people from academy, industry and regulatory agencies who are preparing a Standards Vision Paper on these technologies. As part of its activities, this session will provide a space for discussing how standardization of neurotechnologies is needed to successfully translate the current developments into systems that can really benefit their intended users. Topics to be discussed include:

- What are the biggest challenges in the standardization of neurotechnologies?
- Should there be a separate set of standards for clinical and non-clinical applications? Can standards help to leverage the dynamism of consumer application development to accelerate the clinical translation?
- As neurotechnologies tend to involve multiple components (exoskeletons, AR/VR headsets, neural interfaces).
- How to ensure reliable, safe interoperability in complex, heterogeneous systems.

This session is part of the SMC 2017 BMI Workshop and will be composed of short presentations and panels with different stakeholders from the private, academic, and regulatory sectors. Ample time has been reserved for discussions with contributions from the attendants, including breakout discussion sessions on standards gaps for clinical and nonclinical BMI applications.

The outcome of this session will be used to prepare a vision paper on standards for neurotechnologies and recommendations on future actions (expected release date: Spring 2018).

Contacts:

Ricardo Chavarriaga <ricardo.chavarriaga@epfl.ch>, Bill Ash <w.ash@ieee.org>, Carole Carey c.carey@ieee.org

Note: Attendants should be attentive that there will be different sitting times for lunch. Given the timing of the session, attendants should have lunch during the 11:30-12:25 sitting.

Workshop on Brain-Machine Interface Systems 2017

Invited Speakers

Christoph Guger
BR41N.io series organizer
CEO g.tec medical engineering GmbH, Austria

Paul Sajda
Chair, IEEE Brain initiative
Columbia University, USA

Invited Talks

Current and future brain-computer interface applications
Christoph Guger, CEO g.tec medical engineering GmbH, Austria
Saturday, October 7, 8:30-9:15 AM

EEG-based BCIs can utilize different approaches, such as: (i) transient evoked potentials (like the N200 or P300), (ii) steady-state evoked potentials (visual or somatosensory) or (iii) motor imagery. P300 BCIs are often used for spelling applications, and were tested with locked-in patients in several studies. These systems typically flash different characters on the screen. By silently counting each time a target character flashes, users can produce a P300 to target flashes only, and the BCI can use this signal to infer user intent. Group studies showed classification accuracies of about 90 % for 81 subjects with a black and white speller, and the newer face speller has led to accuracy as high as 100 % for 17 subjects. P300 BCIs based on auditory or vibrotactile stimuli have also been validated. Both auditory and vibrotactile P300 BCIs typically have a smaller vocabulary and lower accuracy than their visual counterparts. However, they can help patients who cannot see, and vibrotactile BCIs can be used in loud environments. Motor imagery BCIs usually instruct the user to imagine a left hand or right-hand movement to produce event-related (de)synchronization (ERD/S) in the alpha and beta frequency ranges over the sensorimotor cortex. In a group study, 20 healthy people attained a mean accuracy of 80.7% after 20 minutes of training.

For BCI usage, it is important to calibrate the system on each individual person. This is done within 5 minutes. Afterwards the user can already control an application in real-time. An important aspect of BCI usage is that EEG electrodes are fixed over the corresponding brain regions to allow high quality EEG control. The talk will highlight important current and future BCI applications like stroke motor rehabilitation, assessment of brain functions, communication with locked-in patients and patients with disorders of consciousness or functional mapping of the eloquent cortex with high-gamma activity. High-gamma activity can also be used to control an avatar or robotic devices in real-time.

Dr. Christoph Guger studied biomedical engineering at the University of Technology Graz and Johns Hopkins University in Baltimore, USA. He then carried out research work at the Department of Medical Informatics (Prof. Pfurtscheller) at the University of Technology Graz and received his PhD degree in 1999. The topic of his PhD work was the design of an EEG-based brain-computer interface. This was the first real-time BCI system with continuous feedback. He also developed the real-time analysis with common spatial patterns, which is still the

fastest and most accurate approach for oscillatory BCIs, and also developed a P300 BCI with very high accuracy and speed. In recent years, he also worked with a wide variety of patients in different countries. Currently the BCI technology is used for the rehabilitation of stroke patients, for assessment and communication with locked-in patients or patients with disorders of consciousness, functional mapping of neurosurgical procedures, for control of avatars and drones. Currently, he is active in about 10 international research projects and is running g.tec medical engineering GmbH in Austria, Spain and the USA.

How to run a real-time BCI application successfully
Christoph Guger, CEO g.tec Medical Engineering GmbH, Austria
Saturday, October 7, 9:15-9:45 AM

Brain-computer interfaces are realized with the non-invasive Electroencephalogram (EEG) or invasive Electrocorticogram (ECoG) recordings. The systems are controlled with (i) evoked potentials, (ii) motor imagery or (iii) steady-state evoked potentials in real-time. Recently stroke rehabilitation with motor imagery BCIs became one of the most important applications to provide a therapy concept in the acute, sub-acute and chronic phase after stroke. Motor imagery and P300 concepts are also used for the assessment of patients with disorders of consciousness (DOC) and to provide a communication channel for DOC and locked-in patients. Beside these medical applications avatar, drone and robot control are important contributions to the field. The talk will highlight current research trends of large EC based research projects and will explain recent results of BCI Hackathons.

Dr. Christoph Guger studied biomedical engineering at the University of Technology Graz and Johns Hopkins University in Baltimore, USA. He then carried out research work at the Department of Medical Informatics (Prof. Pfurtscheller) at the University of Technology Graz and received his PhD degree in 1999. The topic of his PhD work was the design of an EEG-based brain-computer interface. This was the first real-time BCI system with continuous feedback. He also developed the real-time analysis with common spatial patterns, which is still the fastest and most accurate approach for oscillatory BCIs, and developed a P300 BCI with very high accuracy and speed. In recent years, he also worked with a wide variety of patients in different countries. Currently the BCI technology is used for the rehabilitation of stroke patients, for assessment and communication with locked-in patients or patients with disorders of consciousness, functional mapping of neurosurgical procedures, for control of avatars and drones. Currently, he is active in about 10 international research projects and is running g.tec medical engineering GmbH in Austria, Spain and the USA.

Integrating brain-computer interface technology with augmented and virtual reality
Paul Sajda, Columbia University, USA
Sunday, October 8, 9:30-10:20 AM

Augmented and Virtual Reality (AR/VR) are platforms that offer the potential to revolutionize how we interact with media, enabling new forms of experiences in real and/or virtual environments. Brain computer interfaces (BCIs) are new technologies under development to enable direct communication between brain and machine. The integration of BCI with AR/VR offers new opportunities and products for the consumer. It also offers new ways for neuroscientists to understand how the human brain processes information in naturalistic and interactive experiences. In this talk, I will describe our work integrating BCI and AR/VR to opportunistically sense neural and physiological signals for labeling information in a VR environment, using this labeling to optimize navigation through a virtual world. I will also discuss how arousal and workload can be tracked using a BCI in a VR-based flight simulation task, showing how neurofeedback can be used to optimize user performance in terms of flight time for this game-like application.

Paul Sajda is a Professor of Biomedical Engineering, Electrical Engineering and Radiology (Physics) at Columbia University. He is also a Member of Columbia's Data Science Institute. He received a BS in electrical engineering from MIT in 1989 and an MSE and PhD in bioengineering from the University of Pennsylvania, in 1992 and 1994, respectively. Professor Sajda is interested in what happens in our brains when we make a rapid decision and, conversely, what processes and representations in our brains drive our underlying preferences and choices,

particularly when we are under time pressure. His work in understanding the basic principles of rapid decision-making in the human brain relies on measuring human subject behavior simultaneously with cognitive and physiological state. Important in his approach is his use of machine learning and data analytics to fuse these measurements for predicting behavior and infer brain responses to stimuli. Professor Sajda applies the basic principles he uncovers to construct real-time brain-computer interfaces that are aimed at improving interactions between humans and machines. He is also applying his methodology to understand how deficits in rapid decision-making may underlie and be diagnostic of many types of psychiatric diseases and mental illnesses. Professor Sajda is a co-founder of several neurotechnology companies and works closely with a range of scientists and engineers, including neuroscientists, psychologists, computer scientists, and clinicians. He is a Fellow of the IEEE, AMBIE and AAAS, and is Editor-in-Chief of *IEEE Transactions on Neural Systems and Rehabilitation* and Chair of the IEEE Brain Initiative.

Panels

Friday, October 6, 8:00-9:30 AM MB252
BMI Panel: **Merging Minds and Machines: Using BMI to Meld Human Minds with AI; Science Fiction or Inevitable Future?**
Moderator: Jack Gallant, UC Berkeley
Panelists: Randy Goebel, Univ. Alberta; Yingxu Wang, Univ. Calgary; Ricardo Chavarriaga, EPFL; Jianbo Lu, Ford Research

Recent advances in AI have spurred efforts to develop a new generation of more powerful invasive or non-invasive BMIs that would enable seamless brain-to-machine communication. This panel will discuss all aspects of these efforts, including: What are the obstacles to creating a seamless interface between mind and machine? Can AI improve the performance of BMIs? Can BMIs improve the performance of AI? How can AI be used to improve the performance of BMIs? What will emerge out of the melding of mind and machine? What privacy concerns should we be aware of and how should we address them? Are there other risks of merging mind and machine?

Saturday, October 7, 1:20-2:10 PM MB252
BMI Panel: **Important Topics in Designing and Building Real World BMI Systems: What is New?**
Moderator: Jack Gallant, UC Berkeley
Panelists: Tiago Falk, INRS-EMT; Conor Russomanno, OpenBCI; Tom Ladd, Smartstones; Tim Mullen, Qusp; Irene Mikawoz, Natural Sciences and Engineering Research Council of Canada

The goal of the Brain-Machine Interface (BMI) panel is to hear about the current challenges and hot topics in BMI research from experts on the funding, design, and use of Brain-Machine Interface/Brain-Computer Interface (BMI/BCI) systems. By identifying the challenges confronting the successful clinical translation and commercial application of BMI/BCI systems in real-world situations, this panel should identify some opportunities for Systems, Man, and Cybernetics and other efforts to dramatically improve BMI/BCI system performance and benefits for the patients and/or users.

Tutorials

Designing brain-computer interfaces for users motor and cognitive disabilities
Organizers: R. Chavarriaga (EPFL, Switzerland), M. Grosse-Wentrup (MPI Tuebingen, Germany)
Thursday, October 5, 8:30-11:30 AM

One of the main motivations for BCI is to provide assistive technologies for users with sever motor disabilities. Nevertheless, most studies are currently performed with control subjects and their results translate poorly to the target population. Critically, the field lacks knowledge and methods to solve this issue. This tutorial will present state-of-the-art research oriented to advance this field and contribute to overcome this roadblock. Given the characteristics of the intended users, designing reliable systems requires careful evaluation of their requirements and capacities. Proper combination of machine learning techniques, methods for human-machine interaction, and adaptive processes are necessary to adequately suit the developed systems. This tutorial will provide SMC attendees –both novice and with previous BMI expertise- with important tools to deploy and test their systems outside the research laboratories and get them closer to practical applications.

Brain-machine interface systems - overview, applications and research challenges
Organizers: N. Robinson, K. Thomas (NTU, Singapore)
Thursday, October 5, 13:30-17:00 PM

Brain-Machine Interfaces are systems that translate the user's intention coded by brain activity measures into a control signal without using activity of any muscles or peripheral nerves. These control signals can potentially be employed to substitute motor capabilities (e.g. brain-controlled prosthetics for amputees or patients with spinal cord injuries, brain-controlled wheel chair); to help in the restoration of such functions (e.g. as a tool for stroke rehabilitation), to enable alternative communication (e.g. virtual keyboard, speller etc.) for those who are disabled or otherwise unable to communicate, and other applications such as serious games for enhancing cognition skills. This tutorial will provide an overview of Brain-Machine Interface (BMI), real-world applications, methods for brain signal acquisition and their comparison, relevant Electroencephalogram (EEG) signal features for BMI and signal processing & machine learning tools for BMI. Further, the talk will cover research challenges and developments in this BMI. Further, some selected non-invasive BMI research work from our group on decoding arm movement kinematics and motor control as well as biometric identification will also be presented. The tutorial will conclude highlighting potential future BMI research topics.

Special Sessions

See SMC2017 program guide for dates and times.

- Machine learning and signal processing for brain and neural computer interfaces. Organizer: Dongrui Wu (DataNova, USA), R. Chavarriaga (EPFL, Switzerland)
    - Session I: October 5, 13:20-15:00. Session ID: KC205f
    - Session II: October 5, 15:15-17:00. Session ID: 5KC205f
    - Session III: October 7, 8:00- 10:00. Session ID: 7MB251m
- Neuro-Interfacing Wearable Robots: Current State and Future Steps. Organizer: Jose L. Contreras-Vidal (U. Houston, USA), J. M. Azorin (Miguel Hernández University, Spain)
    - Session I: October 7, 15:15-15:45. Session ID: 7KC101-3f
    - Session II: October 8, 8:00-10:20. Session ID: KC101-3-5m
- Wearable BMI Technology for Thought Identification and other High Information Content Applications. Organizer: J. Libove (Furaxa Inc., USA)
    - Session I: October 7, 15:45-17:00. Session ID: 7KC101-3f
- Brain-computer interfaces for users with motor and cognitive disabilities. Organizers: R. Chavarriaga (EPFL, Switzerland), M. Grosse-Wentrup (MPI Tuebingen, Germany)
    - October 7, 13:20- 15:00. Session ID: 7MB251f
- Real world applications of Brain Computer Interface systems. Organizer: V. A. Prasad, S. Kavallur (NTU, Singapore)
    - October 7, 15:15-17:00. Session ID: 7MB251f

IEEE SMC Society BMI Technical Committee

You are welcome to join SMCS Technical Committee on Brain-Machine Interface Systems. You do not have to be a SMC Society member to join our TC, although we do encourage you to become one in order to benefit from a wide range of professional activities and privileges.

To join SMC's BMI TC, contact via e-mail a BMI TC Co-Chair and provide your name, title, position, affiliation, and a self-introduction.

We hope you will enhance your professional skills and potential through your activities in our Technical Committee.

Our Goal

Brain-Machine Interfaces (BMI) are about transforming thought into action, or, conversely, sensation into perception. One example of this paradigm contends that a user can perceive sensory information and enact voluntary motor actions through a direct interface between the brain and a prosthetic device in virtually the same way that we see, hear, walk, or grab an object with our own natural limbs.

The primary objective of the BMI Systems Technical Committee is to bring together specialists from the different areas that will be required as part of any real-world BMI system: systems neuroscience, system integration, sensors, integrated circuits, machine learning, control, robotics, biology, clinical studies, neurologists, system engineers, cybernetic experts, human-machine professionals, and other computer scientists and engineers working in this interdisciplinary environment. The goal of the TC is to provide a basis for the exchange of information and resources among these diverse communities, to enable interactions between groups from these fields and to bring a systems perspective to the field of BMI.

Join Us

- Interact with experts in Brain Machine Interface Systems, which is a relatively new and rapidly growing research field. Both invasive and non-invasive techniques (BCI) for interfacing the brain are included.
- Participate in interesting conferences and workshops.
- Make friends from different regions of the world.
- Exchange research ideas and possibly share research resources.

Additional Information:

http://www.ieeesmc.org/technical-activities/human-machine-systems/brain-machine-interface-systems

IEEE SMC BMI Hackathon Banff

Banff Centre of Arts and Creativity

Max Bell Building Room MB 252

October 7-8, 2017

What's a Hackathon? 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, 36, 48 or more hours to cram and build solutions that they can present.

Why do a Brain Hackathon? 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.

Who Can Participate? Anyone! Both SMC2017 attendees and non-SMC2017 attendees—including university students and professors—with interests in BCI/BMI, cloud technologies, IoT, robotics, AR, VR, machine learning, sensors, 3D printing and design, human-machine interface systems, control, signal processing, big data, haptics, rehabilitation, and similar areas. 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.

How do I Participate? You can register here.

Can I submit a different project? Professional teams can also participate to develop applications during the Hackathon to demonstrate full potential of some of the sponsored hardware/software. If you are looking for team members, your project will be included in the table plan below where people can apply for it. Submit your project to m.h.smith@ieee.org.

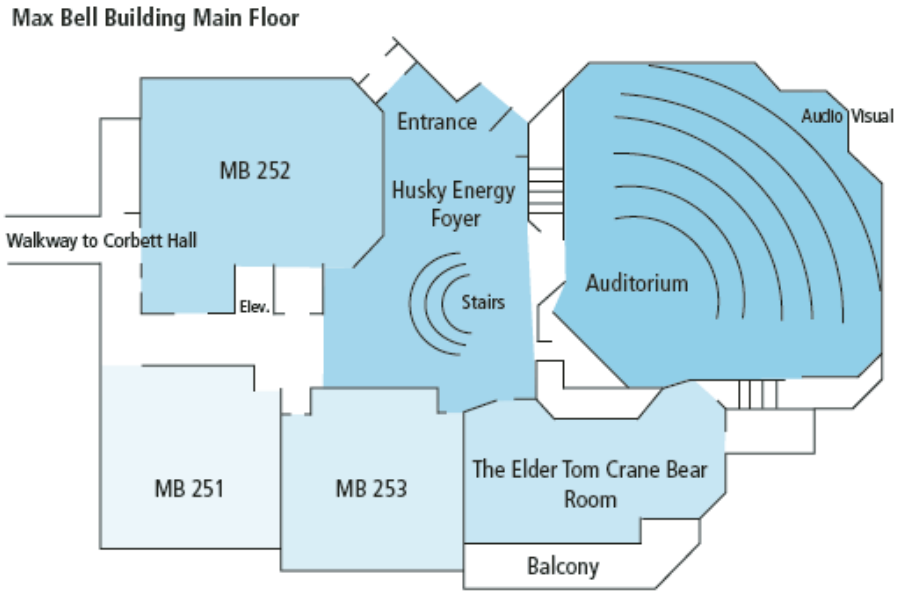
Partnerships: Participants can additionally select from a range of pre-defined Hackathon projects supported by the BR41N.IO Brain-Computer Interface designer Hackathon series. Designers will be able to 3D-print their own headsets and design BCI systems, and—together with programmers—create new BCI systems.

Click here for more details on the Brain Hackathon.

General Information

Date	October 7-8, 2017
Cost	Free
Place	Banff Centre for Arts and Creativity 107 Tunnel Mountain Drive Banff, Alberta, Canada T1L 1H5 Telephone: 403-762-6100
Registration	Click here to access the registration page. We highly encourage participants to register for the IEEE SMC BMI Workshop
Participants	• Teams of up to five persons • Maximum participants: 200 individuals/40 teams • IEEE members will be given priority
Scope	• Integration of neurotechnology with Collaborative (multi-person) Brain-Computer Interfaces (BCIs) • BCI integration with games, mobile technologies, and Virtual/Augmented Reality (VR/AR) • Active BCI control of robotic devices • Design 3D printed headsets; combine BCIs with fashion technology and artistic application (in partnership with BR41N.IO)
Hardware/Software:	A list of available hardware and software (as per the Scope section above) will soon be posted on the 2017 IEEE SMC Brain Hackathon website. Participants are also encouraged to bring their own hardware.
Awards	Over $7,000 in cash and hardware prizes, including a $1,000 IEEE Brain Initiative Brain Hackathon Prize, a $1,000 IEEE SMC Brain Hackathon Prize, a $1,000 Qusp Prize, a $1,000 BR41N.IO Prize, a $1,000 OpenBCI Prize, a $1,000 Smartstones Prize, a $500 NIRx prize, and hardware prizes from Interaxon and Thalmic Myo.
Technical Co-Sponsors	**Institutions**: IEEE, IEEE SMC Society, IEEE Brain Initiative, IEEE Computational Intelligence Society, IEEE Magnetics Society, IEEE Consumer Electronics Society, IEEE Systems Council **Partners**: BR41N.IO Brain-Computer Interface designer Hackathon series **Industry** **Volunteers**: g.tec medical engineering GmbH, Qusp Labs

The Max Bell Building



For additional information or questions about the Hackathon, please contact:

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Michael H. Smith Senior Advisor, IEEE Brain Initiative Past President, IEEE SMC Society Chair 2017 IEEE SMC BMI Workshop m.h.smith@ieee.org	Or visit: http://www.br41n.io/Banff-2017

Papers and BMI Workshop Schedule

IEEE SMC 2017 HMS-BMI oral sessions (subject to minor refinement as necessary)			
Date	**Session**		**Session Chair, Co-Chair**
05-Oct	**8:30-11:30**	**Tutorial: Designing Brain-Computer Interfaces for Users Motor and Cognitive Disabilities**	**R. Chavarriaga, M. Grosse-Wentrup**
05-Oct	**13:30-17:00**	**Tutorial: Brain-Machine Interface Systems - Overview, Applications and Research Challenges**	**N. Robinson, K. Thomas**
05-Oct	**5KC205f 13:20-15:00**	**Machine Learning and Signal Processing for Brain and Neural Computer Interfaces I**	**Dongrui Wu, R. Chavarriaga**
20min	927	Brain Dynamic States Analysis Based on 3D Convolutional Neural Network	
		Yu Chia Hung, Chun-Hsiung Chuang, Yu-Kai Wang*, Mukesh Prasad, Chin-Teng Lin (Australia)	
20min	684	Single trial P300 identification for an auditory BCI: implementation of a 3D input for convolutional neural networks	
		Eduardo Carabez*, Miho Sugi, Isao Nambu, Yasuhiro Wada (Japan)	
20min	1007	Deep Learning-Based Classification for Brain-Computer Interfaces	
		John Thomas*, Tomasz Maszczyk, Sinha Nishant, Kluge Tilmann, Justin Dauwels (Singapore)	
20min	691	Driver's Fatigue Prediction by Deep Covariance Learning from EEG	
		Mehdi Hajinoroozi, Zhang Michelle, Yufei Huang* (USA)	
05-Oct	**5KC205f 15:15-17:00**	**Machine Learning and Signal Processing for Brain and Neural Computer Interfaces II**	**Yu Chia Hung, R. Chavarriaga**
20min	557	Active Semi-Supervised Transfer Learning (ASTL) for Offline BCI Calibration	
		Dongrui Wu* (USA)	
20min	1194	Informative instance transfer learning with subject specific frequency responses for motor imagery Brain Computer Interface	
		Ibrahim Hossain*, Saeid Nahavandi (Australia)	
20min	645	Inverse Solutions for Brain-Computer Interfaces: Effects of Regularisation on Localisation and Classification	
		Mohit Kumar Goel, Ricardo Chavarriaga*, José Millán (Switzerland)	
20min	360	Binary Classification of Hand Movement Directions from EEG Using Wavelet Phase-Locking	
		Tushar Chouhan*, Robinson Neethu, Vinod Achutavarrier Prasad, Kai Keng Ang (Singapore)	
20min	347	Frequency Filter Networks for EEG-Based Recognition	
		Miku Yanagimoto*, Chika Sugimoto, Tomoharu Nagao (Japan)	

06-Oct	**6MB252m 8:00- 9:30**	**BMI Panel: Merging minds and machines: Using BMI to meld human minds with AI; Science fiction or inevitable future?, Moderator: Jack Gallant, UC Berkeley**	**Michael Smith, Ljiljana Trajkovic**
06-Oct	**6MB252f 13:00- 17:00**	**IEEE Standards Meeting: Meeting of the IEEE Industry Connection Group on Neuro-Technologies for Brain-Machine Interfacing**	**R. Chavarriaga, Bill Ash**
07-Oct-08-Oct	**MB252 8:00 Oct 7- 15:00 Oct 8**	**Free Brain Hackathon, Over $7,000 in prizes**	**Chrtistoph Guger, Tiago Falk, Tim Mullen**
07-Oct	**MB252 8:30-9:15**	**Invited Speaker: Current and future applications of Brain-Computer Interfaces, Christoph Guger, g.tec**	**Michael Smith, Stuart Mason Dambrot**
07-Oct	**MB252 9:15-9:45**	**Invited Speaker: How to run a real-time BCI application successfully, Christoph Guger, g,tec**	**Michael Smith, Tiago Falk**
07-Oct	**MB252 1:20-2:10**	**BMI Panel: Important topics in designing and building real world BMI systems: What is new? Moderator: Jack Gallant, UC Berkeley**	**Michael Smith, Ljiljana Trajkovic**
07-Oct	**7MB251m 8:00- 10:00**	**Machine Learning and Signal Processing for Brain and Neural Computer Interfaces III**	**Kavitha Thomas, Smitha Kavallur**
20min	958	Self-Paced Training on Motor Imagery-Based BCI for Minimal Calibration	
		Time Seon-Min Kim, Min-Ho Lee, Seong-Whan Lee* (Korea, South)	
20min	1050	EEG-Based Motor Imagery Classification Using Subject-Specific Spatio-Spectral Features	
		Kavitha Thomas*, Robinson Neethu, Vinod Achutavarrier Prasad (Singapore)	
20min	964	Comparison of Alpha/Beta and High-Gamma Band for Motor-Imagery Based BCI Control	
		Johannes Gruenwald, Christoph Kapeller, Christoph Guger, Hiroshi Ogawa, Kyousuke Kamada, Josef Scharinger	
20min	949	Investigation of the Phase Feature of Low-Frequency Electroencephalography Signals for Decoding Hand Movement Parameters	
		Yuanzi Sun, Hong Zeng*, Aiguo Song, Baoguo Xu, Huijun Li, Jia Liu, Pengcheng Wen (China)	
20min	1051	Canonical Correlation Analysis of EEG for Classification of Motor Imagery	
		Robinson Neethu*, Kavitha Thomas, Vinod Achutavarrier Prasad (Singapore)	
20min	900	Effects of Transcranial Direct Current Stimulation on the Motor-Imagery Brain-Computer Interface for Stroke Recovery: An EEG Source-Space Study	

		Vikram Shenoy Handiru*, Vinod Achutavarrier Prasad, Kai Keng Ang, Effie Chew, Cuntai Guan (Singapore)	
07-Oct	**7MB251f 13:20-15:00**	**Brain-Computer Interfaces for Users with Motor and Cognitive Disabilities**	**Brendan Allison, Mathias Hohmann**
20min	1011	Mindbeagle – a New System for the Assessment and Communication with Patients with Disorders of Consciousness and Complete Locked-In Syndrom	
		Christoph Guger, Brendan Allison, Andrea Kammerhofer, Florian Guttmann, Tim Von Oertzen, Rossella Spataro, Vincenzo La Bella, Jitka Annen, Steven Laureys, Alexander Heilinger*, Rupert Ortner, Woosang Cho (Austria)	
20min	747	Characterization of Cortical Motor Function and Imagery-Related Cortical Activity: Potential Application for Prehabilitation	
		Milena Korostenskaja, Christoph Kapeller, Ki Hyeong Lee, Christoph Guger, James Baumgartner, Eduardo Martinez Castillo	
20min	735	Prediction of Individual Finger Movements for Motor Execution and Imagery: An EEG Study	
		Tetsuro Hayashi*, Hiroshi Yokoyama, Isao Nambu, Yasuhiro Wada (Japan)	
20min	504	Personalized Brain-Computer Interface Models for Motor Rehabilitation	
		Anastasia-Atalanti Mastakouri*, Sebastian Weichwald, Ozan Özdenizci, Timm Meyer, Bernhard Schölkopf, Moritz Grosse-Wentrup (Germany)	
07-Oct	**7KC101-3f 15:15-17:00**	**Neuro-Interfacing Wearable Robots: Current State and Future Steps**	**Joel Libove, Neethu Robinson**
20min	720	Adaptive Multimodal Biosignal Control for Exoskeleton Supported Stroke Rehabilitation	
		Anett Seeland*, Marc Tabie, Su-Kyoung Kim, Frank Kirchner, Elsa Andrea Kirchner (Germany)	
20min	1047	Cortical Features of Locomotion-Mode Transitions via Non-invasive EEG	
		Trieu Phat Luu*, Justin Brantley, Fangshi Zhu, Jose Contreras-Vidal (USA)	
20min	409	The Physiological Influence of Alternating Current Electromagnetic Field Exposure on Human Subjects	
		Hideyuki Okano*, Hiromi Ishiwatari, Akikatsu Fujimura, Keiichi Watanuki (Japan)	
20min	796	Picosecond Pulse Imaging – Uniquely Promising but Challenging Modality for a Wearable BMI	
		Joel Libove*, David Schriebman, Mike Ingle (USA)	
20min	1116	A Two-Target Paradigm for an Auditory Brain-Computer Interface: A Preliminary Study	
		Miho Sugi, Isao Nambu*, Yasuhiro Wada (Japan)	
07-Oct	**7MB251f 15:15-17:00**	**Real World Applications of Brain Computer Interface Systems**	**Dongrui Wu, Stuart Mason Dambrot**

20min	1120	Mobile EEG-Based Situation Awareness Recognition for Air Traffic Controllers	
		Lee Guan Yeo, Haoqi Sun, Yisi Liu*, Fitri Trapsilawati, Olga Sourina, Chun-Hsien Chen, Karl Wolfgang Mueller-wittig, Wei Tech Ang (Singapore)	
20min	400	Classifying Subjective Emotional Stress Response Evoked by Multitasking Using EEG	
		Smitha Kavallur, Yu Xin Ng, Sze Lian Seah, Robinson Neethu	
20min	1209	EEG-Based Auditory Attention Decoding: Impact of Reverberation, Noise and Interference Reduction	
		Ali Aroudi*, Simon Doclo (Germany)	
20min	185	EEG-Based Biometric Authentication Using Self-Referential Visual Stimuli	
		Ericsen Ericsen, Kavitha Thomas*, Vinod Achutavarrier Prasad (Singapore)	
20min	434	EEG-Based Brain-Computer Interface to a Virtual Walking Avatar Engages Cortical Adaptation	
		Trieu Phat Luu*, Yongtian He, Sho Nakagome, Jose Contreras-Vidal (USA)	
08-Oct	**MB252 9:30-10:20**	**Invited Speaker: Integrating brain-computer interface technology with augmented and virtual reality**, Paul Sajda, Columbia University	**Michael Smith, Ljiljana Trajkovic**
08-Oct	**KC101-3-5m 8:00-10:20**	**Neuro-Interfacing Wearable Robots: Current State and Future Steps**	**Chamika Janith Perera, Trieu Phat Luu**
20min	1226	EMG Signal Controlled Transhumeral Prosthetic with EEG-SSVEP Based Approach for Hand Open/Close	
		Ruhunage Isuru*, Chamika Janith Perera, Kalinga Nisal, Madhuranga Janaka Subodha, Thilina Dulantha Lalitharatne (Sri Lanka)	
20min	435	Prediction of EMG Envelopes of Multiple Terrains Over-Ground Walking from EEG Signals Using an Unscented Kalman Filter	
		Sho Nakagome*, Trieu Phat Luu, Justin Brantley, Jose Contreras-Vidal (USA)	
20min	863	Electroencephalography-Guided Upper-Limb Hybrid Robotic Platform to Modulate Cortical Excitability	
		Francisco Resquín Resquín*, Oscar Herrero, Jaime Ibañez Pereda, Jose Gonzalez-Vargas, Fernando Brunetti, José Luis Pons (Spain)	
20min	1174	Model Predictive Control for a Brain-Controlled Mobile Robot	
		Fujian He, Luzheng Bi*, Hongqi Li, Yun Lu, Ling Wang (China)	
20min	652	Building Cognitive Knowledge Bases Sharable by Humans and Cognitive Robots	
		Yingxu Wang* (Canada)	