TwinBrain WORKSHOP 2.0:
MOBILE BRAIN/BODY IMAGING (MOBI) FROM THEORY TO CLINICAL PRACTICE

Key information:

When? 30 June - 2 July 2022

Where? Koper, Slovenia / Online

Who? Students (Masters and PhD), and post docs from the field of kinesiology and movement science, physiotherapy, psychology, cognitive (neuro)science, biomedical engineering and related disciplines.

What? Vertical knowledge for successful implementation of MoBI research – from laboratory to clinical practice.

Pre-requirements? Registration online (free)

Website: www.twinbrain.si

Registration form (deadline 20 June 2022): https://forms.gle/ubyuGzJVVBvdBZKE6

PROGRAMME AND LEARNING OBJECTIVES

DAY 1 (30.6.2022): Biomechanics of human movement (module leader: Uroš Marušič; moderators: Klaus Gramann, Paolo Manganotti; Uroš Marušič)

Speakers: Uroš Marušič, Andrej Olenšek, Andreas Argubi-Wollesen, Erik Bakke.

Speaker 1: Dr. Uroš Marušič (Science and research centre Koper, Slovenia)

Short CV: Uros Marusic is employed at the Science and Research Centre Koper and Alma Mater Europaea University (Slovenia). He graduated from the Faculty of Electrical Engineering, University of Ljubljana, from the department of Cybernetics in Medicine – Biomedical Engineering (2011) and acquired a PhD degree in the study program Applied Kinesiology of the University of Primorska (2015). Uros Marusic is an Associate Professor of Kinesiology, and his research is focused on neuromuscular efficiency of movement, using Mobile Brain/Body Imaging (MoBI). In 2017 he was a visiting research fellow at the University of Michigan (Michigan) and the Albert

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Einstein College of Medicine (NYC). In 2018 he returned as research fellow at the University of Michigan's Functional Neuroimaging, Cognitive and Mobility Laboratory (dr. Nicolaas Bohnen). Since November 2020, he has been leading the international Horizon 2020 project entitled TwinBrain (TWINning the BRAIN with machine learning for neuro-muscular efficiency), worth €0.9 million, funded by the European Commission (ID 952401).

Title: *Mobile Brain/Body Imaging (MoBI) from theory to clinical practice*

Learning goals: In this introductory lecture will demonstrate the necessity to link biomechanics and neurophysiology to be able to holistically understand the human locomotion. Examples from normal as well as pathological gait will be provided with recent applications of MoBI technology in the clinical settings.

Speaker 2: Dr. Andrej Olenšek (University Rehabilitation Institute, Republic of Slovenia)

Short CV: Andrej Olenšek received the B.Sc. and Ph.D. degrees in electrical engineering from the University of Ljubljana, Slovenia, in 2003 and 2008, respectively. He is currently a Research Associate in the Research and Development Unit at the University Rehabilitation Institute, Ljubljana, Slovenia. He is also an assistant professor at the Faculty of Health Sciences, University of Ljubljana, Slovenia. His research interests include human motion analysis and synthesis, gait biomechanics, rehabilitation robotics and human–robot interaction.

Title 1: *Biomechanics of human gait*

Title 2: *Clinical gait analysis – case studies*

Learning goals: In this lecture we are going to focus on elementary mechanisms of human gait. We are going to present the main components of 3D gait analysis and the available instrumentation to measure each component and explain how typical 3D gait measurement is carried out in gait lab. Further we are going to show how 3D gait data are analysed and presented to support decision making process in clinical practice. We are going to consider situations in which gait analysis would typically by considered as an analysis tool. Finally, we are going to demonstrate the application of basic concepts of gait analysis in selected clinical cases.

Speaker 3: Dr. Andreas Argubi-Wollesen (exoIQ GmbH, Hamburg, Germany)

Short CV: Dr. Andreas Argubi-Wollesen studied Human Movement Science in Hamburg, Germany. He specialized in gait analysis and the biomechanical analysis of industrial working tasks using 3D-kinematics, EMG and various other methods. Since 2015 he works in the field of developing occupational exoskeletons and the biomechanical analysis of their use. He currently serves as a biomechanical researcher at the R&D department of exoIQ GmBH, a leading developer of active occupational exoskeletons.

Title: *Kinematic analysis of repetitive movements*

Learning goals:

- The role of occupational exoskeletons in working environments
- Biomechanical analysis of exoskeletons in workplace scenarios

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- The combination of kinematics, electromyography and posturometry in biomechanical analysis
- Data extraction of cyclic motions using Matlab
- Search for statistical differences in kinematic trajectories and corresponding muscular activities using statistical parametric mapping

Speaker 4: Erik Bakke (Motion shadow – industry partner, Washington, USA)

Short CV:

BS, Computer Science - University of Wisconsin, 2000

CG TA, Industrial Light and Magic, 2000-2002

Co-Founder, Motion Workshop 2005-Present

Title: *Whole-body kinematics: recording and real time presentations*

Learning goals:

- overview of the Shadow system
- Shadow app for streaming and recording
- Record a simple take
- Load the take in Mokka and show plots
- Load the take in Matlab and plot data (position, joint angle)
- Load the take in Python and use matplotlib to plot data

DAY 2 (1.7.2022): Muscle-brain crosstalk (module leader: Miloš Kalc; moderators: Aleš Holobar, Alessandro Del Vecchio, Miloš Kalc)

Speakers: Aleš Holobar, Alessandro Del Vecchio, OT Bioelettronica (industry partner)

Speaker 1: **Prof. Aleš Holobar, PhD***:*

CV: Aleš Holobar Ph.D. is a Full Professor at the Faculty of Electrical Engineering and Computer Science (FEECS), University of Maribor (UM). His main research interests include statistical signal processing, compound signal decomposition, identification of multidimensional systems and biomedical imaging with current activities focused on surface electromyography and biomedical signal processing.

Title: *What can we learn from surface electromyograms and neural codes?*

Learning goals: Workshop will focus on analysis of high-density surface EMG signals, their quality check and preconditioning and their decomposition to contributions of individual motor units. The challenges

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of EMG decomposition will be illuminated along with different applications and use case scenarios. The focus will be on the quality control of the EMG decomposition. The last part of the workshop will focus on the extraction of information and physiological parameter assessment from EMG decomposition results. Good practices will be demonstrated and estimation of different physiological parameters will be discussed, such as motor unit recruitment threshold, cumulative spike train, neural drive estimation and coherence analysis of neural drive.

Speaker 2: **Prof. Alessandro Del Vecchio, PhD***:*

CV: Prof. Del Vecchio received a Bachelor and Master's degree in Human Movement Sciences and Exercise Physiology from the University of Parma, Italy and Loughborough University, UK. He then completed a Doctor Europaeus between the University of Rome "Foro Italico" and the University of Medicine in Germany, Gottingen, at the Institute for Neurorehabilitation Engineering. After the PhD, he moved for a 3 years post-doctoral position at Imperial College London, Department of Bioengineering as a Research Associate. He is now an Assistant Professor at the Department of Artificial Intelligence in Biomedical Engineering at the FAU University, Erlangen-Nuremberg, leading the Neuromuscular Physiology and Neural Interfacing Laboratory. Prof Del Vecchio published over 50 publications including 15 first author works in prestigious journals such as Science Advances, Journal of Neuroscience, Journal of Applied Physiology, Journal of Neural Engineering, and the Journal of Physiology. He was awarded the young investigator award at the European College of Sport Science in 2018, Dublin, and the Early Investigator Best Paper Award 2019 by the Journal of Physiology in the Neuroscience section.

Title: *Exploring Neuromechanics of Movement with Motoneuron Interfacing*

Learning goals: The presentation will cover novel finding on neuromechanical principles of rate of force development and how to augment the rate of force development with a new training paradigm. After this initial part on the rate of force development we will see how force is affected by fatigue and what are the exact neuromuscular patterns that regulate force production during muscle fatigue. The talk will finish with a discussion on highly dynamic hand movements and an artificial intelligence system that can learn the myoeletrical activity of the muscles and move a digital hand in a similar way as during voluntary movements in humans.

Speakers 3: **Simone Posella & Selene Malvicino (OT Bioelettronica - Industry partner):**

CV: Simone Posella is a software engineer and has a Master degree in software engineering at the Politecnico of Torino, Italy. He is a software developer at OT Bioelettronica srl. Selene Malvicino is a biomedical engineer and has a master's degree in Neuroengineering and bioICT at the University of Genova, Italy.

OT Bioelettronica company has a detailed specialization in small series development and production related to biomedical equipment. Our products are born through the experience of our technicians who have been trained in the international research field for several years and written several publications. OT Bioelettronica customers include Research Centers and Universities from all over the world.

Title: *Biopotentials, EMG detection and innovations*

Learning goals:

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- OT Bioelettronica Company presentation
- Basics of measuring biopotentials
- EMG generation and detection
- EMG processing
- Examples of applications in advanced myoelectric prothesis control and targeted muscle rehabilitation

DAY 3 (2.7.2022): Analyses approaches to electrocortical data (module leader: Manca Peskar; moderators: Klaus Gramann, Aleksandar Miladinović, Miloš Ajčević, Manca Peskar)

Speaker 1: **Valentina Bianco, PhD (University of Udine, Italy)**

CV: Dr. Valentina Bianco is currently enrolled as a Post-Doctoral Researcher at the University of Udine. Her current research projects aim to further understanding the predictive role of the brain in shaping upcoming perception in social contexts: human brain can be thought as an "anticipation machine" which relies on top-down predictions based not only on past experience of specific actions but also on prior knowledge of the context in which actions are typically embedded. In 2010, she obtained a MSc in Pharmacy at the "University of Chieti and Pescara "G. D'Annunzio". She has always been interested in neuroplasticity, the specific ability of the brain to undergo structure and functional changes in order to adapt to the environmental factors. Therefore, she enrolled as a PhD Student in Human Movement and Sport Science at the University of Foro Italico in Rome where she leveraged EEG techniques to explore the brain adaptations induced by sport exercise and music expertise. In 2016 she spent one year as a visiting Graduate researcher at Neuroimaging and Brain Stimulation Lab at the University of California, Los Angeles, where she learnt to perform non-invasive brain stimulation techniques. Specifically, she was involved in one project of action observation using single pulse Transcranial magnetic stimulation and in one project of neuroplasticity assessment by means of Paired associative stimulation. Afterwards, she spent two years as a research scholar at the Cognitive processes electrophysiology Lab at IRCCS Fondazione Santa Lucia in Rome, with a special focus on probing different cognitive, motor and sensory anticipations among visual, auditory and tactile modalities, by means of ERPs

Title: *Design of ERP experiments: basics of EEG, recording, sources of noise, analysis*

Learning goals:

- Understanding of ERPs recordings;
- understanding of the ERPs meaning;
- understanding of SNR and prevention of artifacts;
- understanding of ERPs pre-processing and analysis

Speaker 2: **Klaus Gramann, PhD (Technische Universität Berlin, Germany)**

CV: Klaus Gramann received his Ph.D. in psychology from RWTH Aachen, Aachen, Germany. He was a postdoc with the LMU Munich, Germany, and the Swartz Center for Computational Neuroscience, University of California at San Diego. After working as a visiting professor at the National Chiao Tung University, Hsinchu, Taiwan he became the chair of Biopsychology and Neuroergonomics with the Technical University of Berlin, Germany in 2012. Since 2017, he has also been a Professor with the University of Technology Sydney, Australia. His research covers the neural foundations of cognitive processes with a focus on the brain dynamics of embodied cognitive

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processes. He directs the Berlin Mobile Brain/Body Imaging Labs (BeMoBIL) that focus on imaging human brain dynamics in actively behaving participants.

Title: *MoBI data cleaning - too much or not enough?*

Learning goals

- understand the basics of EEG signal generation (anatomy and physiology)
- understand ICA decomposition and prerequisites for good decompositions
- understanding different features of independent components and how to use them to select good components and reject bad components
- understanding gait-related ICs
- How to remove ICs from data for further processing

Speaker 3: **Fiorenzo Artoni, Phd (University of Geneva, Switzerland)**

CV: Fiorenzo Artoni is a Maître Assistant – Senior Researcher at the University of Genève, Campus Biotech – Switzerland. Previously he was a Post-Doc at EPFL with a H2020 Marie Curie Individual Fellowship (project "BIREHAB) and NCCR robotics Spin Funds Grant. Before joining the EPFL, he pursued a post-doc at The Biorobotics Institute, Sant'Anna School of Advanced Studies (SSSA), Pisa where he also obtained the PhD in Biorobotics. He holds a double MSc in Automation Engineering and Industrial Engineering and a double BSc in Biomedical Engineering and Industrial Engineering, obtained respectively from University of Pisa and SSSA. His goal in research is to translate his technical knowledge into real-life MoBI applications such as increasing the effectiveness of bidirectional lower limb prostheses and the optimization of Post Stroke and Parkinson's disease rehabilitation protocols.

Title: *An introduction on cortico-cortical and cortico-muscular coherence*

Learning goals:

- Basics of structural, functional and effective connectivity
- Cross correlation, coherence, partial coherence etc.
- Modeling linear dynamical systems
- Var models, Var[p] models
- selecting a Var model order
- selecting a good window length
- An overview of CMC and its applications.

Speakers 4: **Aleksandar Miladinović, PhD & Miloš Ajčević, PhD (University of Trieste, Italy)**

CV: Aleksandar Miladinović, MSc, PhD, is a post-doc researcher at the IRCCS Burlo Garofolo, Trieste, University of Trieste and an assistant at the ZRS Koper. His research interests are biomedical signal processing, the development of the visual system in children, and the development of computer-aided diagnosis.

CV: Miloš Ajčević, MEng, PhD, Senior research associate at the Biomedical Engineering Group, University of Trieste, Italy. His research activities concern biomedical signal and image processing and analysis applied in neurology, ICT solutions for chronic patients, and the development of computer-aided diagnosis.

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Title: *Time-frequency neural time-series analysis*

Learning goals:

- Basic understanding of time-frequency analysis
- What is time-frequency analysis?
- What are the advantages of analysis in the frequency domain?
- Relative vs absolute time-frequency maps
- Basic implementation in Matlab

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