Dipartimento di Ingegneria Informatica
Automatica e Gestionale Antonio Ruberti

Sapienza
Università di Roma

PhD program in Automatic Control, Bioengineering and Operations Research (ABRO)

2023 ABRO Course on Advances in Bioengineering

Future trends in bioengineering and bioinformatics

May-September 2023

Module 1. Components of Electroencephalography (EEG)-based Brain-Computer Interface (BCI) System for User Experience Evaluation

Pinar Onay Durdu, Department of Computer Engineering, Kocaeli University
(pinar.onaydurdu@kocaeli.edu.tr)

Human Computer Interaction (HCI) is an interdisciplinary field of study that deals with the design, evaluation, and application of interactive technology and mainly refers to the interaction and relationship between humans and computers. Up to the present, many innovative interaction modalities have emerged for human interaction with computers. Brain-Computer Interface (BCI) systems are one of the emerging technologies in HCI research recently. Nowadays owing to the release of low-cost consumer-grade devices that make the development of BCI systems easier, it has begun to be employed in various domains. On the other hand, evaluation of user experience (UX) is one of the important focus topics in the field of HCI. It is required for any product to provide a good UX to be successful and to be accepted by its users. In UX research, it is seen that various methods, which are also used for usability evaluations such as surveys, task analysis and observation, and interviews are adopted and used. These methods generally include subjective evaluations of users about their experiences during or after interaction, but they have some limitations because these methods are based on recall. This may lead to ambiguity or inconsistencies due to the user's memory. It is believed that the use of electroencephalography (EEG) based BCI systems for emotion recognition will provide more objective and direct findings when used with traditional methods in UX evaluation. These systems have the potential to assist the enrichment of human-computer interaction with implicit information since they can enable understanding of the cognitive and emotional activities of humans. In this study, preliminary research on the development of a UX evaluation framework that uses real-time EEG based BCI system to objectively acquire users' emotions is presented. This preliminary research was conducted as a systematic review. Based on the review, the main components for emotion recognition with EEG-based BCIs are summarized as the signal stimulus module, which includes the employed device, signal stimuli, data processing modality, and the signal-processing module, which includes signal acquisition, pre-processing, feature extraction, feature selection, classification algorithms, and performance evaluation. This study provides a background overview of all the required components to shed light on the development of a UX evaluation framework.

Module 2. Measuring workers' mental and emotional states in real environments: theory and applications

Vincenzo Ronca, DIAG Sapienza (vincenzo.ronca@uniroma1.it)

Is it possible to monitor the wellbeing of a workers by inferring their mental and emotional states online from their brain and autonomic activities? In particular, is it possible to compute such information compatibly with an online evaluation based on non-invasive sensors? These are the experimental questions that will be treated along the module. In particular, the present module will describe the development of methodologies able to evaluate, even online, the user's mental workload, stress, and emotional state based on the workers' brain and autonomic activities measured by Electroencephalography, Electrodermal Activity, and Photoplethysmography, in operational environments, facing all the issues related to perform reliable neurophysiological measures outside the laboratory-controlled conditions. In fact, several previous works already investigated and validated different techniques for evaluating humans' mental and emotional states through the neurophysiological and autonomic signals analyses. However, despite the relevant

technological advancements developed in the context of the neurophysiological characterization of workers in operational environments, there is still the need of methodologies to evaluate mental and emotional states compatible with a daily use and within everyone's reach. These aspects play a crucial role in the context of workers' monitoring in real world. The present module will describe how such methodologies were optimized and furtherly developed according with the real-world monitoring and their applications in real contexts.

Module 3. A network-based algorithm for identifying drug-repurposing opportunities along with its application to complex diseases

Giulia Fiscon, DIAG Sapienza (giulia.fiscon@uniroma1.it)

Drug repositioning (or drug repurposing) represents an effective drug discovery strategy to find new uses from existing drugs out of the scope of their original medical indication, which could shorten the time and reduce the cost compared to de novo drug discovery. In this context, we developed a new network-based algorithm for drug repurposing called SAveRUNNER (Searching off-lAbel dRUg aNd NEtwoRk), with the aim to offer a promising framework to efficiently detect putative novel indications for currently marketed drugs against diseases of interest. SAveRUNNER predicts drug-disease associations by quantifying the interplay between the drug targets and the disease-associated proteins in the human interactome through the computation of a novel network-based similarity measure, which prioritizes associations between drugs and diseases located in the same network neighbourhoods. SAveRUNNER was successfully applied to predict off-label drugs to be repositioned against the new human coronavirus (2019-nCoV/SARS-CoV-2), and it achieved high accuracy in the identification of well-known drug indications, thus revealing itself as a powerful tool to rapidly detect potential novel medical indications for various drugs that are worthy of further investigation. More recently, it has been successfully applied to identify candidate repurposable drugs for breast invasive carcinoma subtypes, neurodegenerative diseases such as Alzheimer's Disease (AD), Amyotrophic Lateral Sclerosis (ALS), and Multiple Sclerosis (MS). By prioritizing the network-predicted drugs according to the decreasing value of their network similarity with ALS and MS, SAveRUNNER highlighted some interesting drugs related to histamine pathways, worthy of further investigation. This tool has been developed in R and its source code is freely available at https://github.com/sportingCode/SAveRUNNER.git, along with a comprehensive user guide.

Module 4. Applied neuroscience is not only a matter of Central Nervous System. Autonomic Nervous System, its biosignals and related processing for a multimodal approach

Gianluca Di Flumeri, Medicina Molecolare, Sapienza (gianluca.diflumeri@uniroma1.it)

Assessing human behavior in applied contexts usually relies on deploying neuroimaging technologies, such as Electroencephalography (EEG) and functional Near-Infrared Spectroscopy (fNIRs) for investigating brain-related neurophysiological activities. However, even if the Central Nervous System (CNS), and specifically the brain, is the main player in regulating human cognition and behavior, there are usually some underpinning physiological phenomena that arise at the level of the peripheral, and specifically the Autonomic Nervous System (ANS), such as skin sweating, heart and ocular activities. Proper processing procedures allow to obtain information from these biosignals that is often complementary to that obtained from the analysis of CNS, and relevant as well. During the lecture it will be contextualized the role of the ANS with respect to human behavior, cognition and emotions, and it will be provided an overview of the most significant biosignals to be used in applied neuroscience, as well as the current state of art in terms of data processing, in order to obtain relevant and reliable informative features. After that, two case histories will be presented in order to highlight the added value of a multimodal approach, i.e. the simultaneous recording of different biosignals, with respect to the single use of CNS-related biosignals such as the EEG.

Program at a glance

	When	Where	Who	Title
Module 1	31/05/2023 11:00-12:00	Room A5, Via Ariosto 25	Pinar Onay Durdu	Components of Electroencephalography (EEG)-based Brain-Computer Interface (BCI) System for User Experience Evaluation
Module 2	07/09/2023 10:00-14:00	Room A6, Via Ariosto 25	Vincenzo Ronca	Measuring workers' mental and emotional states in real environments: theory and applications
Module 3	26/09/2023 9:30-13:30	Room A3, Via Ariosto 25	Giulia Fiscon	A network-based algorithm for identifying drug-repurposing opportunities along with its application to complex diseases
Module 4	29/09/2023 9:30-13:30	Room A3, Via Ariosto 25	Gianluca Di Flumeri	Applied neuroscience is not only a matter of Central Nervous System. Autonomic Nervous System, its biosignals and related processing for a multimodal approach

All lectures will be given at **DIAG**, Via Ariosto 25, 00185 Rome, Italy, and also streamed on **Zoom**
https://uniroma1.zoom.us/j/98809128656?pwd=WjZrZC9uMFZQdFdHcHJhZnRwRkcxQT09
Meeting ID: 98809128656 Passcode: 923812

Organizer/Contact: **Pietro Aricò**, pietro.arico@uniroma1.it