Special issue containing contributions from the Fourth International Brain–Computer Interface Meeting

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EDITORIAL

Special issue containing contributions from the Fourth International Brain–Computer Interface Meeting

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Guest Editors

This special issue of *Journal of Neural Engineering* is a result of the Fourth International Brain–Computer Interface Meeting, which was held at the Asilomar Conference Center in Monterey, California, USA from 31 May to 4 June, 2010. The meeting was sponsored by the National Institutes of Health, The National Science Foundation and the Department of Defense, and was organized by the Wadsworth Center of the New York State Department of Health. It attracted over 260 participants from 17 countries—including many graduate students and postdoctoral fellows—and featured 19 workshops, platform presentations from 26 research groups, 170 posters, multiple brain–computer interface (BCI) demonstrations, and a keynote address by W Zev Rymer of the Rehabilitation Institute of Chicago. The number of participants and the diversity of the topics covered greatly exceeded those of the previous meeting in 2005, and testified to the continuing rapid expansion and growing sophistication of this exciting and still relatively new research field.

BCI research focuses primarily on using brain signals to replace or restore the motor functions that people have lost due to amyotrophic lateral sclerosis (ALS), a brainstem stroke, or some other devastating neuromuscular disorder. In the last few years, attention has also turned towards using BCIs to improve rehabilitation after a stroke, and beyond that to enhancing or supplementing the capabilities of even those without disabilities. These diverse interests were represented in the wide range of topics covered in the workshops. While some workshops addressed broad traditional topics, such as signal acquisition, feature extraction and translation, and software development, many addressed topics that were entirely new or focused sharply on areas that have become important only recently. These included workshops on optimizing P300-based BCIs; improving the mutual adaptations of the BCI and the user; BCIs that can control neuroprostheses, robotic arms, and other complex devices; moving BCIs from the laboratory to the home; BCIs that can induce neural plasticity and restore function; BCIs that use metabolic brain signals; novel BCI designs; non-medical BCI applications; ethical issues in BCI research; and contentious issues in BCI research.

Dr Rymer's keynote address, 'BCI: a long range view from within a rehabilitation hospital', applied lessons from the field of rehabilitation robotics to the current state and future prospects of BCI technology. He noted that the present enthusiasm for BCI research and development reflects a desire to help people and to make basic research serve clinical needs, the excitement of the challenges for engineers and scientists, and (perhaps overly optimistic) anticipation of future benefits. He emphasized the importance of focusing research on major clinical problems that affect large numbers of people and can be addressed by BCI technology. In this regard, he identified the common and devastating motor problems produced by hemispheric stroke and limb loss as realistic and important targets for BCI research. He also cautioned against overly aggressive invasive BCI studies that might produce adverse events that could sharply curtail support and enthusiasm for further work.

The keynote address, and presentations and discussions throughout the meeting, brought out five major issues that will help determine whether BCIs realize the exciting future that many envision for them. The first issue is the identification and characterization of those brain signals that are best able to encode user intent and the development of improved methods for recording these signals. Both noninvasive and invasive BCIs need sensors and associated hardware that are robust, convenient, cosmetically acceptable and function reliably and safely for long periods with minimal ongoing technical support. The second issue is the need for BCI software that optimizes the ongoing adaptive interactions between the BCI and the user to achieve the reliability lacking in current BCIs. Marked improvement in reliability is essential if BCIs are to move from the laboratory into widespread practical use for significant purposes in real life. The third issue is the development of BCI applications that serve the most important unmet needs of specific populations of potential users. BCI applications are needed that can extend the current spectrum of assistive technology or augment rehabilitation to move beyond what is possible using conventional methods. The fourth issue is the critical requirement for well-designed studies that validate the ability of BCIs to serve the needs and improve the lives of people with severe disabilities. Without such translational studies, BCIs will never realize the promise projected from laboratory results. Finally, the future of BCI technology depends on the realization of clinically and economically viable models for implementing and supporting its widespread dissemination.

Effective attention to these five issues requires cooperation among researchers from many diverse disciplines: neuroscientists, engineers, psychologists, applied mathematicians, computer scientists, clinicians and rehabilitation specialists. The translational research essential for the validation of BCI technology is particularly dependent on such multidisciplinary collaborations. The need for multidisciplinary interactions has been the primary impetus for the four international BCI meetings to date. In the service of this continuing need, a discussion session at the meeting resulted in the formation of a multidisciplinary steering committee to organize future meetings at three-year intervals. Chaired by Jane E Huggins of the University of Michigan, this committee is planning the next meeting for 2013.

The 28 primary research articles and workshop-based reviews that comprise this special issue reflect the substance and range of the meeting, and illustrate the current state of the field. The articles are loosely organized into three groups: signal acquisition; feature extraction and translation; and applications. The large number of application studies indicates the critical importance of this area for the ultimate significance of BCI research and development.