

OPINION

for the dissertation of **Assist. MSc Eng. Vasil Georgiev Tsvetkov** on acquisition of scientific and educational "PhD" degree with the title "*Enhancing the cognitive abilities of robots through optimization of their sensor system*" in the Field of Higher Education: 5. Technical Sciences; Professional field: 5.2 Electrical Engineering, Electronics and Automation; Scientific specialty: "Application of the principles and methods of cybernetics in the field of technical sciences"

Prepared the opinion : Prof. Dr. Siya Lozanova, Institute of Robotics at the Bulgarian Academy of Sciences

1. General information about the dissertation

The material contains 122 pages, including: Introduction, Four Chapters, List of Literature, Appendices and List of Abbreviations. The main text contains 42 figures and 8 tables, the bibliographical sources cover 96 titles, of which 16 are in Cyrillic and 80 in Latin. The appendices are on 17 pages with program assembler code. The material is well illustrated with figures, graphs, photos, etc. The text is competently structured and the style is professional. The introduction and the accompanying introductory paragraphs at the beginning of each chapter are sufficient to highlight the essence of the research in the respective chapter.

2. Relevance of the dissertation topic, goal and objectives

The topic of the dissertation is dedicated to the most modern scientific and technological field - sensors and robotics. This makes it very relevant. The material includes elements of artificial intelligence, which forms the study as complete and application-oriented. The key role of robotics in all engineering activities orients the dissertation research as a bridge between the purely conceptual side of the topic and, to a large extent, the purely experimental one. It is this symbiosis that makes the work a complete treatise with aspects of an aid for a wide range of PhD students and assistants. I cannot but mention the original solutions to many non-trivial tasks arising in the process of applications of cognitive robotics. I positively evaluate the author's approach to clearly and professionally present these aspects of the problem, containing the main ideas and results on which the dissertation research is based. I find the classification of sensor elements and devices related to the cognitive part of robots useful. Sensor elements and cognitive capabilities of service robots, and not only them, expand their cooperative functions of interaction with the environment. In the introductory part of the study, Eng. V. Tsvetkov has sufficiently fully presented the connection between the robotic systems and the specific environment around them

through sensor platforms. The PhD student uses in his research the multisensor components proposed, researched and patented some time ago by Acad. Ch. Roumenin. These technological solutions contain diverse capabilities and functions, including for cognitive robotics.

The dissertation clearly and motivatedly presents the key role of cognitive robots in making well-defined and informed decisions within the framework of a specific reality in which they are situated. Here the importance of sensory their abilities. That is why, developed in this way, the dissertation work successfully implemented the goal and the tasks arising from it. The goal of the dissertation is multi-layered and allows for different approaches in the research process. The author has focused on one of them, which I find unifying the results obtained - implementation for effective design of a new type of sensor system for robots, aimed at improving the quality of their cognitive capabilities by optimizing the technical characteristics. The tasks arising from it are immanently related to the scope of the specific results. The tasks are four and are mutually complementary: classification of the main sensors and devices in robotics; development and testing of a method for designing and optimizing the characteristics of a sensor system for cognitive robots; and experimental verification of the newly proposed methodology of the sensor platform. I find the experimentally implemented mobile wheeled platform for verification of cognitive robots, the formulation and creation of simulation sensor models and the design and implementation of intelligent multi-sensor modules important. In the presentation, I have not found any fundamental errors or ignorance of theoretical methodology, experimental methods and measuring devices, etc.

3. Contributions to the dissertation

In the dissertation work, a total of 3 scientific-applied and 5 applied contributions have been formulated and proven by the PhD student. I accept them in this format. The more significant results, achievements and outcomes are as follows:

A. Scientific-applied contributions

- a) Based on the critical analysis on the topic in the literature review, an overview classification of existing sensors and microsystems and their characteristics in the context of their applicability in various robotic configurations has been carried out.
- b) A method for designing an optimal sensor system intended for multifunctional cognitive robots is proposed and developed .
- c) An evaluation of the experimental results in the study of optimally designed sensor modules and devices was carried out.

Among **the scientific-applied contributions** of particular value for the dissertation topic, I appreciate the basic method for designing an optimal sensor system intended for cognitive robots, including its experimental verification.

B. Applied contributions

1. A mobile platform with an omni-wheel sub-system has been designed , constructed and implemented, suitable through its kinematic and geometric parameters for use as a universal engineering tool for testing the functional capabilities and characteristics of the developed sensor and multi-sensor modules.

2. Sensor platforms for temperature measurement, for determining the intensity of the light flux in the visible part of the spectrum, sound analyzers, etc. have been implemented and experimentally studied.

3. Formulated, justified and analyzed are multiple functional modules that perform: initialization of the selected optimal PIC microcontroller; digital device controlling the communication between the microcontroller and the multisensor unit; seven-segment display visualization subsystem; a software module has been formulated and developed to convert data packets into a digital form suitable for processing for the purposes of cognitive robots.

4. A human-machine interface mobile application for Android has been implemented to control the mobile platform designed for cognitive robots.

5. Experimental studies were conducted and analyzed, and the metrological characteristics and states of sensors and multisensors were evaluated as a component of the design of an optimal sensor system for cognitive robots.

In general, I define the contributions of the PhD student as the formulation and justification of a new scientific concept in the existing field of robotics and the creation of original methods and constructions for the purposes of cognitive systems with elements of artificial intelligence.

4. Critical notes and abstract

The dissertation contains unclear sentences, spelling errors and repetitions. I consider the results achieved, the contributions and everything claimed in the dissertation to be the personal work of the PhD student. This conclusion is structurally decisive for me and there is no incorrect behavior of the author with regard to intellectual property. In addition, I declare that I have no joint works with Eng. Tsvetkov or financial relations for a possible conflict of interest. The developed robotic omni-wheel platform contains original modules, connections and control and could be patented.

The abstract is entirely based on the dissertation work, with no data that was not discussed in the dissertation. The contributions and conclusions in the abstract are the same as those in the main material. There are three scientific publications and they are directly related to the dissertation research.

CONCLUSION

Achieved original scientific-applied and applied contributions and results, the new approaches and ideas embodied in the dissertation work give me the confidence to recommend to the esteemed Scientific Jury to give a high rating of the dissertation work and to award the scientific and educational degree " **Doctor** " in the field of Technical Sciences to **Assist. MSc Eng. Vasil Georgiev Tsvetkov** in the field of higher education: 5. Technical Sciences; Professional field: 5.2 Electrical Engineering, Electronics and Automation; Scientific specialty: "Application of the principles and methods of cybernetics in technical sciences" .

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