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Advancing Brain-Computer Interface

Workshop organizers:

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Abstract

A brain-Computer interface (BCI), also known as brain-machine interface (BMI), utilizes neuro-physiological correlates of voluntary cognitive tasks to facilitate direct communication between human brain and computing devices without the involvement of neuro-muscular pathways. This emerging research area has the potential to contribute significantly to enhancing the accessibility of ICT systems for the elderly and disabled people. It is, in general, progressing in two main areas: BCI for communication for improving independence & quality of life of severely disabled people such as sufferers of motor neurone disease (MND) and spinal chord injury, and BCI for rehabilitation purposes, e.g. motor restoration in paralysis due to stroke. Current BCI systems however, lack sufficient robustness and the performance variability among users is quite high. One of the critical limitations is because of the non-stationary characteristics of the brain's neurophysiological responses, which makes it very hard to extract time-invariant stable features unique to voluntary cognitive tasks. Under these inherent limitations, devising real-world BCI applications for constant use is a real challenge. The workshop aims to discuss recent developments in robust BCI design and practical real-world applications made possible through advances in one or more BCI design phases: paradigm design, invasive and non-invasive brain signal selection and acquisition, signal pre-processing, feature selection and extraction, feature classification, and application interface design.

(1). Recent Industrial Developments in Invasive and Non-invasive BCI Systems: Goal-oriented control with Brain-Computer Interface 09:00-10:00

Günter Edlinger, Dipl.-Ing., Dr. techn., CEO g.tec medical engineering GmbH GUGER TECHNOLOGIES OG Herbersteinstr. 60, 8020 Graz, Austria.

BCI technology converts direct measures of brain activity into messages or commands and provide the user with real-time feedback. Such systems represent an additional output channel without relying on the brain's normal pathways of muscles or peripheral nerves. A BCI converts specific brain signals into control commands using ICT methods extracting the relevant information from the brain signals for the subsequent pattern recognition. In order to properly operate a BCI system, an adaptive training and learning process both on the computer interface as well as on the user (brain) side is necessary. Such BCI devices are typically trained on subject specific brain activity data and over time subjects learn to optimally operate such a system supported by the provided feedback. The use of endogenous (e.g. motor imagery) and exogenous (e.g. P300 or SSVEP) BCIs is important, because each BCI approach has a critical problem: a certain percentage of the people cannot use it. About 20% of the investigated subjects cannot use a certain type of BCI. However, it could be demonstrated that a subject can attain control with a different BCI approach. Hence using both types of BNCI should greatly improve the effectiveness and reliability of such a system. In this presentation different state of the art BCI technologies in both motor imagery and evoked potential based BCI systems will be discussed and applications used for control and communication in real world and virtual reality will be presented.

(2). Designing a Motor Imagery based BCI under Non-stationary Brain Signals: Challenges and Way Forward 10:00-11:00

Girijesh Prasad, PhD,
Intelligent Systems Research Centre, School of Computing and Intelligent Systems, University of Ulster, Magee Campus, Londonderry, N. Ireland, United Kingdom.

An EEG-based brain-computer interface (BCI) is a non-stationary system, in which a communication link is established between a computer and the user through a process of simply thinking or imagining a set of cognitive tasks. In this, a classifier is used to detect the electrophysiological correlates appearing in the non-stationary EEG, resulting from the cognitive tasks performed by the user. The non-stationary characteristics of EEG has been one of the primary impediments in developing a practical BCI for constant use. In this presentation, main techniques proposed in the literature for accounting non-stationarity in the brain signals will be reviewed. This will be followed by the discussion of our experiences with techniques based on computational intelligence and covariate shift minimisation and further way forward.

(3). Recent Advances in ECoG BCI Systems 11:00-12:00

Gerwin Schalk, Ph.D.
Research Scientist V, Wadsworth Center, New York State Department of Health Assoc. Prof., Dept. of Neurology, Albany Medical College Assoc. Prof., Dept. of Biomed. Sci., State Univ. of New York at Albany Adj. Assist. Prof., Dept. of Neurosurgery, Washington Univ. in St. Louis Adj. Faculty, Dept. of Biomed. Eng., Rensselaer Polytechnic Institute

Brain-computer interfaces (BCIs) convert brain signals into outputs that communicate a user's intent. BCIs can be used by people to communicate and interact with their environment. However, the prevailing non-invasive and invasive sensor methods have important limitations. Electrocorticographic (ECoG) recordings from the surface of the brain could be a robust and high-fidelity alternative to existing methods.

In this talk, I will describe the types of signals present in ECoG and their relationship to signals detected using EEG and intracortical microelectrodes. I will then demonstrate that ECoG can give detailed information about motor and language function that is in important ways comparable to that provided by intracortical recordings. I will also give examples of successful use of these signals in real time for BCI and other purposes.

(4). Principles for efficient non-invasive neuroprosthetics: Machine learning, shared control and cognitive states, 12:00-13:00

Ricardo Chavarriaga, PhD,
CNBI - Chair on Non-Invasive Brain-Machine Interface, Ecole Polytechnique Fédérale de Lausanne, Institute of Bioengineering, Switzerland.

A non-invasive brain-computer interface (BCI) is a system that translates user's intent, coded by spatiotemporal neural activity (usually EEG), into a control signal without using activity of any †muscles or peripheral nerves. Current EEG-based BCIs are limited by a low information transfer rate and are generally considered too slow for controlling complex devices. Nevertheless, in this talk I'll show how online asynchronous analysis of spontaneous EEG signals, in combination with statistical machine learning techniques and smart interaction designs, is sufficient for allowing humans to do so. Based on the principles of mutual learning and shared control, users convey high level mental commands that the devices interpret and execute in the most appropriate way to achieve the goal. Thus allowing the efficient control of mobile robots (e.g. automated wheelchairs), or neuroprosthesis.

In addition, brain-computer interaction can be enriched by detection of user's cognitive states. These states may provide information about interaction errors as perceived by the user, as well as fatigue or perception of relevant feedback information. In particular, we have shown how EEG correlates of error awareness can be used for correcting BCI misclassifications of the user's intent, as well as be used as a teaching signal to improve the performance of an adaptive device through human supervision. Experiments using simulated and real interaction with mobile robots shows the feasibility of detecting such signals in real time; thus providing an alternative, natural way of interaction to current BCI systems, while reducing the user demands in terms of cognitive attention and effort.

Afternoon: Practical demos P300/SSVEP/Motor Imagery 14:00 -17:00