REVIEW

of a dissertation for acquiring of educational and scientific degree "doctor" in higher education area 5. Technical Sciences, professional field 5.2. Electrical Engineering, Electronics and Automation in doctoral program "Automated systems for information processing and control" at the Institute of Information and Communication Technologies of the Bulgarian Academy of Sciences

1. Assessment for compliance with the minimum national requirements.

The review is prepared by professor eng. Marin Simeonov Marinov, Ph.D., Faculty of "Aviation" of the "Georgi Benkovski" Bulgarian Air Force Academy, Dolna Mitropolia, in his capacity as a member of the scientific jury for the evaluation of a dissertation on topic "Multifunctional learning mobile robot platform" with author Eng. Stanislav Yovchev Yovkov. The scientific jury was appointed with order № 33/31.01.2024 of the Director of the Institute of Information and Communication Technologies of the Bulgarian Academy of Sciences (IICT-BAS).

As a reviewer, I have received the following materials:

- dissertation for acquiring of educational and scientific degree "doctor";
- summary of the dissertation in Bulgarian and in English languages;
- reference for the compliance with the minimum requirements of IICT for acquiring of educational and scientific degree "doctor";
- list of the dissertation publications;
- copies of the full-text of six dissertation publications
- a copy of the attestation for the doctoral student's work in 2023.

Since there are no additional requirements in the Regulations for the specific conditions for acquiring scientific degrees and holding academic positions at the Institute of Information and Communication Technologies, I assess the dissertation according to the requirements of the Act on the development of the academic staff in the Republic of Bulgaria (ADASRB) an the Regulations on its implementation (RIADASRB).

In my opinion, the dissertation submitted to me meets the requirements of art. 6, para 2 of the ADASRB and art. 27 of the RIADASRB. This gives me reason to assume that the minimum required 50 points under the group of indicators A for the educational and scientific degree "doctor" in table 1 of the Annex to Art. 1a, para 1 of the RIADASRB for the higher education area 5. Technical Sciences, professional field 5.2. Electrical Engineering, Electronics and Automation.

In the provided to me reference for the compliance with the minimum requirements of IICT for acquiring of educational and scientific degree "doctor", it is correctly reflected in which indicator from the group of indicators D do the dissertation publications fall. It is also correctly stated the contribution of the PhD student in each

publication. This gives me the reason to recognize 51.33 points under group of indicators D, which exceeds the minimum requirements for educational and scientific degree "doctor" in table 1 of the Annex to Art. 1a, para 1 of the RIADASRB for the higher education area 5. Technical Sciences, professional field 5.2. Electrical Engineering, Electronics and Automation.

The individual results of Eng. Yovkov on the indicators are not less than the minimum number of points and according to art. 2b, para 4 of the ADASRB fulfills the minimum requirements for acquiring the educational and scientific degree "doctor".

I am not aware of any written notification of plagiarism or unreliability of the scientific data presented in the dissertation within the meaning of art. 4, para. 11 of the ADASRB.

In accordance with art. 2, para. 1 of RIADASRB, I accept the dissertation and the publications provided to me for review.

2. Structure and content of the dissertation.

The volume of the dissertation is 114 pages and it consists of Introduction, 4 chapters, Conclusion, Contributions, Reference list, Declaration of originality, List of dissertation publications. There are 111 figures and 5 tables in the dissertation.

There are 75 sources in the Reference list, including from internet sites. Twelve of the sources are scientific editions, 24 are internet sites and 39 are from web archives. From the sources that are not internet sites 50 are in English and 1 is in Spanish.

The list of dissertation publications at the end of the dissertation contents 8 publications, but in the provided reference for the compliance with the minimum requirements of IICT for acquiring of educational and scientific degree "doctor" and the separate list of the dissertation publications are included only 6 of them.

3. Actuality of the problem regarded in the dissertation.

The goal set in the dissertation outlines as the main problem considered in it the creation and control of educational robots. Such robots are mandatory equipment in the modern robotics labs in the schools and the universities.

The learning of the robotics in schools is extremely relevant in the context of STEM (Science, Technology, Engineering and Mathematics) education. This learning enables students to take part in experiments, and they are encouraged to share their ideas and contribute to the development of group projects aimed at learning about the world around them. One of the main advantages of STEM education is the integration of individual subjects into an integrated curriculum. This allows students to understand the interconnections between the subjects they study at school. The use of this type of training will lead to a much better preparation of students for the rapidly developing modern technologies and will prepare them for the demands of the labor market. Proof of the relevance of such training is the start of the construction of STEM classrooms in all over 2,200 schools and centers for special educational support in the country. The Minister of Education and Science announced in March that an investment of BGN 37 million was planned for the establishment of a national STEM center in cooperation between the Ministry of Education and Science and the Ministry of Innovation and Growth.

Some of the STEM labs are planned to be in robotics. For them, it will be necessary to equip them with educational robots. This requires research on different types of robots, as well as the development and research of different algorithms for their control, in order to select the most suitable ones for different age groups of students. The studies and analysis in the dissertation are closely related to previously mentioned topics, which makes them undeniably relevant.

4. Degree of knowledge of the problem state.

In the first chapter of the dissertation, a brief historical overview of the development of robotics is made, from the emergence of the idea of robots at the beginning of the 20th century through the creation of the first robots to the robots used in the last decade.

The PhD student has presented two criteria classification of robots - according to their purpose and according to the method of navigation used in them. He also has presented examples of the application of different types of robots.

A review and analysis of the development of educational robotics in recent years is made. He has substantiated a forecast for the further development of learning robots and their use to support the learning process. A survey of the educational potential of educational robotics is made and its benefits in education are formulated, as well as the advantages of educational robots.

Different ways of actuating the mobile robots are discussed, showing their advantages and disadvantages. The technologies for solving different types of tasks, such as avoiding obstacles, following a line, etc. are regarded. Examples of robots used in the classroom are also presented.

What has been mentioned above shows that the PhD student is well acquainted with various aspects of the regarded in dissertation problem.

5. Correspondence of the goal and tasks with the achieved results in the dissertation.

The following goal is formulated in the dissertation work – "Research, development and synthesizing of algorithms and systems for controlling educational robots".

To achieve the set goal, the following tasks are formulated:
- A structure of the control system of mobile educational robots must be proposed.
- Some innovative approaches for developing algorithms of a mobile educational robot Nitrobot working in autonomous and manual mode must be proposed.
- A comparative analysis of the algorithms of mobile educational robots in the performance of certain tasks must be carried out.
- Some experiments based on the developed algorithms must be conducted.
- The results of all tasks must be analyzed.

The research methodology includes an analysis of the methods for solving various tasks by the educational robots. Based on this analysis, the methods to be

implemented are selected. To implement the methods, suitable hardware devices are chosen and the algorithms for control and navigation of the robots are developed.

The chosen approach in the dissertation fully corresponds to the set goal. The obtained results show that all the tasks are fulfilled, which also achieved the goal set in the dissertation.

6. Characteristics of the dissertation.

In the introduction, a brief justification of the relevance of the problem considered in the dissertation has been made. The goal of the dissertation and the tasks for its achievement are formulated.

In the first chapter a review of the historical development of robotics and robots is done. Robot classifications are considered and mobile robot actuating methods are analyzed. An analysis and forecast for the development of educational robotics are done. Three main tasks have been formulated that educational robots must be able to solve - avoiding obstacles, finding a way out of a maze and following a line.

In the second chapter, the methods for solving the formulated tasks for the developed educational robots are analyzed. Algorithms for implementing the control of robots are analyzed. For each task, the necessary hardware modules (sensors, power supply, driving electric motors, etc.) are chosen and control block diagrams have been synthesized. A Nitrobot mobile educational platform with differential drive are developed, and the cost of all components is estimated to not exceed 100 euros. The chassis, the necessary hardware modules and the power supply are chosen. A block diagram of the robot control is synthesized.

Algorithms for navigation and control of the robot, that solving the following tasks have been developed:
- avoiding obstacles;
- finding a way out of a maze;
- following a line.

Experiments and a comparative analysis of the results of them are made in the cases of the robot moving from one point to another in the absence and presence of previously undefined obstacles for two robots with different wheel drives.

For this purpose, a second robot with mecanum wheels and a platform with dimensions similar to Nitrobot is developed. The block diagrams and control algorithms of the second platform are developed.

Algorithms to control a mobile robotic platform using a machine vision sensor aren developed.

In the third chapter, the methods for remote control of robotic platforms are analyzed. The block diagrams and algorithms for remote control of a robot by infrared remote control, by joystick on a radio channel and by buttons on a radio channel are developed. A software with interface for Android devices is developed based on the MIT App Invertor application for remote control of an educational mobile robot through Bluetooth communication.

In the fourth chapter, the experiments carried out with the developed robots using the synthesized algorithms are described. The conditions for performing each experiment are described precisely. The troubles in the first experiments and the

additional adjustments and corrections that have been made are correctly indicated. The results of the experiments show that the developed robots successfully perform the assigned tasks. In the comparative analysis of the results, it has been concluded that the robot with mecanum wheels performs better than the robot with differential wheel drive for the set tasks.

The Conclusion part summarizes the obtained results and makes recommendations for future research. The applied and the practical contributions of the dissertation are formulated.

The dissertation is characterized by in-depth knowledge of issues related to the principles of work, implementation and programming of educational robots. Sufficient experimental material is presented, illustrating the capabilities of the developed robotic platforms and the synthesized algorithms for their control.

7. Scientific, applied and practical contributions of the dissertation.

I accept and positively assess the applied and practical contributions formulated in the dissertation and in the summary. In summary, they can be grouped as follows:

1. Applied contributions:
   - research and analysis of methods and algorithms for control and navigation of educational robots in overcoming obstacles, searching for an exit from a maze, exit from a closed space and following a line;
   - research and analysis of methods and algorithms for remote control of educational robots;
   - developing of algorithms for control and navigation of educational robots with differential wheel drive and using mecanum wheels;
   - performing a comparative analysis of the performance of robots with different navigation and driving wheels.
2. Practical contributions:
   - making educational robots;
   - implementation of innovative line-tracking and object-tracking algorithms for a robot navigating using a HUSKYLENS smart camera;
   - development of an interface for Android devices based on the MIT App Invertor application, designed for remote control of an mobile educational robot, using Bluetooth communication.

8. Assessment of the degree of personal involvement of the PhD student in the contributions.

I consider the dissertation and its contributions to be the personal work of the PhD student, obtained under the direct supervision of the supervisor.

9. Evaluation of the dissertation publications.

Submitted to me 6 publications consist of 4 papers at international scientific conferences and 2 journal articles. One of the publications is independent, and 5 are co-authored. Of those in co-authorship, the PhD student is listed first in 3 of them and

second in 2, indicating that Eng. Yovkov is a major contributor to these publications. Four of the publications are in English and two are in Bulgarian. Four of the publications are in science editions indexed in Scopus, and 2 are in not referenced journals with scientific reviewing. All publications were made in the period from 2021 to 2023 years. The content of the publications fully reflects the PhD student's research in the dissertation. The contributions in the publications overlap completely with those formulated by me for the dissertation.

The content of the publications and the editions in which they were published guarantee that the research in the dissertation and their results have become widely known in Bulgaria and abroad. I also consider it a strength that most of them are in science editions indexed in Scopus.

10. Significance of the results of the dissertation in science and practice.

In my opinion, the significance of the dissertation is in the practical applicability of the obtained results. It consists in providing the algorithmic control of educational robots in STEM labs, as well as providing an interface for remote control of such robots. The developed algorithms and interface can be used both by students to build educational robots and by teachers to develop the learning content of educational programs.

11. Assessment of compliance of the summary to the requirements.

The summary is 37 pages long and generally meets the requirements for its formatting. The content of the summary corresponds to the content of the dissertation and accurately presents the main results of the dissertation. As a recommendation, I would point out that it would have been better to shorten the presentation of the first chapter of the dissertation, and instead, the diagrams of some of the developed algorithms should have been included in the summary.

A summary of the dissertation in English in a volume of 33 pages is also presented.

12. Personal impressions of the candidate for educational and scientific degree "doctor".

I do not know the PhD student personally and have no personal impressions of him.

13. Opinion, recommendations and remarks.

The dissertation has been developed in the necessary volume and represents a completed scientific and research work. The PhD student has carried out a thorough and systematic study of the problem and has proposed original solutions with scientific and applied results that fully meet the set goal and tasks of the dissertation.

I have no critical remarks on the substance of the dissertation and the presented results, but I have remarks on the layout and style.

My main remarks on the layout are as follows:
- the chapters do not start on a new page;
- there are places where the font of the text is not the same (for example, in the penultimate paragraph on page 22 and the third paragraph on page 28);

- there are lines where the text is on a gray background (for example, in the first paragraph of point 2.1.1.);
- some of the figures do not have captions (for example, the first figure on page 14);
- there are different figures with the same caption (for example, from page 12 to page 14 there are 4 figures marked with Fig. 1.4);
- there are no equation captions;
- there are no table captions, and some are labeled as figures (for example, Fig. 2.8 on page 68);
- the first line of the text in the tables are indented.

Regarding the style, I have the following remarks:
- active and passive voice are used in the dissertation;
- the text in the block diagrams and the algorithms in the dissertation are in English, but it is appropriate that it is in Bulgarian;
- for many figures there is no explanation in the caption (for example, Fig. 1.6 on page 15);
- the volume of the historical overview of robotics is unnecessarily large (12 pages), especially since it mainly covers robots that are not the subject of the dissertation;
- there are a wrong references to figures (for example, on page 73, the first paragraph begins in this way "Fig. 2.10. illustrates an algorithm ...", but in fact, the algorithm is shown in Fig. 2.14);
- there are figures in the dissertation that are not the author's, and it is proper to indicate the source from which they were taken;
- in some places, a literal translation from English was obviously used, without using the established technical terms in Bulgarian (for example, on page 40 in the sentence "... of the frame attached to the body", it is obviously meant "... of the body-related coordinate system".

Some grammatical errors were also made in the dissertation.

These remarks are not of the essence of the work and do not diminish the value of the contributions in the dissertation.

My recommendations to the PhD student are as follows:
- To pay more attention to the layout, because it creates the first impression of the scientific work and can lead to the rejection or poor evaluation of a very good scientific work in content.
- To use passive voice in his future publications.
- In order to avoid errors in the captions of figures and equations, it is better to use the automatic captions in text editors.
- To continue his work in the field of robotics by expanding research beyond the field of educational robots.

CONCLUSION

I positively assess the work done and the results obtained in the dissertation. The dissertation sufficiently meets the requirements of the ADASRB, the Regulations on

its implementation, as well as the Regulations for the specific conditions for acquiring scientific degrees and holding academic positions at the IICT. I propose to the respected Scientific Jury to award the M.Sc. Eng. Stanislav Yovchev Yovkov the educational and scientific degree "doctor" in higher education area 5. Technical Sciences, professional field 5.2. Electrical Engineering, Electronics and Automation in doctoral program "Automated systems for information processing and control".

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На основание

ЗЗЛД