

# Developing a Standard Unified Terminology for Brain-Computer Interfaces

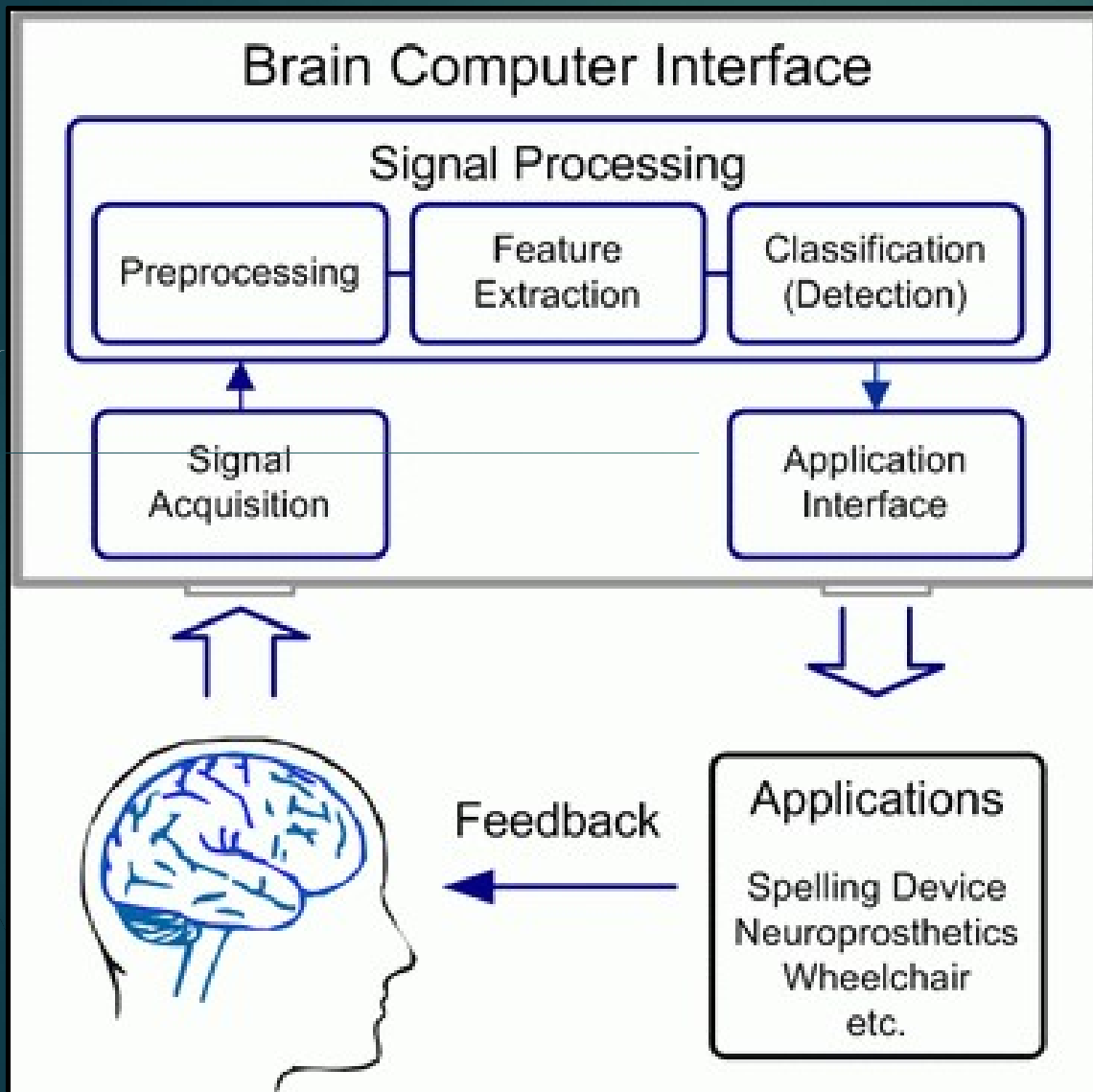
LUIGI BIANCHI, PH. D.

'TOR VERGATA' UNIVERSITY OF ROME, ITALY

EMAIL: [LUIGI.BIANCHI@UNIROMA2.IT](mailto:LUIGI.BIANCHI@UNIROMA2.IT)



# Typical BCI system structure



## Multidisciplinary

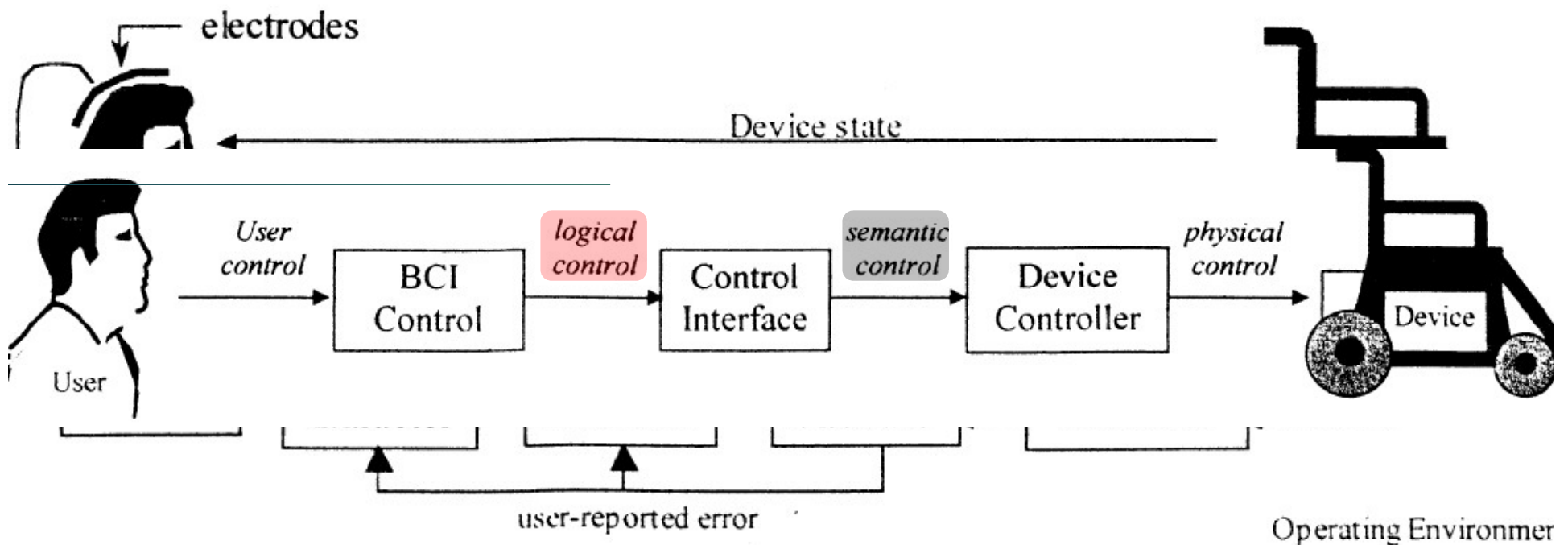
- Psychology
- Engineering
- Neurology
- Computer Science
- Information Theory
- Neuroscience
- Robotics
- ...

## 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

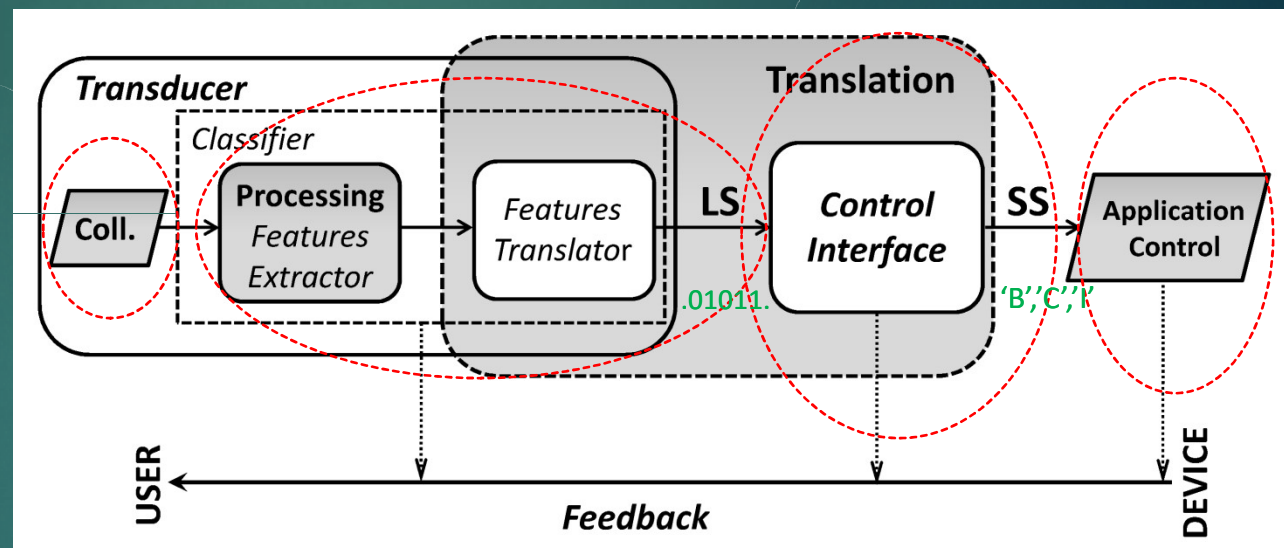
Translation of LSs into Semantic Symbols (SSs) by means of encoding strategies

## 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

# P300



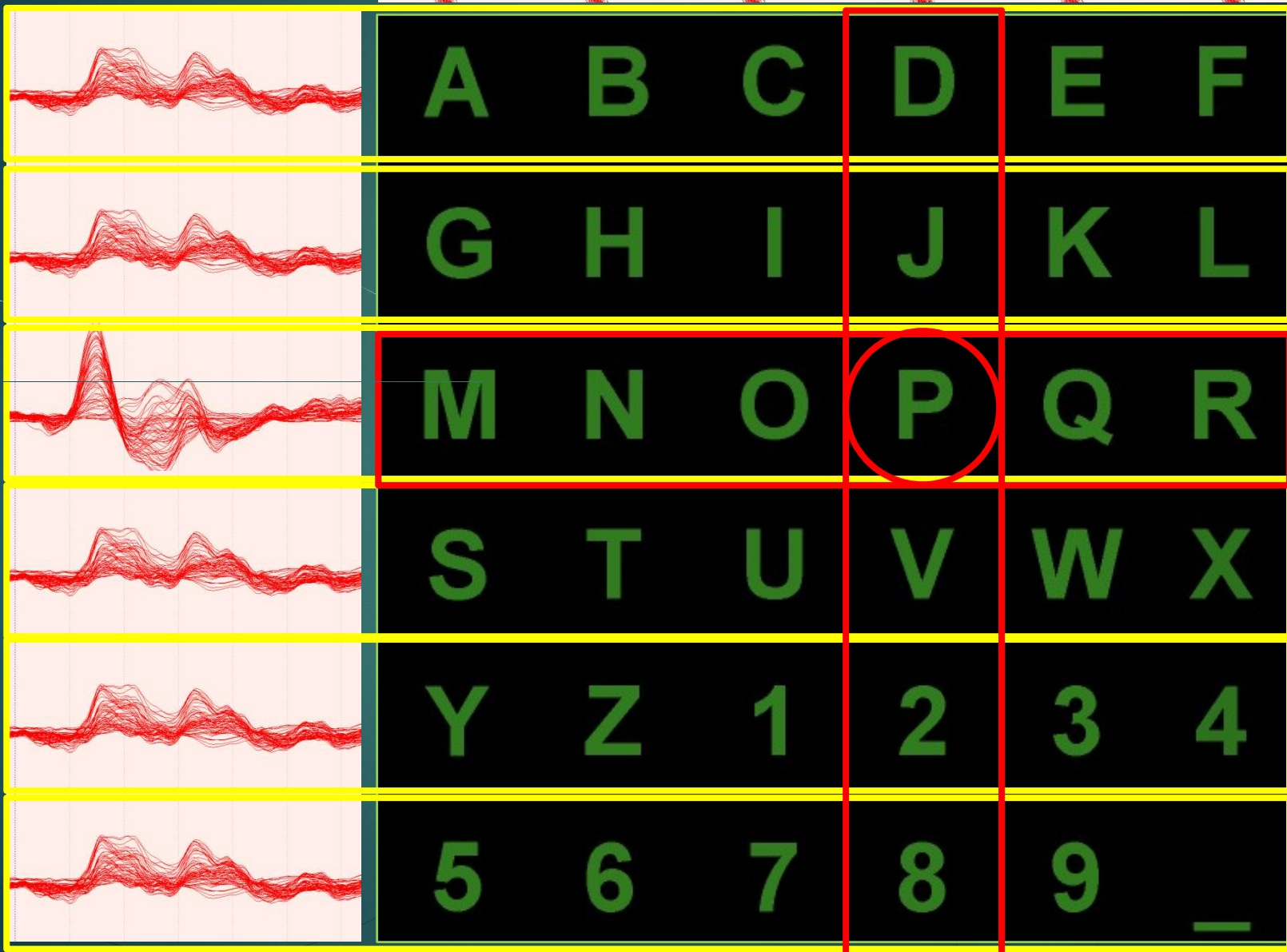
# An example: a visual ERP-based protocol

A	B	C	D	E	F
G	H	I	J	K	L
M	N	O	P	Q	R
S	T	U	V	W	X
Y	Z	1	2	3	4
5	6	7	8	9	_





IEEE  
EMBC  
19

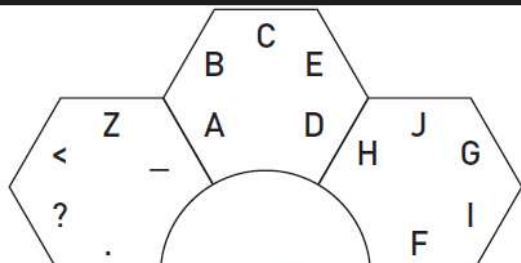


N/A

N/A

N/A

N/A



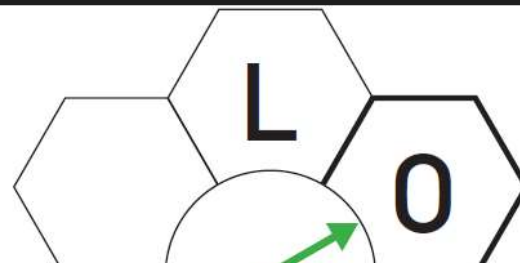
(a)

N/A

N/A

N/A

N/A



(b)

(c)

19" TFT 60 Hz 1280x1024 px 60 cm



(a)

19" TFT 60 Hz 1280x1024 px 60 cm



(b)

19" TFT 60 Hz 1280x1024 px 60 cm



N/A

N/A

N/A

N/A

ABC  
1

DEF  
2

GHI  
3

JKL  
4

**MNO**  
**5**

PQRS  
6

TUV  
7

WXYZ  
8

DEL  
9

N/A

N/A

N/A

N/A

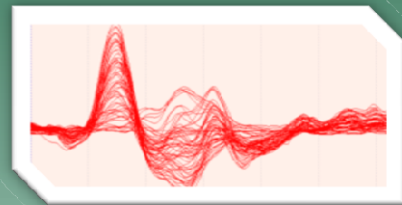
select one suggestion



1. Mother
2. Mountain
3. Mouth
4. Move
5. Movement
6. Not
7. Note
8. Nothing
9. Notice

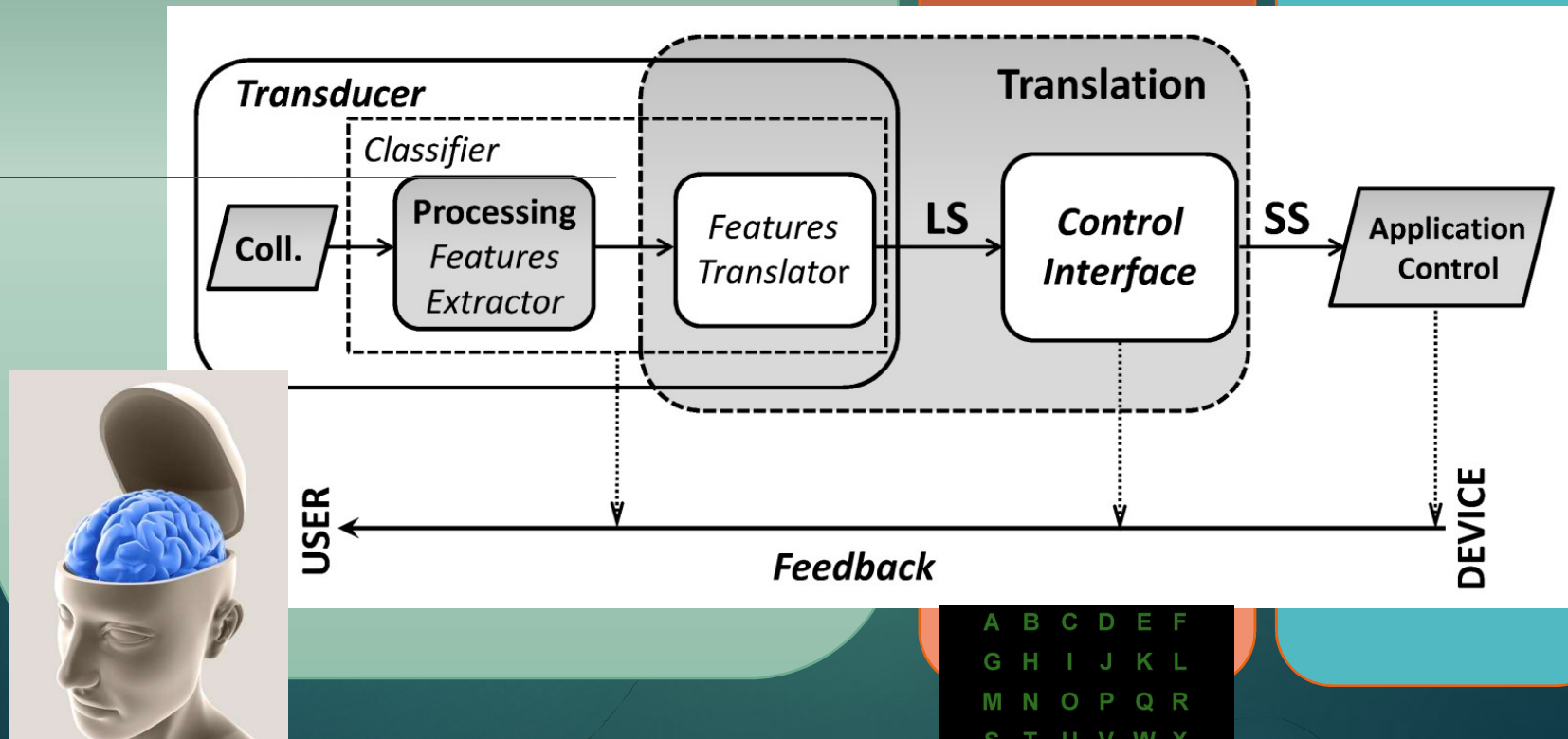


# An example: a P3 Speller



**Encoder**  
 $R1 \cdot C1 = A$   
 $R1 \cdot C2 = B$   
...  
 $R3 \cdot C4 = P$

**Output**  
Write an email  
P...



A	B	C	D	E	F
G	H	I	J	K	L
M	N	O	P	Q	R
S	T	U	V	W	X
Y	Z	1	2	3	4
5	6	7	8	9	_

# 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 Wierzgała<sup>1</sup>, Dariusz Zapala<sup>2</sup>, Grzegorz M. Wojcik<sup>1\*</sup> and Jolanta Masiak<sup>3</sup>

<sup>1</sup> Department of Neuroinformatics, Faculty of Mathematics, Physics and Computer Science, Institute of Computer Science, Maria Curie-Skłodowska University, Lublin, Poland, <sup>2</sup> Department of Experimental Psychology, The John Paul II Catholic University of Lublin, Lublin, Poland, <sup>3</sup> Neurophysiological Independent Unit of the Department of Psychiatry, Medical University of Lublin, Lublin, 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 (MIBCI). The present article is a review of 131 articles published from 1997 to 2017 discussing various procedures of data processing in MIBCI. 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 MIBCI 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 MIBCI.

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

## OPEN ACCESS

### Edited by:

Antonio Fernández-Caballero,  
Universidad de Castilla-La Mancha,  
Spain

### Reviewed by:

Ronen Sosnik,  
Holon Institute of Technology, Israel  
Gary N. Garcia-Molina,  
Philips, United States

### \*Correspondence:

Grzegorz M. Wojcik  
gmwojcik@live.umcs.edu.pl

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

## Settings

Amplifier model  
Cap model  
Type of electrodes  
Recorded channels [N]  
Analyzed channels [N]  
Reference  
Ground  
Impedance

## Data set

Name  
Source

## Study group

Subjects [N]  
Males [N]  
Females [N]  
Right-handed [N]  
Healthy [N]  
Experienced [N]  
Age (Avg)  
Age (SD)

## Procedure

Motor imagery task description  
Trials [N]  
Trial duration [s]  
Synchronous [Y/N]  
On-line [Y/N]

## Methods

Pre-processing  
Feature extraction  
Feature selection  
Feature classification

## Results

Accuracy (Avg) [%]  
Accuracy (SD) [%]  
ITR [bps]

## References



# 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!

# IEEE-Standards Association

## P2731

---

**Submitter Email:** [luigi.bianchi@uniroma2.it](mailto: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)

**Contact Information for Working Group Chair**

**Name:** Luigi Bianchi

**Email Address:** [luigi.bianchi@uniroma2.it](mailto:luigi.bianchi@uniroma2.it)

**Phone:** +39-552 2009620

**Contact Information for Working Group Vice-Chair**

None

---

**3.2 Sponsoring Society and Committee:** IEEE Engineering in Medicine and Biology Society/Standards Committee (EMB/Std Com)

**Contact Information for Sponsor Chair**

**Name:** Carole Carey

**Email Address:** [c.carey@ieee.org](mailto:c.carey@ieee.org)

**Phone:** 301-776 9882

**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/bou

https://iee-sa.imeetcentral.com/ut-bci/folder/WzlwLDExMjQ4MTQ1XQ/WzlsNjU0NDE1ODFd/

IEEE

Search for Workspaces and Files


CreateHelp/ResourcesLuigi Bianchi

What are the areas/boundaries of P2731?

P2731 - Unified Terminology for Brain-Computer Interfaces / Standard Development

ShareMore

Hide sidebar



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:

a. Hardware

b. Software

c. Protocol

d. Performance

e. Ethics

f. Application

g. File Format

h. ...


What are the areas/boundaries of P2731?

Aug 19, 2019

Like

Comments

Sort oldest first



Janis Peksa

Dear Luigi, I can add this thought:

h. Data Transfer Protocol.


24 days ago

Reply

Edit

Delete

View 1 previous reply...



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

DETAILS

Draft

Modified Aug 19 2019 by Luigi Bianchi

Tags

Add tags

https://iee-sa.imeetcentral.com/ut-bci/folder/WzlwLDExMjQ4MTQ1XQ/WzlsNjU0NDE1ODFd/

Which BCI group of pe...

# 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.

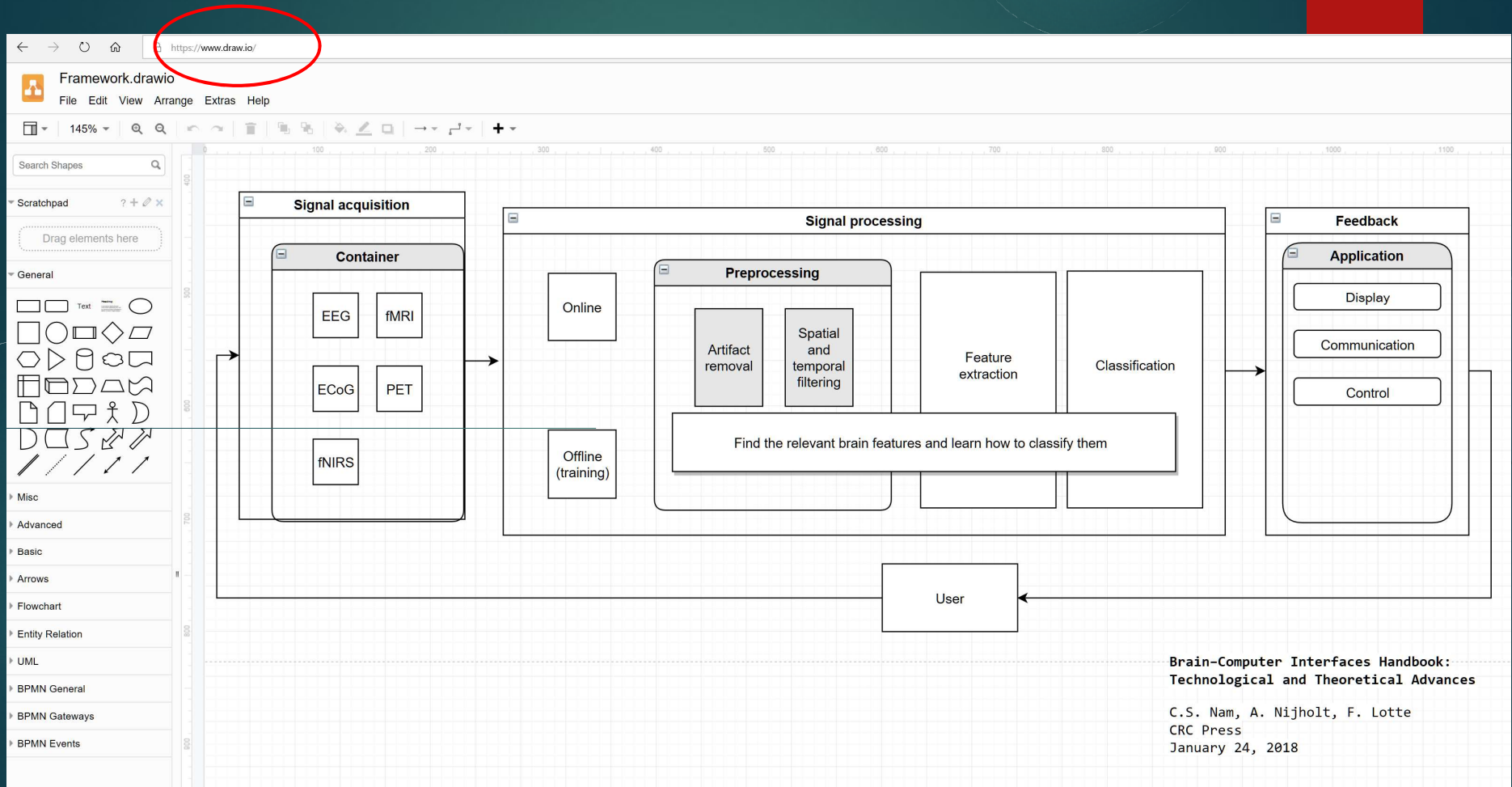
2) **BCI Functional model**. I think this is also very important: having a good functional model would ease the description of a BCI, especially regarding methods, setup, hardware, etc...

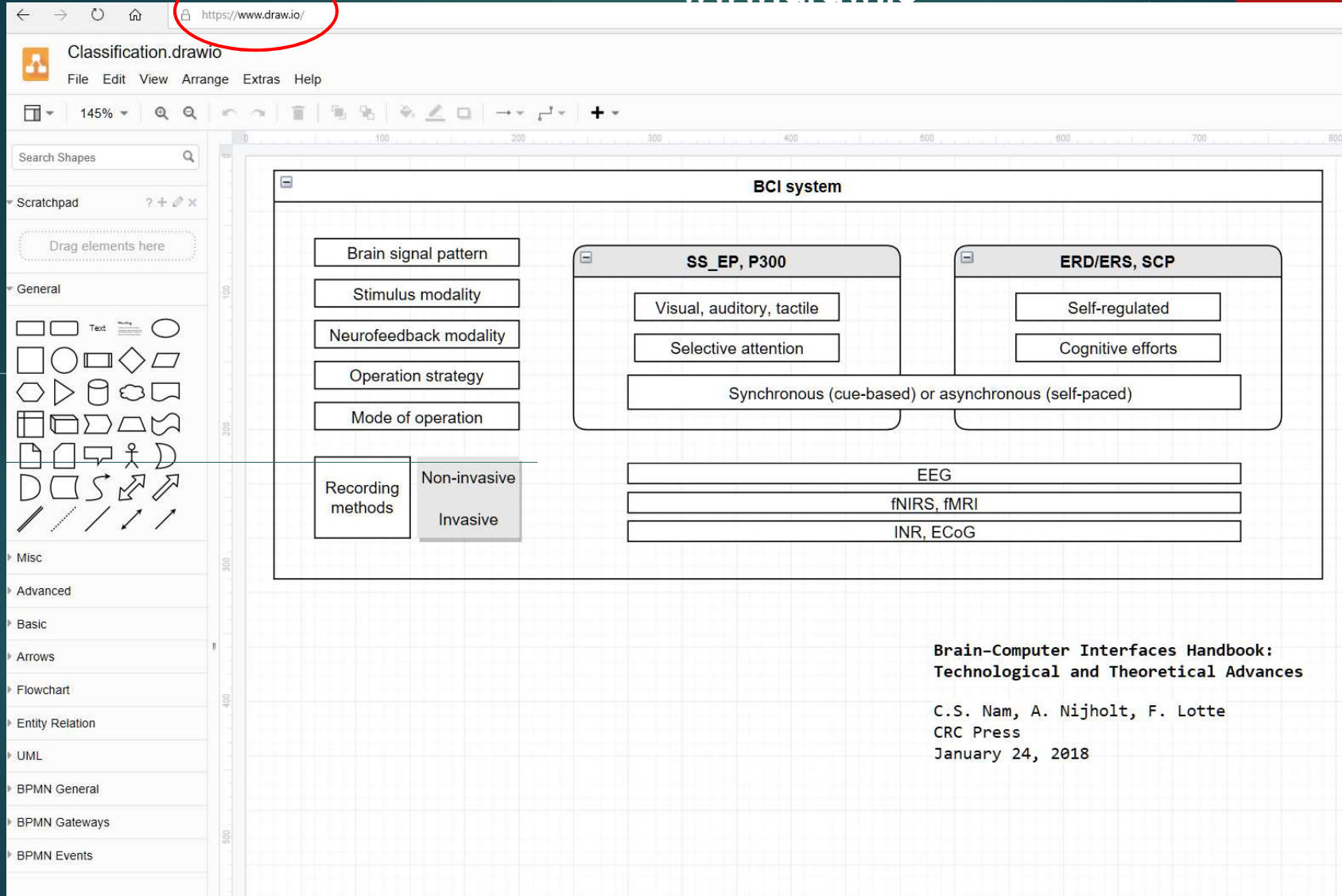
### 3) **BCI Description**.

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,  
....



www.draw.io





**Brain-Computer Interfaces Handbook:  
Technological and Theoretical Advances**

C.S. Nam, A. Nijholt, F. Lotte  
CRC Press  
January 24, 2018

# Thank you!

23

