Brain-Computer Interfaces Handbook

Instructions for contributors:

(1) Review topics of the chapters other contributors have suggested.

(2) Review the tentative TOC based on keywords.

(3) Choose the topic keyword you think your proposed chapter best matches with, and then let CS (csnam@ncsu.edu) know via email (in particular **invasive BCI and BCI H/W related topics**).

(4) Suggest CS other topic keywords you think we have to include to the handbook via email (csnam@ncsu.edu).

(5) **Please note that we are still in the process of inviting people in order to cover all domains of BCI.**

(6) Refer to "**BCI Handbook_Author's Guide to Publishing.pdf**" and "**Example chapter_Contributors .doc**" Download

--------- List of Contributors --------------

1. Fernando Quivira, Shen Feng, Dmitry Sinyukov, Matt Higger, Hooman Nezamfar, Taskin Padir, Gunar Schirner, & Deniz Erdogmus. **Human-in-the-loop Cyber Physical System Framework for the Design and Implementation of Brain Computer Interfaces**
2. Ali Haider & Reza Fazel-Rezai. **Brain Computer Interface Paradigm Design**
3. Dennis McFarland. **Therapeutic Applications of BCI Technologies**
4. Noman Naseer & Keum-Shik Hong. **Technological developments in fNIRS and hybrid EEG-fNIRS BCI**
5. Disha Gupta & Jeremy Hill. **Engineering your Customized Electronics for a BCI System**
6. Emmanuel Kalunga, Sylvain Chevallier, Quentin Barthelemy, & Florian Yger. **Riemannian approaches for SSVEP based on block diagonal decomposition**
7. David Thompson, Rakibul Mowla, & Jane Huggins. **Evaluation and Performance Assessment of Brain-Computer Interface System**

8. Boyla Mainsah, Leslie Collins, & Chandra Throckmorton. **Designing a BCI Stimulus Presentation Paradigm using a Performance-based Approach**
9. Natalie Mrachacz-Kersting, Ning Jiang, & Dario Farina. **Associative plasticity induced by a brain computer interface based on movement related cortical potentials**
10. Eduardo Iáñez, Álvaro Costa, Andrés Úbeda, Enrique Hortal, Rocío Salazar, & José M. Azorín. **Evaluation of cortical phenomenons during human walking**
11. Vojkan Mihajlović, Paruthi Pradhapan, Ulf Großekathöfer, Giuseppina Schiavone, & Bernard Grundlehner. **Towards Practical BCI Solutions for Entertainment and Art Performance**
12. Sonja Kleih & Andrea Kübler. **The user-centered design in Brain-Computer Interface protocols**
13. Jelena Mladenovic, Jeremie Mattout, & Fabien Lotte. **A framework and review of adaptive BCI training and operation**
14. Ilsun Rhiu,Yu Shin Lee, Inchul Choi, Myung Hwan Yun, & Chang Nam. **Towards an Usability Evaluation for Brain-Computer Interfaces**
15. Melissa Smith, Jared Olson, Felix Darvas, & Rajesh Rao. **Utilizing Subdermal Electrodes as a Non-invasive Alternative for Motor-based BCIs**
16. Davide Valeriani & Ana Matran-Fernandez. **Past and Future of Multi-Mind Brain-Computer Interfaces**
17. Marvin Andujar, Anton Nijholt, & Juan E. Gilbert. **The Measurement of Affective Engagement in Brain-Computer Interfaces from a Human-Computer Interaction & Human Factors Perspective**
18. Mark Wronkiewicz, Eric Larson, & Adrian KC Lee. **Incorporating modern neuroscience into BCIs**
19. Philip Kennedy, Dinal Andreasen, Jess Bartels, Princewill Ehirim, Joe Wright, Steven Seibert, & Andre Cervantes. **Validation of the long-term Neurotrophic Electrode**
20. Piotr Stawicki, Felix Gembler, & Ivan Volosyak. **Design and development of user friendly SSVEP-based BCI applications for elderly people**
21. Christoph Guger. **Brain-computer interfaces for motor rehabilitation, DOC assessment and communication**
22. Damien Coyle. TBA - **BCI & games**

23. Hohyun Cho & Sung Chan Jun. **A Step-by-step tutorial for a motor imagery based BCI**
24. Minho Lee. TBA
25. Aureli Soria-Frisch & Stephen Dunne. TBA - StarLabs research
26. Reinhold Scherer. TBA - **Serious gaming & training**
27. Jordi Thielen, A.J. van Duijn, E.C. Lalor, Jason Farquhar, Peter Desain. **Broadband stimuli and evoked responses in Brain Computer Interfaces**
28. Gerwin Schalk & Aysegul Gunduz. TBA
29. Duncan Williams.
30. Jan van Erp. TBA - **BCI & haptics**
31. C. P. Brennan, P. J. McCullagh, L. Galway, G. Lightbody. **Brain-Computer Interface and Eye Tracker as Collaborative Assistive Technologies: A Guided Tutorial**
32. Doron Friedman. TBA - **BCI & VR**
33. Pepe Contreras-Vidal et al., TBA - **BCI and Art Creation**

--------- Tentative Table Of Contents --------------

Introduction: Evolution of BCIs (Nam, Nijholt & Lotte)

(History, application, taxonomy, etc.)

Part I. BCI Applications

A. Communication
1. P300
2. SS_EP (V, A & S)
3. ERD/ERS (Non-Invasive)
4. ERD/ERS (Invasive)
5. Manual for Communication BCI

B. Restoration and Rehabilitation
1. P300
2. SS_EP
3. ERD/ERS (Non-Invasive)

    4. ERD/ERS (Invasive)

    5. SCP

    6. Manual for Restoration and Rehabilitation BCI

C. Arts and BCIs

    1. Artistic BCIs

    2. BCI and art creation

    3. Serious gaming & training

    4. Manual for art BCI

D. Affective Computing & Neuroergonomics
(Emotion, Attention, WM, Decision Making, Engagement, etc.)

    1. Affective BCI

    2. BCI and Virtual Reality

    3. Human augmentation (Attention; Engagement)

    4. Manual for Affective Comp & Neuroergonomics BCI

Part II. Human Factors & Ergonomics in BCI

    1. User-centered design

    2. Training, Procedure, & Feedback

    3. Usability (Safety, performance, Satisfaction)

    4. Design of experiment (DOE) & UX/UI

Part III. Signal Acquisition in BCI

A. Signal Type

    1. Electromagnetic vs. Hemodynamics (Brain function, Montage…)

    2. Electromagnetic: EEG

    3. Electromagnetic: ECoG (Invasive)

    4. Electromagnetic: Intra Cortical (Invasive)

    5. Hemodynamics: fNIRS

    6. Hemodynamics: fMRI

    7. Potential methods (MEG, SPECT, PET)

B. Open source and platform in BCI

    1. BCI2000 (2.0)

2. EEGLAB & BCILAB
   3. OpenViBE

Part IV. Features in BCI (intro-Taxonomy of task paradigms)

   1. P300
   2. SSVEP (Stimulation unit, Pattern, Pros & Cons)
   3. SSSEP & SSAEP (Stimulation unit, Pattern, Pros & Cons)
   4. ERP in Responsive BCI
   5. ERP in Passive BCI - Attention, Emotion, ERN, …
   6. ERD/ERS – Motor Imagery, Mirror Neuron, Speech imagination
   7. SCP
   8. Spectra of deoxy-Hb and oxy-Hb (fNIRS, fMRI)

Part V. Signal processing in BCI

A. Signal Preprocessing
   1. Artifact removal (muscle, power line, electrode drift …)
   2. Referencing Method
   3. Signal Filtering (Spatial and Temporal)
B. Feature Extraction
   1. Statistical Analysis (Overview; multiple, detailed techniques)
   2. Correlation & Coherence (Overview; multiple, detailed techniques)
   3. Temporal (Overview; multiple, detailed techniques)
   4. Spatio-temporal (Overview; multiple, detailed techniques)
   5. Manual for feature extraction and selection

Part VI. Classification in BCI

   1. Threshold detection
   2. Linear discriminant analysis (LDA) family
   3. Support vector machine (SVM) family
   4. Bayesian

5. Hidden Markov model (HMM) family
6. Neural network families
7. Nearest neighbor families
8. Manual for feature classification

Part VII. Emerging Issues & Future BCIs

1. Ethics & Privacy
2. Future directions in BCI R&D

Conclusion (Nam, Nijholt & Lotte)