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Information technology - Brain-computer interfaces - Data format for non-invasive brain information collection

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FOREWORD

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ISO/IEC TS 27571 has been prepared by subcommittee 43: Brain–computer interfaces, of ISO/IEC joint technical committee 1: Information technology. It is a Technical Specification.

The text of this Technical Specification is based on the following documents:

Draft	Report on voting
JTC1-SC43/185/DTS	JTC1-SC43/205/RVDTS

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this Technical Specification is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1, and the ISO/IEC Directives, JTC 1 Supplement available at www.iec.ch/members_experts/refdocs and www.iso.org/directives.

INTRODUCTION

Brain–computer interfaces (BCIs) have emerged as a promising area of research with applications spanning from neurorehabilitation to human–computer interaction. Non-invasive BCI technologies such as electroencephalography (EEG), magnetoencephalography (MEG), functional near-infrared spectroscopy (fNIRS) and functional magnetic resonance imaging (fMRI) have contributed significantly to our understanding of the human brain. [1][1] However, the lack of a standardized data format for these diverse BCI technologies poses challenges to data sharing, integration and analysis. This document specifically addresses the integration challenges posed by multi-modal BCI systems, ensuring that data from different technologies can be combined effectively and efficiently. By establishing a uniform data format, this document facilitates deeper insights into neurological processes and enhances the practical deployment of BCI technologies across various fields.

To address this issue, this document provides a description of the current state-of-the-art and the need for a data fusion system to integrate and analyse data from different non-invasive BCI technologies. This document focuses on the following components: defining basic data elements for each technology, identifying technical information and metadata, designing an extensible and modular data structure, specifying metadata and annotation information for data comprehension and traceability, and establishing a unified data format for consistent data integration.

Data fusion demands situational awareness. It is a set of closed control loops that are responsible for

a) ingesting each type of data and applying appropriate processing (e.g. data deduplication and cleansing and anonymization),
b) normalizing those data into a common language using a consensual vocabulary,
c) semantically enriching the normalized data based on context,
d) understanding the normalized data in order to make decisions about the meaning of the data, and
e) recording this understanding as a set of conclusions.

The resulting standardization will accelerate advancements in BCI research and applications by promoting consistent data organization, enhancing data quality, and enabling more effective collaboration among researchers and practitioners in the field.

[1] Numbers in square brackets refer to the Bibliography.

1 Scope

This document specifies the basic brain–computer interface (BCI) data format including the definition of basic data elements, technology-specific information and metadata, design of an extensible and modular data structure, specification of metadata and annotation information, and the development of a standardized data format and naming convention for BCI data. This document is applicable to non-invasive BCI technologies, such as electroencephalography (EEG), magnetoencephalography (MEG), functional near-infrared spectroscopy (fNIRS) and functional magnetic resonance imaging (fMRI), and provides a comprehensive approach to BCI metadata formats in the product development environment. It takes into consideration various applications, ranging from neurological rehabilitation to human–computer interaction.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 8663, *Information technology - Brain–computer interfaces - Vocabulary*

ISO/TS 21526:2019, *Health informatics - Metadata repository requirements (MetaRep)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 8663 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

– IEC Electropedia: available at https://www.electropedia.org/
– ISO Online browsing platform: available at https://www.iso.org/obp

3.1
annotation
specific type of metadata that provides additional information or explanation about a concept

3.2
application programming interface
API
interface used for communication between software applications

3.3
dataset
collection of related data used for a common purpose or task, organized in a structured format

3.4
extensibility
capability of a system to be expanded with new features

3.5
interface
shared boundary across which two or more separate components of a computer system exchange information

3.6
modularity
ability to separate and recombine selected elements of a system

Note 1 to entry: Modularity is typically facilitated by software architecture designed for data fusion.

3.7
data encryption
conversion of plaintext into ciphertext using an encryption algorithm to protect the confidentiality of the stored or transmitted data

4 Abbreviated terms

EEG	electroencephalography
ENI	experiential networked intelligence
ETSI	European Telecommunications Standards Institute
fNIRS	functional near-infrared spectroscopy
fMRI	functional magnetic resonance imaging
LED	light emitting diode
MEG	magnetoencephalography

5 Basic data elements

5.1 Electroencephalography (EEG)

Electroencephalography (EEG) measures the electrical activity of the brain through electrodes placed on the scalp. Basic data elements for EEG include timestamps, channel labels, electrode type (wet, semi-wet, or dry), number and positions of electrodes, and whether electrodes are active or passive. The data set also includes the sampling rate and raw voltage values. Additionally, information about the reference electrode and ground electrode, filtering settings, and electrode impedance should be included to ensure accurate data interpretation and analysis. The ground electrode provides a stable zero-voltage point, which is essential for reducing electrical noise and improving the overall quality of the EEG data.

5.2 Magnetoencephalography (MEG)

Magnetoencephalography (MEG) records the magnetic fields generated by neuronal currents in the brain. Basic data elements for MEG include timestamps, channel labels, sensor positions, sampling rate, and raw magnetic field values. Technology-specific information for MEG consists of sensor types (e.g. magnetometers, gradiometers), reference sensors, and noise reduction techniques.

5.3 Functional near-infrared spectroscopy (fNIRS)

Functional near-infrared spectroscopy (fNIRS) measures changes in haemoglobin concentration in the brain using near-infrared light. Basic data elements for fNIRS include timestamps, channel labels that specify the positions and types of light sources (LEDs or lasers) and detectors, optode positions, sampling rate, and raw optical density values. Wavelengths of near-infrared light, differential pathlength factor, and baseline correction methods should also be specified as technology-specific information.