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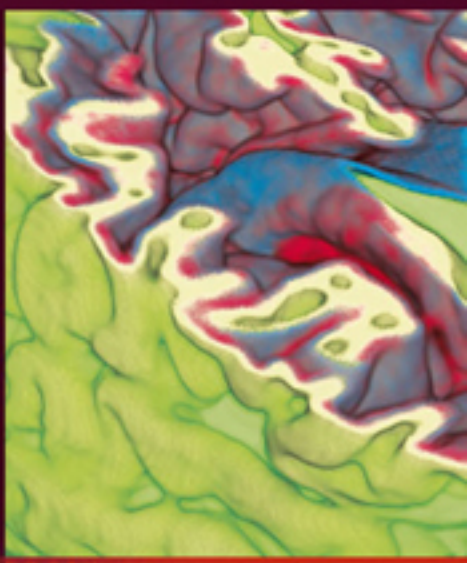

Bernhard Graimann
Brendan Allison
Gert Pfurtscheller (Eds.)

BRAIN–COMPUTER INTERFACES

Revolutionizing Human–Computer Interaction

Springer

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Preface

It's an exciting time to work in Brain–Computer Interface (BCI) research. A few years ago, BCIs were just laboratory gadgets that only worked with a few test subjects in highly controlled laboratory settings. Since then, many different types of BCIs have succeeded in providing real-world communication solutions for several severely disabled users. Contributions have emerged from a myriad of research disciplines across academic, medical, industrial, and nonprofit sectors. New systems, components, ideas, papers, research groups, and success stories are becoming more common. Many scientific conferences now include BCI related special sessions, symposia, talks, posters, demonstrations, discussions, and workshops. The popular media and general public have also paid more attention to BCI research.

However, the field remains in its infancy, with many fundamental challenges remaining. BCI success stories are still expensive, time consuming, and excruciatingly infrequent. We still cannot measure nor understand the substantial majority of brain activity, which limits any BCI's speed, usability, and reliability. Communication and collaboration across disciplines and sectors must improve. Despite increased efforts from many groups, you still can't really do very much with a BCI. The increased publicity has also brought some stories that are biased, misleading, confusing, or inaccurate.

All of the above reasons inspired a book about BCIs intended for non-expert readers. There is a growing need for a straightforward overview of the field for educated readers who do not have a background in BCI research nor some of its disciplines. This book was written by authors from different backgrounds working on a variety of BCIs. Authors include experts in psychology, neuroscience, electrical engineering, signal processing, software development, and medicine. The chapters describe different systems as well as common principles and issues. Many chapters present emerging ideas, research, or analysis spanning different disciplines and BCI approaches. The style and content provide a readable and informative overview aimed toward non-specialists.

The first chapter gives a particularly easy introduction to BCIs. The next three chapters cover the foundations of BCIs in more detail. Chapters 4 through 8 describe the four most cited non-invasive BCI systems, and chapters 9 and 10 cover neurorehabilitation. Chapter 11 focuses on BCIs for locked-in patients and presents a unique

interview with a locked-in patient. Invasive approaches are addressed in chapters 12 to 14. Chapters 15 and 16 present a freely available BCI framework (BCI 2000) and one of the first commercial BCI systems. Chapters 17 and 18 deal with signal processing. The last chapter gives a look into the future of BCIs.

Graz, Austria
April 2010

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List of Abbreviations

ADHD	Attention deficit hyperactivity disorder
AEP	Auditory evoked potential
ALS	Amyotrophic lateral sclerosis
AP	Action potential
AR	Autoregressive model
BCI	Brain–Computer Interface
BMI	Brain–Machine Interface
BOLD	Blood oxygenation level dependent
BSS	Blind source separation
CLIS	Completely locked-in state
CNS	Central nervous system
CSP	Common spatial patterns
ECG	Electrocardiogram, electrocardiography
ECoG	Electrocorticogram, electrocorticography
EEG	Electroencephalogram, electroencephalography
EMG	Electromyogram, electromyography
EOG	Electrooculogram
EP	Evoked potential
EPSP	Excitatory postsynaptic potential
ERD	Event-related desynchronization
ERP	Event-related potential
ERS	Event-related synchronization
FES	Functional electrical stimulation
fMRI	Functional magnetic resonance imaging
fNIR	Functional near infrared
HCI	Human–computer interface
ICA	Independent component analysis
IPSP	Inhibitory postsynaptic potential
ITR	Information transfer rate
LDA	Linear discriminant analysis
LFP	Local field potential
LIS	Locked-in state

MEG	Magnetoencephalogram, magentoencephalography
MEP	Movement-evoked potential
MI	Motor imagery
MND	Motor neuron disease
MRI	Magnetic resonance imaging
NIRS	Near-infrared spectroscopy
PCA	Principal component analysis
PET	Positron emission tomography
SCP	Slow cortical potential
SMA	Supplementary motor area
SMR	Sensorimotor rhythm
SNR	Signal-to-noise ratio
SSVEP	Steady-state visual-evoked potential
VEP	Visual evoked potential
VR	Virtual reality