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Human-Computer Interaction is a multidisciplinary field focused on human aspects of the development of computer technology. As computer-based technology becomes increasingly pervasive – not just in developed countries, but worldwide – the need to take a human-centered approach in the design and development of this technology becomes ever more important. For roughly 30 years now, researchers and practitioners in computational and behavioral sciences have worked to identify theory and practice that influences the direction of these technologies, and this diverse work makes up the field of human-computer interaction. Broadly speaking, it includes the study of what technology might be able to do for people and how people might interact with the technology.

In this series, we present work which advances the science and technology of developing systems which are both effective and satisfying for people in a wide variety of contexts. The human-computer interaction series will focus on theoretical perspectives (such as formal approaches drawn from a variety of behavioral sciences), practical approaches (such as the techniques for effectively integrating user needs in system development), and social issues (such as the determinants of utility, usability and acceptability).

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Desney S. Tan • Anton Nijholt
Editors

Brain-Computer Interfaces

Applying our Minds to Human-Computer Interaction

Springer
Human-Computer Interaction (HCI) research used to be about the ergonomics of interfaces and, interfaces used to consist of a keyboard, a mouse and whatever could be displayed on the screen of a monitor, that is, the graphical user interface. Nowadays, when we talk about Human-Computer Interaction research, we are talking about multimodal interaction in environments where we research natural human behavior characteristics in general, rather than looking at keyboard and mouse interaction. The environments we live in support us in our activities. Sensor-equipped environments know about us, our activities, our preferences, and about our interactions in the past. This knowledge is obtained from our interaction behavior, behavior that can be observed and interpreted using knowledge that becomes available and that can be fused from cameras, microphones, and position sensors. This allows the environment to not only be reactive, but also proactive, anticipating the user’s activities, needs and preferences.

Less traditional sensors are now being introduced in the Human-Computer Interaction field. The aim is to gather as much information as possible from the human interaction partner and the context, including the interaction history, that can be sensed, interpreted, and stored. This information makes it possible for the environment to improve its performance when supporting its users or inhabitants in their daily activities. These sensors detect our activities, whether we move and how we move and they can be embedded in our clothes and in devices we carry with us. In the past, physiological sensors have been used to evaluate user interfaces. How does the user experience a particular user interface? What can we learn from information about heart rate, blood pressure and skin conductivity about how a user experiences a particular interface? Such information can help in improving the design of an interface. At present we see the introduction of these physiological sensors in devices we carry with us or that are embedded in devices that allow explicit control of computer or computer controlled environments. Hence, this information can be used ‘on-line’, that is, to improve the real-time interaction, rather than ‘off-line’, that is, to improve the quality of the interface. This information gives insight in the user’s affective and cognitive state and it helps us to understand the utterances and activities of the user. It can be used to provide appropriate feedback or to adapt the interface to the user.
Now we see the introduction of sensors that provide us with information that comes directly from the human brain. As in the case of the physiological sensors mentioned above, information from these neuro-physiological sensors can be used to provide more context that helps us to interpret a user’s activities and desires. In addition, brain activity can be controlled by the user and it can be used to control an application. Hence, a user can decide to use his or her brain activity to issue commands. One example is motor imagery, where the user imagines a certain movement in order to, for example, navigate in a virtual or physical environment. On the other hand, an environment can attempt to issue signals from which it can become clear, by looking at the initiated brain activity, what the user is interested in or wants to achieve.

The advances in cognitive neuroscience and brain imaging technologies provide us with the increasing ability to interface directly with activity in the brain. Researchers have begun to use these technologies to build brain-computer interfaces. Originally, these interfaces were meant to allow patients with severe motor disabilities to communicate and to control devices by thought alone. Removing the need for motor movements in computer interfaces is challenging and rewarding, but there is also the potential of brain sensing technologies as input mechanisms that give access to extremely rich information about the state of the user. Having access to this information is valuable to Human-Computer Interaction researchers and opens up at least three distinct areas of research: controlling computers by using thought alone or as a complementary input modality, evaluating systems and interfaces, and building adaptive user interfaces.

Specifically, this book aims to identify and discuss

- Brain-computer interface applications for users with permanent and situational physical disabilities, as well as for able-bodied users; this includes application in domains such as traditional communication and productivity tasks, as well as in games and entertainment computing;
- Sensing technologies and data processing techniques that apply well to the suite of applications in which HCI researchers are interested;
- Techniques for integrating brain activity, whether induced by thought or by performing a task, in the palette of input modalities for (multimodal) Human-Computer Interaction

The Human-Computer Interaction field has matured much in the last several decades. It is now firmly rooted as a field that connects more traditional fields such as computer science, design, and psychology in such a way as to allow us to leverage and synthesize work in these spaces to build technologies that augment our lives in some way. The field has also built up well-defined methodologies for repeating this work across a series of disciplines. Simultaneously, neuroscience continues to advance sufficiently fast and brain-computer interfaces are starting to gain enough traction so that we believe it is a field ripe for collaboration with others such as HCI. In fact, we argue that the specific properties of the two fields make them extremely well suited to cross-fertilization, and that is the intent of this book. That said, we hope that the specific way we have crafted this book will also provide brain-
computer interface researchers with the appropriate background to engage with HCI researchers in their work.

Acknowledgements The editors are grateful to Hendri Hondorp for his help with editing this book.

Redmond/Enschede  

Desney Tan  
Anton Nijholt
## Contents

### Part I  Overview and Techniques

1 **Brain-Computer Interfaces and Human-Computer Interaction**  
   Desney Tan and Anton Nijholt  
   1.1 Introduction  
   1.1.1 The Evolution of BCIs and the Bridge with Human Computer Interaction  
   1.2 Brain Imaging Primer  
   1.2.1 Architecture of the Brain  
   1.2.2 Geography of Thought  
   1.2.3 Measuring Thought with Brain Imaging  
   1.2.4 Brain Imaging Technologies  
   1.3 Brain Imaging to Directly Control Devices  
   1.3.1 Bypassing Physical Movement to Specify Intent  
   1.3.2 Learning to Control Brain Signals  
   1.3.3 Evaluation of Potential Impact  
   1.4 Brain Imaging as an Indirect Communication Channel  
   1.4.1 Exploring Brain Imaging for End-User Applications  
   1.4.2 Understanding Cognition in the Real World  
   1.4.3 Cognitive State as an Evaluation Metric  
   1.4.4 Adaptive Interfaces Based on Cognitive State  
   1.5 The Rest of the Book  
   Appendix  
   References  

2 **Neural Control Interfaces**  
   Melody Moore Jackson and Rudolph Mappus  
   2.1 Introduction  
   2.2 Background-Biofeedback  
   2.3 Control Tasks  

---

ix
2.3.1 Exogenous Control Task Paradigms .......... 23
2.3.2 Endogenous Control Task Paradigms ......... 24
2.4 Cognitive Models of Interaction ................ 25
2.5 Interaction Task Frameworks ................... 26
2.5.1 Selection ................................ 27
2.5.2 Text and Quantify ........................... 28
2.5.3 Position ................................ 28
2.6 Dialog Initiative ................................ 28
2.6.1 Synchronous Interfaces ...................... 29
2.6.2 Asynchronous Interfaces ..................... 29
2.6.3 User Autonomy ............................... 29
2.7 Improving BCI Control Interface Usability ...... 30
2.7.1 User Training ................................ 31
2.8 Conclusions .................................... 31
References ........................................ 31

3 Could Anyone Use a BCI? .......................... 35
Brendan Z. Allison and Christa Neuper
3.1 Why BCIs (Sometimes) Don’t Work ............ 35
3.2 Illiteracy in Different BCI Approaches ......... 37
3.2.1 Illiteracy in ERD BCIs ....................... 37
3.2.2 Illiteracy in SSVEP BCIs ..................... 39
3.2.3 Illiteracy in P300 BCIs ....................... 40
3.3 Improving BCI Functionality .................... 42
3.3.1 Improve Selection and/or Classification Algorithms 42
3.3.2 Explore Different Neuroimaging Technologies 43
3.3.3 Apply Error Correction or Reduction .......... 44
3.3.4 Generate Brain Signals that are Easier to Categorize 44
3.3.5 Predicting Illiteracy ......................... 46
3.4 Towards Standardized Terms, Definitions, and Measurement Metrics ......................... 47
3.4.1 The Relative Severity of Illiteracy ............ 49
3.4.2 (Re) Defining “BCI Illiteracy” ............... 50
3.5 Summary ....................................... 50
References ........................................ 51

4 Using Rest Class and Control Paradigms for Brain Computer Interfacing ......................... 55
Siamac Fazli, Márton Danóczy, Florin Popescu, Benjamin Blankertz, and Klaus-Robert Müller
4.1 Introduction .................................... 56
4.1.1 Challenges in BCI ......................... 56
4.1.2 Background on Rest Class and Controller Concepts .. 58
4.2 Methods ....................................... 59
4.2.1 Experimental Paradigm ..................... 59
4.2.2 Feature Extraction ........................... 60
5 EEG-Based Navigation from a Human Factors Perspective ..... 71
Marieke E. Thurlings, Jan B.F. van Erp, Anne-Marie Brouwer, and
Peter J. Werkhoven
5.1 Introduction .................................. 71
5.1.1 Human Navigation Models ................. 72
5.1.2 BCI as a Navigation Device ............... 74
5.1.3 A Short Overview of the Different Types of BCIs .... 74
5.1.4 Reactive BCIs ........................... 75
5.2 BCIs Operating on a Planning Level of Navigation .... 77
5.2.1 Active Planning BCIs ........................ 77
5.2.2 Reactive Planning BCIs ................... 77
5.2.3 Passive Planning BCIs .................... 78
5.3 BCIs Operating on a Steering Level of Navigation .... 78
5.3.1 Active Steering BCIs ........................ 78
5.3.2 Reactive Steering BCIs ................... 79
5.3.3 Passive Steering BCIs .................... 80
5.4 BCIs Operating on a Control Level of Navigation ..... 81
5.5 Discussion ................................... 81
5.5.1 Control Level ........................... 81
5.5.2 Steering Level ........................... 82
5.5.3 Planning Level ........................... 83
5.5.4 Sensory Modalities ........................ 83
5.6 Conclusion and Recommendations ................. 83
References ..................................... 84

6 Applications for Brain-Computer Interfaces ............... 89
Melody Moore Jackson and Rudolph Mappus
6.1 Introduction .................................. 89
6.2 BCIs for Assistive Technology ................... 90
6.2.1 Communication .......................... 90
6.2.2 Environmental Control .................... 93
6.2.3 Mobility ............................. 93
6.3 BCIs for Recreation .......................... 95
6.3.1 Games ............................. 95
6.3.2 Virtual Reality .......................... 96
6.3.3 Creative Expression ................................................. 97
6.4 BCIs for Cognitive Diagnostics and Augmented Cognition .... 97
  6.4.1 Coma Detection ............................................... 98
  6.4.2 Meditation Training ......................................... 98
  6.4.3 Computational User Experience ......................... 98
  6.4.4 Visual Image Classification ............................... 99
  6.4.5 Attention Monitoring ...................................... 99
6.5 Rehabilitation and Prosthetics .................................. 100
6.6 Conclusions ......................................................... 101
References ............................................................. 101

7 Direct Neural Control of Anatomically Correct Robotic Hands .... 105
  Alik S. Widge, Chet T. Moritz, and Yoky Matsuoka
  7.1 Introduction ....................................................... 105
  7.2 Cortical Interface Technology and Control Strategies .......... 106
    7.2.1 Interface Technologies ................................... 107
    7.2.2 Control Strategies: Population Decoding .............. 107
    7.2.3 Control Strategies: Direct Control .................... 108
  7.3 Neurochip: A Flexible Platform for Direct Control ............ 112
  7.4 Anatomical Prosthetic Design .................................. 113
  7.5 The Anatomically Correct Testbed (ACT) Hand ................. 114
    7.5.1 General Overview .......................................... 114
    7.5.2 Anatomically Correct Hands Under Direct Neural Control 115
  7.6 Synthesis: Visions for BCI-Based Prosthetics ................. 116
    References ......................................................... 117

8 Functional Near-Infrared Sensing (fNIR) and Environmental
  Control Applications ................................................ 121
  Erin M. Nishimura, Evan D. Rapoport, Peter M. Wubbels, Traci H.
  Downs, and J. Hunter Downs III
  8.1 Near Infrared Sensing Technology ................................ 121
    8.1.1 Physiological Monitoring .................................. 122
    8.1.2 Functional Brain Imaging .................................. 123
  8.2 The OTIS System .................................................. 123
  8.3 Basic BCI Applications ......................................... 125
    8.3.1 Hemodynamic Response Detection .......................... 125
    8.3.2 Yes/No Response ............................................. 125
  8.4 Environmental Control with fNIR ................................ 126
    8.4.1 Software Framework for Control Applications .......... 126
    8.4.2 Electronics/Appliance Control ............................ 128
    8.4.3 Dolphin Trainer ............................................. 128
    8.4.4 Dolphin Interface for Communication/Control .......... 129
    8.4.5 Brain Painting for Creative Expression .............. 129
  8.5 Conclusion ......................................................... 131
    References ......................................................... 131
9 Cortically-Coupled Computer Vision ........................................ 133
Paul Sajda, Eric Pohlmeier, Jun Wang, Barbara Hanna, Lucas C. Parra,
and Shih-Fu Chang
9.1 Introduction ......................................................... 134
9.2 The EEG Interest Score .......................................... 136
9.3 C3Vision for Remote Sensing .................................... 137
9.4 C3Vision for Image Retrieval ................................. 142
9.5 Conclusions ....................................................... 146
References ............................................................ 147

10 Brain-Computer Interfacing and Games ............................. 149
Danny Plass-Oude Bos, Boris Reuderink, Bram van de Laar, Hayrettin
Gürkök, Christian Mühl, Mannes Poel, Anton Nijholt, and Dirk Heylen
10.1 Introduction ....................................................... 150
10.2 The State of the Art ............................................. 152
10.3 Human-Computer Interaction for BCI ...................... 155
10.3.1 Learnability and Memorability ............................ 156
10.3.2 Efficiency and Effectiveness ............................... 157
10.3.3 Error Handling ............................................. 157
10.3.4 Satisfaction ................................................. 158
10.4 BCI for Controlling and Adapting Games .................... 159
10.4.1 User Experience ............................................ 159
10.4.2 Passive BCI and Affect-Based Game Adaptation ........ 160
10.4.3 BCI as Game Controller ................................. 164
10.4.4 Intuitive BCI .............................................. 167
10.4.5 Multimodal Signals, or Artifacts? ....................... 169
10.5 Conclusions ....................................................... 172
References ............................................................ 173

Part III Brain Sensing in Adaptive User Interfaces

11 Enhancing Human-Computer Interaction with Input from Active
and Passive Brain-Computer Interfaces ................................ 181
Thorsten O. Zander, Christian Kothe, Sabine Jatzev, and Matti Gaertner
11.1 Accessing and Utilizing User State for Human-Computer
Interaction .......................................................... 182
11.1.1 Utilizing User State for Human-Computer Interaction . 182
11.1.2 Accessing User State with Psycho-Physiological Measures 183
11.1.3 Covert Aspects of User State .............................. 183
11.2 Classical BCIs from an HCI Viewpoint ...................... 184
11.3 Generalized Notions of BCIs .................................. 184
11.3.1 BCI Categories ........................................... 185
11.3.2 Passive BCIs ............................................. 185
11.4 Refining the BCI Training Sequence .......................... 187
11.5 An Active and Hybrid BCI: Combining Eye Gaze Input with BCI
for Touchless Interaction ........................................... 189
11.6 A Passive BCI: Automated Error Detection to Enhance Human-Computer Interaction via Secondary Input
11.6.1 Experimental Design
11.6.2 Offline Experiment
11.6.3 Online Experiment
11.6.4 Discussion
11.7 Conclusion
References

12 Brain-Based Indices for User System Symbiosis
Jan B.F. van Erp, Hans J.A. Veltman, and Marc Grootjen
12.1 Introduction
12.1.1 Evolution of Human Computer Interaction
12.1.2 Information Models for Future Symbiosis
12.1.3 This Chapter
12.2 Brain-Based Indices for Adaptive Interfaces
12.2.1 Brain-Based Workload Indices
12.2.2 Brain-Based Vigilance and Drowsiness Indices
12.2.3 Discussion on Brain-Based Indices
12.3 Input for an Operator Model
12.3.1 Relation Between Workload, Task Demand and Performance
12.3.2 Operator State Regulation, Workload and Performance
12.4 Discussion
12.4.1 Sense and Non-sense of Brain-Based Adaptation
12.4.2 Opportunities for Brain-Based Indices in User-System Symbiosis
References

13 From Brain Signals to Adaptive Interfaces: Using fNIRS in HCI
Audrey Girouard, Erin Treacy Solovey, Leanne M. Hirshfield, Evan M. Peck, Krysta Chauncey, Angelo Sassaroli, Sergio Fantini, and Robert J.K. Jacob
13.1 Introduction
13.2 fNIRS Background
13.3 fNIRS Considerations for HCI Research
13.3.1 Head Movement
13.3.2 Facial Movement
13.3.3 Ambient Light
13.3.4 Ambient Noise
13.3.5 Respiration and Heartbeat
13.3.6 Muscle Movement
13.3.7 Slow Hemodynamic Response
13.3.8 Summary of Guidelines and Considerations
13.4 Measuring Mental Workload
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<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAT</td>
<td>Alpha Attenuation Test</td>
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<tr>
<td>ACT</td>
<td>Anatomically Correct Testbed</td>
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<td>A-LOC</td>
<td>Almost Loss of Consciousness</td>
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<td>ALS</td>
<td>Amyotrophic Lateral Sclerosis</td>
</tr>
<tr>
<td>AP</td>
<td>Average Precision</td>
</tr>
<tr>
<td>aPFC</td>
<td>Anterior PreFrontal Cortex</td>
</tr>
<tr>
<td>BCI</td>
<td>Brain-Computer Interaction</td>
</tr>
<tr>
<td>BIRT</td>
<td>Brain-Interface Run-Time</td>
</tr>
<tr>
<td>BMI</td>
<td>Brain-Machine Interaction</td>
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