



OPINION

on a dissertation submitted for the acquisition of the educational and scientific degree
"Doctor"

Author of the dissertation: MSc Eng. Svetoslav Emilov Kremenski

Title of the dissertation: "Integration of a Brain-Machine Interface and Social Robots for Applications in Various Domains"

Professional field: 5.2 Electrical Engineering, Electronics and Automation

Doctoral programme: "Application of the Principles and Methods of Cybernetics in Various Fields of Science"

Member of the Scientific Jury: Prof. Tanio Kolev Tanev, PhD, Institute of Robotics, Bulgarian Academy of Sciences

1. General Description of the Dissertation

The dissertation has a total length of 119 pages, plus 58 pages of appendices. It is organised into four chapters and includes a title page; table of contents; introduction; main body; conclusion; contributions of the dissertation; a bibliography comprising 138 references; and a list of publications related to the dissertation (three publications on the dissertation topic).

2. Relevance of the Problem Addressed in the Dissertation from a Scientific and Applied-Scientific Perspective

The dissertation addresses a relevant and promising scientific and applied problem at the intersection of robotics, brain-computer interfaces, IoT technologies, and intelligent human-robot interaction. The topic is particularly significant in view of the growing role of social robots and non-invasive EEG-based interfaces in areas such as education, healthcare, rehabilitation, customer service, smart homes, and neuromarketing.

3. Degree of Familiarity with the State of the Art

The dissertation cites 138 references, a large proportion of which were published within the last ten years. In substance, they are directly related to the dissertation topic.

Chapter 1 presents an overview of the scientific and technological foundations of brain-machine interfaces and social robots, with an emphasis on their integration within an IoT environment. The chapter defines the research domain as the integration of EEG-based brain-machine interfaces with social robots for applications in education, customer service, healthcare, social inclusion, rehabilitation, smart homes, and neuromarketing. It

discusses the nature of EEG signals, the principal frequency bands of brain activity, and existing portable, non-invasive brain-machine interface devices, including Emotiv EPOC+ and OpenBCI. A literature review of social robots such as Pepper, NAO, Furhat, Misty, and QTrobot is also provided, describing their communication capabilities, sensors, programming environments, and fields of application. Particular attention is devoted to EEG-based brain-robot interaction in both active and passive forms. A separate section examines neuromarketing as an application area in which EEG signals may be used to investigate consumer preferences and purchasing decisions more objectively than traditional questionnaire-based methods.

The presented review and bibliography demonstrate that the doctoral candidate has a sound understanding of the problem, as well as of the methods and techniques associated with the dissertation topic, and correctly interprets the achievements in this field.

4. Correspondence of the Selected Research Methodology, Objectives and Tasks with the Contributions Achieved

The dissertation is well structured. Chapter 1 reviews brain-machine interfaces and social robots; Chapter 2 analyses software platforms and methods for integration within an IoT environment; Chapter 3 proposes original methods and algorithms for converting the Pepper and Furhat robots into IoT devices; and Chapter 4 presents experimental verification using OpenBCI and the Furhat social robot in the field of neuromarketing.

The dissertation methodology is well aligned with the stated objective: to develop and validate a universal approach for integrating a brain-machine interface and social robots within an IoT environment. It is logically constructed through a coherent progression from the literature review and systematic study of software platforms to the development of original methods and their experimental verification. The methodology is not limited to the conceptual level; it is implemented through specific methods for converting social robots into IoT devices, algorithms for communication between EEG devices and robots, and experimental validation using OpenBCI and Furhat in the field of neuromarketing. This demonstrates the applicability of the approach and confirms that the proposed architecture can be used in real-world human-robot interaction scenarios.

From a robotics perspective, I positively assess the effort to overcome dependence on specific hardware and software through the use of IoT architectures and visual programming. This is an important practical advantage, as such solutions may facilitate the deployment of social robots in real-world environments by non-specialists. The demonstration of the approach with Pepper and Furhat is particularly valuable because they represent different classes of social robots with different programming and communication interfaces.

5. Scientific and/or Applied-Scientific Contributions of the Dissertation

Six scientific contributions are formulated, each of which also has an applied dimension. I consider these contributions to have been genuinely achieved in the dissertation.

The most significant contributions include the development of a conceptual model for interaction with social robots through EEG signals in an IoT environment; original algorithms for integrating social robots using Node-RED, MQTT, and HTTP GET/POST requests; and the proposal of a new neuromarker based on the spatio-temporal similarity of the second derivatives of EEG signal power. These results have clear scientific and applied value, as they point towards more flexible and universal integration between different BCI devices and social robots.

6. Assessment of the Publications Related to the Dissertation

The results of the dissertation are presented in three publications, in two of which the doctoral candidate is the first author. One publication has an impact factor and is ranked in quartile Q3, while another has an SJR indicator.

These publications demonstrate that the dissertation results have been presented to a broad section of the scientific community and satisfy the publication requirements for the defence of a doctoral dissertation.

7. Author's Abstract (Autoreferat)

The author's abstract is 54 pages long and presents each chapter of the dissertation briefly and accurately. The principal contributions of the dissertation are included. The author's abstract is also available in English.

8. Critical Remarks and Recommendations

I found no significant errors in the dissertation and have no substantial critical remarks. Some technical inaccuracies and omissions were identified, including cases of incomplete bibliographic information for cited sources, such as a missing year of publication or source.

Recommendations: The experimental verification should be extended to include a larger number of participants and more repetitions, particularly in the analysis of "Buy" decisions, for which the dissertation itself notes a limitation arising from the small number of such responses. Future research would also benefit from a broader comparison with

classical EEG analysis and machine-learning methods in order to assess the advantage of the proposed neuromarker more precisely.

9. Conclusion

In conclusion, I consider the dissertation to be a complete, relevant, and scientifically and practically significant study. The results obtained comply with the requirements for acquiring the educational and scientific degree "Doctor". I also consider that the requirements of the Act on the Development of the Academic Staff in the Republic of Bulgaria, the Regulations for its implementation, and the Regulations of the Bulgarian Academy of Sciences have been fulfilled. I therefore give a **positive assessment** of this dissertation, which gives me grounds to propose that MSc Eng. Svetoslav Emilov Kremenski be awarded the educational and scientific degree "**Doctor**" in **Professional field**: 5.2 Electrical Engineering, Electronics and Automation.

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/ Prof. Tanio Tanev, PhD /