As the invited editor of this special issue on brain-computer interface (BCI), I am pleased to give a comment on the state-of-the-art with the introduction of recent advances made at the Chengdu BCI Group, University of Electronic Science and Technology of China (UESTC).

The ability to “talk” with others, no matter using speech, face expression, writing, gesture, or soul induction if possible, is a crucial factor that makes our life more enjoyable. Also, communication is the groundwork of human existence, makes us available to understand each other, share happiness or sadness, and run the daily life. However, there is also a group around us who lost all or part of these evolutionary outputs, no matter due to accident or pathology. How to repair or replace such an output is the main dream of the brain-computer interface.

The study on BCI was initiated about 40 years ago, and is now becoming a hot topic in neuroscience. BCI or brain-machine interface (BMI) is usually considered as an effective pathway connecting the human brain (or some primate animals) to a computer which directly translates human intentions into sequences of control commands for an output device. Meanwhile, BCIs can also be taken as a novel and interesting tool of communication for normal persons. For example, in the field of multimedia, BCIs could possibly be utilized as an additional modality, such as imagine games in which BCIs are used for control.

BCIs can be invasive or non-invasive. The invasive way may provide more detailed and comprehensive information about the brain mental events, thus augment the communication between the computer and the brain. But the involved technical and scientific problems are not solved completely; much more efforts are still on the way. The non-invasive mode is assumed being based on the scalp electroencephalogram (EEG), and the main remaining problems are clear, i.e. how to get efficient features of the underlying mental activities and classify these features accurately. The current efforts are focused on maturing the techniques to have the large variety of proof-of-concept systems to go into our life. The issues include reliable and repeatable neural information estimation, robust and intelligent classifier, cheap and flexible hardware, valuable specificity directed systems.

In the past few decades, “neurofeedback” has been explored in clinical, and neuron-information mining has been involved in neuron-psychology and neurology. What’s the difference between them and BCI? We argue that BCI is part of both of them, which means that BCI is a “bidirectional” communication system instead of a simple mental translation interface. In fact, various bidirectional BCI systems are in progress, such as BCI for individual rehabilitation of disable person, epilepsy control, driver fatigue alarm, and emotion modulation from personal brainwave music.

In recent years, Chengdu BCI Group (CBCI) (www.neuro.uestc.edu.cn) has made great efforts in developing non-invasive and bidirectional communication systems between the human brain and computer. For feature estimation, we developed a novel spatial filter: discriminative spatial patterns (DSP) for spatial feature detection of the movement-related potentials (MRPs) in motor imagination based BCI\(^1\). With DSP for MRPs and the widely adopted common spatial patterns (CSP) for event-related desynchronization/synchronization (ERD/ERS), the classification accuracy may be significantly improved\(^1\). For feature classification, based on the well-known support vector machine (SVM)\(^2\) where the machine is trained by labeled data only, we developed a semi-supervised transductive SVM (TSVM) where the unlabeled data was also utilized in the classification machine construction, and our study confirmed that the training effort may be greatly reduced\(^3\). About the mental tasks for BCI, we explored three possible categories of signal sources. The first one is the endogenous mental task (“free thinking”), such as the motor imagination with ERD/ERS and MRP\(^{1,3}\). The second is the exogenous mental task (“evoked” potentials) such as the steady-state visual evoked potential (SSVEP), where we proposed a stability coefficient for improving the frequency detection in (SSVEP)-based BCIs\(^4\) and investigated the differences among the various stimulators in generating SSVEP\(^5\). The third one is the modulated response (biofeedback-adaptation), where we developed a novel brainwave music mode\(^6,7\).
This special issue was motivated to highlight some of our recent progresses. The contents include: motor imagination based BCI, SSVEP based BCI, on-line BCI system, on-line brainwave music system, and BCI related EEG and MRI. These papers cover the main hot topics in current BCI study, such as semi-supervised learning, idle-state detection, fMRI-BCI, mini-on-line BCI system, brainwave music, and animal robot. We hope that some insights have been presented in these papers. And we are quite aware that great and hard efforts are still necessary for us to take the challenges, such as asynchronous BCI, BCI without training, wearable BCI, brain-computer co-adaptation, and efficient bidirectional communication, etc. Many innovations are demanded to mature the technology underlying BCIs to have an outside BCI system for daily life.

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References


De-Zhong Yao, Guest Editor
University of Electronic Science and Technology of China
Chengdu 610054, China

De-Zhong Yao was born in Chongqing, China, 1965. He received the Ph.D. degree in applied geophysics from the Chengdu University of Technology, Chengdu, China, in 1991, and completed his postdoctoral fellowship in electromagnetic field with UESTC in 1993. He has been a faculty member since 1993, a professor since 1995, and the Dean of the School of Life Science and Technology, UESTC since 2001, the director of the Key Laboratory for NeuroInformation of Ministry of Education, since 2009. He was a visiting scholar with the University of Illinois at Chicago, USA, from September 1997 to August 1998, and a visiting professor with the McMaster University, Canada, from November 2000 to May 2001 and with the Aalborg University, Denmark, from November 2003 to February 2004. He has published more than 80 peer reviewed papers in international journals and conferences. His current research interests include EEG and fMRI with their applications in cognitive science and neurological problems.