Developing a Standard Unified Terminology for Brain-Computer Interfaces

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**Multidisciplinarity**
- Psychology
- Engineering
- Neurology
- Computer Science
- Information Theory
- Neuroscience
- Robotics
- ...

**Classification**
- Cortical area recorded
- Extracted features
- Feedback sensory modality
- Application
- Input signals
- ...
A General Framework for Brain–Computer Interface Design

Steven G. Mason, Member, IEEE, and Gary E. Birch, Member, IEEE
(Static) Functional Model of a BCI

**Control Interface**
Translation of LSs into Semantic Symbols (SSs) by means of encoding strategies

**Classifier**
Extraction of the features of interest and translation into Logical Symbols (LSs)

**Collection Stage**
EEG, ECoG, fMRI, fNIRS

**Application Control**
Encoding of SSs into commands towards output devices

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An example: a visual ERP-based protocol
(a) N/A  N/A  N/A  N/A
   (b) N/A  N/A  N/A  N/A
   (c) N/A  N/A  N/A  N/A

(a) 19" TFT  60 Hz  1280x1024 px  60 cm
(b) 19" TFT  60 Hz  1280x1024 px  60 cm
(c) 19" TFT  60 Hz  1280x1024 px  60 cm

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>ABC</td>
<td>DEF</td>
<td>GHI</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>JKL</td>
<td>MNO</td>
<td>PQRS</td>
<td></td>
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<tr>
<td>4</td>
<td>5</td>
<td>6</td>
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</tr>
<tr>
<td>TUV</td>
<td>WXYZ</td>
<td>DEL</td>
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</tr>
<tr>
<td>7</td>
<td>8</td>
<td>9</td>
<td></td>
</tr>
</tbody>
</table>

Select one suggestion:
1. Mother
2. Mountain
3. Mouth
4. Move
5. Movement
6. Not
7. Note
8. Nothing
9. Notice
An example: a P3 Speller

Encoder

R1·C1 = A
R1·C2 = B
...
R3·C4 = P

Output
Write an email

P...

P300 Confusion example

- Performance evaluation
  - Characters per second
  - Selections per second
  - Words per seconds
  - Bit-rate
  - Information Transfer Rate
  - Accuracy
  - Efficiency
  - Mutual Information

- Protocol description
  - Trial? Session? Run?
Most Popular Signal Processing Methods in Motor-Imagery BCI: A Review and Meta-Analysis

Piotr Wierzgala*, Dariusz Zapala*, Grzegorz M. Wojcik* and Jolanta Masiak*

*Department of Neuroinformatics, Faculty of Mathematics, Physics and Computer Science, University of Zielona Gora, Poland

Brain-Computer Interfaces (BCI) constitute an alternative channel of communication between humans and environment. There are a number of different technologies which enable the recording of brain activity. One of these is electroencephalography (EEG). The most common EEG methods include interfaces whose operation is based on changes in the activity of Sensorimotor Rhythms (SMR) during imagery movement, so-called Motor Imagery BCI (MIBC). The present article is a review of 131 articles published from 1997 to 2017 discussing various procedures of data processing in MIBC. The experiments described in these publications have been compared in terms of the methods used for data registration and analysis. Some of the studies (76 reports) were subjected to meta-analysis which showed corrected average classification accuracy achieved in these studies at the level of 51.96%, a high degree of heterogeneity of results ($Q = 1806577.61; df = 486; p < 0.001; I^2 = 99.97$%), as well as significant effects of number of channels, number of mental images, and method of spatial filtering. On the other hand the meta-regression failed to provide evidence that there was an increase in the effectiveness of the solutions proposed in the articles published in recent years. The authors have proposed a newly developed standard for presenting results acquired during MIBC experiments, which is designed to facilitate communication and comparison of essential information regarding the effects observed. Also, based on the findings of descriptive analysis and meta-analysis, the authors formulated recommendations regarding practices applied in research on signal processing in MIBC.

Keywords: brain-computer interfaces, motor imagery, electroencephalography, meta-analysis, sensorimotor rhythms

TABLE 3 | The sample design of table that could be used to summarize relevant information about a study.

<table>
<thead>
<tr>
<th>Settings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amplifier model</td>
</tr>
<tr>
<td>Cap model</td>
</tr>
<tr>
<td>Type of electrodes</td>
</tr>
<tr>
<td>Recorded channels [N]</td>
</tr>
<tr>
<td>Analyzed channels [N]</td>
</tr>
<tr>
<td>Reference</td>
</tr>
<tr>
<td>Ground</td>
</tr>
<tr>
<td>Impedance</td>
</tr>
<tr>
<td>Data set</td>
</tr>
<tr>
<td>Name</td>
</tr>
<tr>
<td>Source</td>
</tr>
<tr>
<td>Study group</td>
</tr>
<tr>
<td>Subjects [N]</td>
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<tr>
<td>Males [N]</td>
</tr>
<tr>
<td>Females [N]</td>
</tr>
<tr>
<td>Right-handed [N]</td>
</tr>
<tr>
<td>Healthy [N]</td>
</tr>
<tr>
<td>Experienced [N]</td>
</tr>
<tr>
<td>Age (Avg)</td>
</tr>
<tr>
<td>Age (SD)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor imagery task description</td>
</tr>
<tr>
<td>Trials [N]</td>
</tr>
<tr>
<td>Trial duration [s]</td>
</tr>
<tr>
<td>Synchronous [Y/N]</td>
</tr>
<tr>
<td>On-line [Y/N]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-processing</td>
</tr>
<tr>
<td>Feature extraction</td>
</tr>
<tr>
<td>Feature selection</td>
</tr>
<tr>
<td>Feature classification</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy (Avg) [%]</td>
</tr>
<tr>
<td>Accuracy (SD) [%]</td>
</tr>
<tr>
<td>ITR [bps]</td>
</tr>
</tbody>
</table>
Motivation for BCI Standards

- Too much time spent to «synchronize» the terminology among groups
- Too often impossible to compare systems
- Too much time spent to reproduce/adapt tools and methods
- Too much effort spent to share resources
- Virtually impossible to allow interoperability among existing systems.
- ...
- CAN A USER REALIZE WHICH BCI IS MORE SUITABLE FOR HIS NEEDS?
- THIS DRAMATICALLY LIMITS PROGRESS!
P2731

Submitter Email: luigi.bianchi@uniroma2.it
Type of Project: New IEEE Standard
PAR Request Date: 26-Jun-2018
PAR Approval Date: 27-Sep-2018
PAR Expiration Date: 31-Dec-2022
Status: PAR for a New IEEE Standard

1.1 Project Number: P2731
1.2 Type of Document: Standard
1.3 Life Cycle: Full Use

2.1 Title: Standard for a Unified Terminology for Brain-Computer Interfaces

3.1 Working Group: Unified Terminology for BCI Working Group (EMB/Std Com/UT-BCI)
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3.2 Sponsoring Society and Committee: IEEE Engineering in Medicine and Biology Society/Standards Committee (EMB/Std Com)
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  Phone: 301-770-3882
Contact Information for Standards Representative
None
IEEE P2731 Unified Terminology for BCI - WG

- standards must provide clear **advantages** to the whole community, including patients, manufacturers, scientists and health professionals, in terms of **quality, safety and efficiency**;

- they must be **minimally “invasive”** with existing systems. In other words, actual system should not need to be largely modified in order to make them standard compliant;

- they should not reinvent the wheel, but possibly make use of already available standards

- they must be **easy to understand**;

- they should **not represent a limitation** to the implementation of new paradigms or an obstacle to innovation;
What are the areas/boundaries of P2731?

Luigi Bianchi

Dear Team, what are the areas that should be covered by our standard? This is a very important issue, that needs to be defined as soon as possible. Please, suggest addition/removal to the following list:

- Hardware
- Software
- Protocol
- Performance
- Ethics
- Application
- File Format
- ...

Aug 19, 2019  Like

Comments

Janis Peksa

Dear Luigi, I can add this thought:

h. Data Transfer Protocol.

24 days ago  Reply  Edit  Delete

Zygmunt Ryznar

@Janis Peksa @Luigi Bianchi Probably the new iso standard to be developed: ISO xxx Health informatics—Identification of medical devices—communication protocols(?) with own internal structure according specificity of brain- Data elements and structures for the unique identification and data exchange of regulated medical devices information

23 days ago  Edit  Delete
iMeet discussions

What are the areas/boundaries of P2731?

1. Hardware
2. Software
3. Protocol
4. Performance
5. Ethics
6. Application
7. File Format
8. Methods
9. Data Transfer Protocol
10. Security

- Janis Peksa
- Zygmunt Ryznar
- Surendra Tipparaju
- Chuck Easttom
- Guillermo Sahonero Alvarez
- Jeremy Gleick
- Ali Hossaini

Q: Is the protocol section referring to users' training procedures?
A: No, I meant P300, SSVEP, C-VEP, etc..

CONCLUSION: The protocol term seems too wide.
iMeet discussions

What are the areas/boundaries of P2731?

Dealing with file formats

Chuck Easttom
I think it is probably beyond our bounds to standardize the format of data? Medical data has HL7 format, and many other areas have specific data formats that allow interoperability. But that seems as if such a project would be a separate standards group in and off itself.

Guillermo Sahonero Alvarez
I agree. Perhaps, we could establish some aspects that data format should have instead of standardizing the format of data strictly?
iMeet discussions

Who should benefit from P2731?

1. Healthy users
2. Patients
3. Caregivers
4. Acquaintances
5. Medical doctors
6. Neurologists
7. Psychologists
8. Engineers
9. Computer Scientists
10. Programmers
11. Manufacturers
12. Technicians
13. Ethical Committees
14. Bio engineers
15. Electrical engineers
16. Neuroscience researchers
17. ....

Chuck Easttom
Davide Valeriani
Zygmunt Ryznar
Mirza Ishraq Yeahia
Guillermo Sahonero
Alvarez
Surendra Tipparaju
Ali Hossaini
iMeet discussions

Davide Valeriani

I understand the importance of capturing the different stakeholders, but we should not go into too fine-grained details.

Ali Hossaini

TARGET STAKEHOLDERS

1. Users: Healthy users, patients, caregivers
2. Computer Scientists: Programmers, database designers
3. Medical Doctors
4. Researchers: Neuroscientists, psychologists, behavioural scientists
5. Engineers: Bioengineers, electrical engineers
6. Manufacturers
7. Technicians:
8. Policymakers: Ethical committees, privacy committees
9. Designers: UI / interface designers, artists, game designers
10. Marketing
iMeet discussions

Proposal for the creation of subgroups

1) **BCI Vocabulary (glossary):**
   - start collecting available definitions: most of them are widely accepted…..
   - make them understandable by all stakeholders, possibly defining the same term with different languages, such as the one of the user or the computer scientist. Some of the definitions will be paradigm specific (e.g. iteration in a P300), some others will be more general (dependent BCI or reactive BCI). With this simple output, we could also gain some visibility.

2) **BCI Functional model.** I think this is also very important: having a good functional model would ease the description of a BCI, especially regarding methods, setup, hardware, etc...

3) **BCI Description.**
   - methods (e.g. performance evaluation),
   - what should be stored into a file (precedes the definition of a file format)-> P2731 compliant
   - what should be transmitted,
   ....
Brain-Computer Interfaces Handbook: Technological and Theoretical Advances
C.S. Nam, A. Nijholt, F. Lotte
CRC Press
January 24, 2018
Thank you!