Guest Editorial
The Third International Meeting on Brain-Computer Interface Technology: Making a Difference

***Abstract*—This special issue of the IEEE TRANSACTIONS ON NEURAL SYSTEMS AND REHABILITATION ENGINEERING provides a representative and comprehensive bird's-eye view of the most recent developments in brain–computer interface (BCI) technology from laboratories around the world. The 30 research communications and papers are the direct outcome of the Third International Meeting on Brain–Computer Interface Technology held at the Rensselaerville Institute, Rensselaerville, NY, in June 2005. Fifty-three research groups from North and South America, Europe, and Asia, representing the majority of all the existing BCI laboratories around the world, participated in this highly focused meeting sponsored by the National Institutes of Health and organized by the BCI Laboratory of the Wadsworth Center of the New York State Department of Health. As demonstrated by the papers in this special issue, the rapid advances in BCI research and development make this technology capable of providing communication and control to people severely disabled by amyotrophic lateral sclerosis (ALS), brainstem stroke, cerebral palsy, and other neuromuscular disorders. Future work is expected to improve the performance and utility of BCIs, and to focus increasingly on making them a viable, practical, and affordable communication alternative for many thousands of severely disabled people worldwide.**

***Index Terms*—Augmentative communication, brain–computer interface (BCI), electrocortiocogram (ECoG), electroencephalography (EEG), microelectrodes, motor control, neurons, rehabilitation, severe motor disorders.**

I. INTRODUCTION

THIS special issue of the IEEE TRANSACTIONS ON NEURAL SYSTEMS AND REHABILITATION ENGINEERING is a direct outcome of the Third International Meeting on Brain–Computer Interface Technology held at the Rensselaerville Institute, Rensselaerville, NY, in June 2005. This meeting focused on the most recent advances in development of brain–computer interface (BCI) technology to provide communication and control that does not depend on the brain's normal neuromuscular output channels. The main themes of the meeting are addressed in the 30 peer-reviewed research communications and four workshop papers that comprise this special issue. The meeting was the third in a series that started in 1999 to bring together the diverse disciplines required for successful BCI research and development: neuroscience, psychology, engineering, mathematics, computer science, and clinical rehabilitation. Sponsored by the National Institutes of Health (NIH) and organized by the Wadsworth Center of the New York State Department of Health, the 2005 meeting included presentations by 53 laboratories, four workshops that focused on four specific topics crucial to the continuing progress of BCI research and development, a keynote address by William J. Heetderks, practical demonstrations, and a poster session. It was preceded by a satellite symposium on the general-purpose BCI software platform BCI2000.

The presentations by the individual laboratories covered the full spectrum of disciplines and approaches involved in BCI research around the world. The topics ranged from details of signal processing and analysis to the psychosocial considerations of patients in the clinical setting, to basic science studies of relevant brain activity, to the material science of recording electrodes, to the comparison of invasive versus noninvasive methods, to methods of signal acquisition, to discussion of clinical issues. The peer-reviewed short communications in this special issue contain the substance of most of these presentations and include contributions of many different kinds from BCI laboratories around the world. Also included are four papers describing the discussions and outcomes of the four workshops and a paper summarizing the major results of the Internet-based BCI data analysis competition, the outcome of which was announced at the meeting. Taken together, these papers provide a good overall view of the major developments in current BCI research. At the same time, it is important to note that space constraints did not allow us to publish here all of the work presented at the meeting.

This Special Issue begins with summaries of the four workshops. These workshops were essentially small meetings within the meeting where both experienced and novice researchers interacted as panel members and presenters. Their goal was to highlight and discuss in depth the most pressing issues and most crucial needs for continuing development in each of four major areas. The Signals and Recording Methods Workshop considered the characteristics, advantages, and disadvantages for BCI use of different brain signals and recording methods. It also addressed the ethical issues raised by these various methods, and the key steps critical for their widespread use. The Signal Processing Workshop focused on the signal acquisition, processing,

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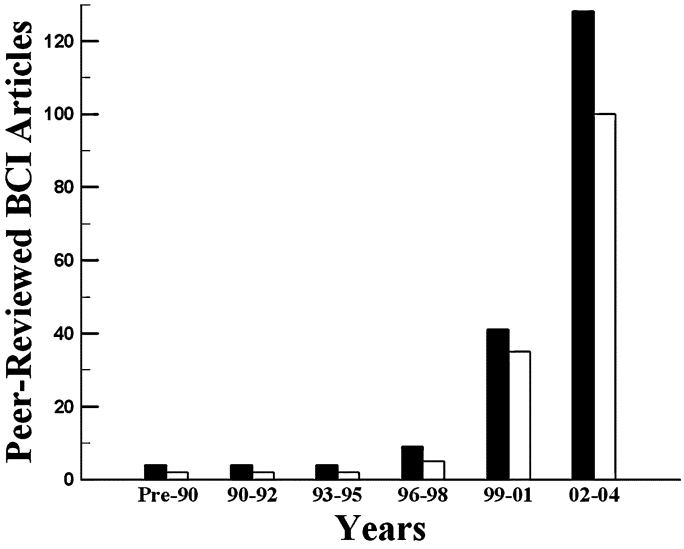

Fig. 1. Explosive growth of BCI research. Shaded bars are all articles. Open bars are articles with one or more authors who attended one or both of the first two international BCI meetings. (Based on Medline search with all relevant keywords and other sources.)

and analysis that are essential for effective BCI systems. It considered: feature extraction and translation methods; interdependencies of time, frequency, and space; optimization schemes; the importance of adaptation; and evaluation criteria. The Clinical Issues Workshop focused on the central goal of BCI research: to provide new communication and control options for people with severe motor disabilities. Topics included: identification of appropriate user groups; crucial applications; validation of efficacy; convenience of use; minimization of technical support; and issues of commercialization, dissemination, and reimbursement issues. The workshop on BCI Hardware and Software focused on the hardware and software needed for both laboratory and clinical BCI uses. It discussed: the technical requirements of BCI systems; the available technologies; general-purpose tools for analyzing BCI signals; standards for evaluating and comparing different BCI systems; and accommodation and incorporation of future technological trends.

The depth and breadth of BCI research in progress today is fairly breathtaking by the standards of even a few years ago. Indeed, it was noted at the meeting that well over half of all the peer-reviewed BCI papers ever published had appeared in the preceding 2.5 years (Fig. 1). At the same time, the meeting repeatedly emphasized the critical importance of addressing and beginning to achieve the central goal of BCI research: to restore communication and control to those who are not adequately served by conventional technology. By satisfying the highest standards of scientific research and by providing clinically useful applications, BCI researchers can ensure that the field continues to develop, and that this radically new communication and control technology increases the capacity for self-care and productive employment of people with severe motor disabilities.

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