

OPINION

from Prof. D.Sc. Krasimira Petrova Stoilova

Institute of Information and Communication Technologies –
Bulgarian Academy of Sciences,
about the Ph.D. thesis for acquisition of the scientific degree “doctor”
in the professional area 5.2 Electrical Engineering, Electronics and Automation,
scientific specialty Automated system for information processing and management

Author of the PhD thesis: **Milena Filipova Groueva**

Topic of the PhD thesis: **Group control of robotized means for transport of loads**
Ph.D. Supervisor: prof. Ph.D. Dimitar Karastoyanov, ICT-BAS, Department Embedded
Intelligent Systems

1. Overview of the Ph.D. thesis and analysis of the results

The PhD thesis addresses an important topic, related with the control and management of a class of mechatronic systems - group control, following a leader by set of slave robotic transportation units. The PhD dissertation contains 151 pages, including introduction, 4 chapters, conclusion, reference list and declaration for originality of the results. It has been used 101 references mainly in English. It is a good approach that the PhD thesis includes in the reference list research results of Bulgarian scientists. The content of the thesis is described in logical sequence, which serves for the goal of an interdisciplinary research. The goal of the PhD thesis is defined as “...to investigate the types of mobile group control and to offer innovative approaches for group control of transportation robots...”. this goal is decomposed to five working problems, which are solved in the PhD thesis: 1) Analytical overview and classification of the mobile robots and methods for their group control; 2) Assessment of the existing approaches for group control of mobile robots for the case of “following the leader” in distributed environment; 3) Design of architecture, organization and content of a control system for group control; 4) Development of innovation approach for implementation of robotic transportation tools under group control; 5) Engineering experiments for group control of transportation robots operating in different environments and assessment of the experimental results.

The first working problem is worked out in Chapter 1 of the thesis. It is presented an overview and classification of the different sets of mobile robots.

The second and third problems are worked out in Chapter 2. It has been assessed different policies for group control of robots. Special attention is paid to the main object of the PhD thesis concerning transportation robots.

It is analysed the policy of the group control where the slave robots must follow the leader. It is designed a technical architecture of the control system for the set of transportation robots. Particularly, it has been applied a special kind of robot, which motion lacks from literally sliding. It is presented this specific kinematics of the robot (position, linear and angular velocity, angle of orientation). This robot is the main participant in the group of robots, where the control policy for following the leader is applied. It has been analysed different cases of the group operation,

analytical results are derived, which are used for the definition of control algorithms for the distributed control of a group of transportation robots.

Chapter 3 makes contribution for the fourth problem, defined by the thesis: development of innovative approach for the implementation of robotic transportation tools under group control. This part of the PhD thesis presents the results of the researches of the PhD student. It has been presented the means of communications in a centralized and distributed set of mobile robots. It is performed a software modeling and simulation of robot set with the software suit Webots. For the control of the robot motion it has been use the special operation system ROS (Robot Operating System). The software simulations applied different control algorithms.

In chapter 4 are presented the results from real engineering experiments, which are stated in the fifth problem of the PhD thesis. It has been presented the content of the communication protocols, applied for the group control. Additionally it was given comparisons with existing wireless protocols and appropriate communication standards. On my point of view the assessment of the standardization of the wireless protocols should be included in Chapter 2 of the thesis instead of the last chapter.

2. Correspondence between the PhD abstract and the thesis

The PhD abstract presents the results of the PhD thesis. It contains mainly the author's developments, presented in Chapters 1 and 4.

3. Characteristics and assessment of the contributions of the PhD thesis

The PhD thesis contains theoretical and application results.

1. It has been designed technical architectures of a centralized and decentralized control system for group control of transportation robots.
2. It has been developed an innovative approach for the simulation of the group control of mobile robots, where each robot is under control of ROS operating system. The simulations of the mobile group were performed with the software suit Webots.
3. Real engineering experiments were provided for the group control of mobile transportation robots under different requirements with one and several leaders.

My personal assesment of the PhD results is positive. To achieve these results the PhD student applied different theories and approaches: theory of automatic control, data communications, modeling and simulation, application of information technology.

4. Assessment of the publications made for the PhD thesis

The PhD student presents 9 publications, related to the researches in the thesis. Three of them are published in journals; the rested 6 are presented on conferences. The legislative requirements for the PhD thesis insist 30 points, however the student has achieved twice more – 73.32. This information, together with my acquaintance with the publications give me a ground to claim that there are done personally by the PhD student. These results satisfy the institutional regulations of the Institute of Information and Communication Technologies for awarding the research and educational degree “PhD”.

5. Critical remarks end comments

The PhD thesis demonstrates the interdisciplinary competence of the student. The thesis has cosize style of writing supported by rich illustrative material.

My remarks have technical nature, which does not decrease the importance of the achived research results. I recommend in the end of each chapter to be given information which author's publications have been submitted with these results.

I find inappropriate the usage of foreign words instead of well known bulgarin ones: pattern (p.67-68), infinitive prognostic horizon (p.73), sensor alterirat (p.110) and others.

It should be presented somewhere in the document information about the PhD procedure the legislative requirements for awording the research and educational degree PhD.

6. Conclusion

My estimation is that the legislative requirements of the Law for academic growth in Bulgaria, the Regulations for its application and the specific requirements of the Institute of information and communication technologies – Bulgarian Academy of Sciences are satisfied. The PhD thesis of eng. Milena Filipova Grueva contains all needed properties as a PhD thesis, which I assess positively. The PhD thesis contains theoretical and applicational results which are original contribution for the domain of group robot control. The PhD student acwuires deep theoretical knowledge and can provide independently scientific researches. I recommend to the honorable Scientific Jury Milena Filipova Groueva to be awarded with the Educational and scientific degree “doctor” in the professional field 5.2 Electrical engineering, Electronics and Automation, scientific specialty Automated system for information processing and management.

14 July 2020

Member of the Jury:

**NOT FOR
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/ D.Sc. K. Stoilova/