

OPINION

on a dissertation for the award of the educational and scientific degree "Doctor" (PhD)

Field of higher education: 5. "Technical Sciences", professional direction: 5.2. "Electrical Engineering, Electronics and Automation", scientific specialty: "Application of the principles and methods of cybernetics in various fields of science"

Author of the dissertation: *M.Sc. Gagandeep Kaur*

Dissertation topic: "A Neurocognitive Approach Based on a Brain-Computer Interface for Identifying Emotional and Mental States"

Scientific supervisor: *Prof. Dr. Anna Lekova* – Institute of Robotics at the Bulgarian Academy of Sciences (IR-BAS)

Member of the scientific jury: *Prof. Dr. George Ilinchev Popov* – Technical University – Sofia

1. Relevance of the problem being developed in scientific and applied terms

The dissertation work of M.Sc. Gagandeep Kaur examines an extremely topical scientific and applied science problem – the creation and validation of an integrated methodology based on wireless brain-computer interfaces (BCI) and electroencephalography (EEG), aimed at objectively reporting and quantitatively assessing mental and emotional states in humans. Specifically, the research focuses on the detection and analysis of mental fatigue in teachers in a real educational environment. The problem of professional burnout and accumulated cognitive load among teachers represents a serious socio-economic and health risk. The work has high scientific and ecological validity, since the experimental EEG recordings in a resting state were conducted immediately before and after real teaching activity, avoiding the limitations of typical and highly artificial laboratory simulations.

2. Degree of knowledge of the state of the problem and creative interpretation of the literary material

In the presented Chapter 1, the doctoral student demonstrates a very good and detailed knowledge of the current state of research in the field of EEG-based analysis of cognitive load. A comprehensive literature review of the functional significance of the main EEG rhythms (delta, theta, alpha and beta) and modern architectures of BCI systems is made. It is important to emphasize that the introductory part and the review have a clearly expressed critical, and not simply narrative, character. The author purposefully analyzes the weaknesses of the existing literature and identifies defined gaps (Gaps in existing research). The predominant use of artificial laboratory tests, the lack of specificity of neuronal markers and the complete neglect of teachers as a target risk group in previous studies are criticized. The literary material is interpreted creatively, which has served as a solid theoretical basis for defining the purpose of the dissertation.

3. Purpose, objectives and methodology of the study

The main goal of the work is the development of a new model and EEG-based BCI methodology for objective neurocognitive analysis of mental and emotional states in working adults in real conditions. To achieve this, specific research tasks have been formulated: study of EEG methods, design of experimental procedures, pre-processing of biosignals, extraction of informative spectral characteristics (relative power) and application of modern statistical apparatus. The methodology includes bandpass filtering, spherical interpolation to eliminate artifacts and normalization of relative power in order to overcome interindividual differences, which is a standard and correct practice in engineering.

4. Analysis of results and scientific contributions

The contributions claimed by the doctoral student are real, completely sufficient for a PhD thesis. They are very well structured, so I acknowledge them in the form they are given.

5. Publications and validation of results

The results of the dissertation work have received the necessary publicity through scientific publications in scientific journals and conference reports, which testifies to the approbation of the developed methodology. The work is directly related and developed within the framework of a project funded by the Scientific Research Fund (SRF), concerning the study of the Suggestopedia method through new neuropsychological knowledge.

6. Opinions, recommendations and notes

Despite the undeniable merits of the work, as a member of the scientific jury I make the following recommendation aimed at improving future research work: Chapter 2 and Chapter 4 describe in detail basic and widely known statistical formulas in the scientific community, as well as the accompanying MATLAB/Octave software code. Since these methods are classical and correctly cited in the bibliography (e.g. Cohen 1988, Efron & Tibshirani 1993), their detailed mathematical description in the dissertation is unnecessary.

It was appropriate to shorten the text in these sections, shifting the emphasis to more complex engineering approaches – such as the analysis of functional connectivity between EEG channels.

7. Conclusion

The dissertation work "A Neurocognitive Approach Based on a Brain-Computer Interface for Identifying Emotional and Mental States" presented by Mag. Gagandeep Kaur is a complete, up-to-date and scientifically sound work. The results obtained have **a clear scientific and scientifically applied nature** and **fully meet the requirements** of the Act on the Development of the Academic Staff in the Republic of Bulgaria for the acquisition of the educational and scientific degree "Doctor" (PhD).

Knowing the requirements for engineering dissertations in the scientific field, I give my **categorical positive assessment** of the dissertation work and propose to the esteemed scientific jury **to award the educational and scientific degree "Doctor" (PhD)** to M.Sc. Gagandeep Kaur in the field of higher education 5. "Technical Sciences", professional field 5.2. "Electrical Engineering, Electronics and Automation".

Date: 05.06.2026

Prepared the opinion:

/Prof. George Popov/