

REVIEW

under the procedure for acquisition of the educational and scientific degree “Doctor”
by candidate Lyubomira Lachezarova Miteva,
of the PhD Thesis entitled: “Modelling and Control of an Antropomorphic Robot Arm”,
In the Scientific field: **4. Natural Sciences, Mathematics and Informatics**
Professional field: **4.6. Informatics and Computer Sciences /**
Doctoral program “Information systems” – Embedded and autonomous systems”,
Department „Computer Informatics”,
Faculty of Mathematics and Informatics (FMI), Sofia University “St. Kliment Ohridski”
(SU),

The review has been prepared by: **Prof. Stefka Fidanova, PhD, IICT-BAS**

(academic position, scientific degree, given names, surname - place of work)

as a member of the scientific jury for the defense of this PhD thesis according to Order № ПД 38-114/06.03.2023y of the Rector of the Sofia University.

1. General characteristics of the dissertation thesis and the presented materials

My presented dissertation: contains 132 pages and consists of: introduction and 4 chapters; 76 figures; 11 tables and 98 titles in the presented bibliography.

The first chapter is an overview and introduces the subject area.

Chapter 2 is devoted to modeling a planar anthropomorphic robot. An approach has been developed to classify the inverse problem by type.

In Chapter 3, a software design for controlling a planar robot is presented. Steering in the presence of obstacles is considered.

In Chapter 4, experimental verification of the developed model is done using a 3D printed robot. The experiments were done with a planar robot prototype. In this chapter, prospects for further development of the subject are given. Dynamic obstacles can be introduced. An analysis of the sensitivity of the proposed algorithms to their parameters could be done.

2. Short CV and personal impressions of the candidate

he candidate obtained a bachelor's degree in software engineering from Sofia University "St. Kliment Ohridski" in 2017, master's degree in informatics-mechatronics and robotics from Sofia University "St. Kliment Ohridski" in 2019. She was a full-time doctoral student at Sofia University "St. Kliment Ohridski", Faculty of Mathematics and Informatics in doctoral program "Information Systems" - Embedded and autonomous systems, during the period February 2020 - February 2023.

I do not know the candidate personally and have no personal impressions of his work.

3. Content analysis of the scientific and applied achievements of the candidate, contained in the presented PhD thesis and the publications to it, included in the procedure

Robotic systems are used in more and more spheres of industry, and in recent years they have entered widely into the sphere of services. This increases the flexibility of production and reduces the probability of errors. It can be concluded that the topic of the presented dissertation is relevant.

The aim of this thesis is to create a mathematical model and prototype of a planar anthropomorphic robot with additional degrees of freedom, as well as to research and create methods for controlling its movement.

To achieve this goal, the following tasks can be formulated:

- 1. Classification of different types of solutions to the inverse kinematics problem for a planar robot with additional degrees of freedom.*
- 2. Research and creation of trajectory planning algorithms for the researched planar anthropomorphic robot with additional degrees of freedom in order to overcome static and/or dynamic obstacles and reach a desired target position.*
- 3. Analysis and selection of appropriate hardware components and design of suitable software system to control the created planar robot with additional degrees of freedom.*
- 4. Creation of a planar robot prototype with additional degrees of freedom, using 3D printing methods.*
- 5. Verification of the proposed hardware and software control system and the trajectory planning algorithms, through computer simulation and experiment with the designed robotic system.*

We can divide the contributions of the dissertation into scientifically applied and applied:

Scientific and applied contributions:

- An approach was created to classify by type the solutions of the inverse kinematics problem for a planar robot with additional degrees of freedom.*
- An analysis of the workspace of a planar robot with additional degrees of freedom depending on the available obstacles was performed.*
- The angle of service in the workspace of a planar robot with additional degrees of freedom was investigated.*
- A planar robot trajectory planning algorithm with additional degrees of freedom and limited joint space based on graph theory was created.*
- A motion planning approach in the presence of static obstacles for a planar robot with additional degrees of freedom has been created.*
- An algorithm was created for real-time dynamic obstacle avoidance in the workspace of a planar robot with additional degrees of freedom.*

Applied Contributions

- A hardware and software system was designed to control a planar robot with additional degrees of freedom.*
- A computer experiment of the developed trajectory planning methods was created using Webots simulation software.*
- Real experiments were conducted with a 3D printed prototype of a planar robot with additional degrees of freedom in order to verify the algorithms for planning a trajectory in the presence of static or dynamic obstacles in the robot's workspace.*

Bearing in mind that the candidate's publications are in publications referenced and indexed in the world referencing and indexing system, the originality of the presented dissertation work and the publications to it is indisputable. The doctoral student presented guidelines for future work and development of the topic. I would also add the management of autonomous vehicles to the mentioned guidelines, an extremely topical topic.

4. Approbation of the results

The results of Lubomira Miteva's dissertation were reported at 4 international conferences. She has presented 6 publications in which the results of the dissertation are presented. 3 of the publications have an impact rank on Scopus, and the remaining 3 are referenced in the global referencing and indexing system. One of the publications was awarded as the best paper in the section. Impressively, the dissertation has 20 publications visible in Scopus and 6 citations. All publications are co-authored with one or two other authors, but considering the multidisciplinary nature of the subject, I believe that the doctoral student has made a significant contribution.

It is clearly stated that:

- a) *the scientific works meet / do not meet the minimum national requirements (under Art. 2b, para. 2 and 3 of ADASRB*) and respectively to the additional requirements of Sofia University "St. Kliment Ohridski" for acquiring the educational and scientific degree "Doctor"/ scientific degree "Doctor of Science" in the scientific field and professional field of the procedure;*
- b) *the results presented by the candidate in the dissertation work and scientific works to it do not repeat / repeat (it is explained which and to what extent) such from previous procedures for acquiring a scientific title and academic position;*
- c) *there is no / there is plagiarism proven in the legally established order in the submitted dissertation work and scientific papers under this procedure.*

5. Qualities of the abstract

The abstract meets the requirements and correctly presents the thesis.

6. Critical notes and recommendations

The dissertation is well structured and clearly presents the tasks and their solution. The dissertation student shows in-depth knowledge in the field under consideration. The ability to work in a team is important for scientific activity, but nevertheless, I recommend that the dissertation student also publish independent works.

7. Conclusion

Having become acquainted with the PhD thesis presented in the procedure and the accompanying scientific papers and on the basis of the analysis of their importance and the scientific and applied contributions contained therein, **I confirm** that the presented PhD thesis and the scientific publications to it, as well as the quality and originality of the results and achievements presented in them, meet the requirements of the ADAS in the Republic of Bulgaria, the Rules for its Implementation and the corresponding Rules at the Sofia University “St. Kliment Ohridski” (FMI-SU) for acquisition by the candidate of educational and scientific degree “Doctor”/the scientific degree “Doctor of Science” in the Scientific field 4. Natural Sciences, mathematics and informatics, Professional field 4.6 Informatics and computer science. In particular, the candidate meets the minimal national requirements in the professional field and no plagiarism has been detected in the scientific papers submitted for the competition.

Based on the above, **I strongly recommend** the scientific jury to award Lyubomira Lachezarova Miteva, the educational and scientific degree “Doctor” in the Scientific field 4. Natural Sciences, mathematics and informatics, Professional field 4.6 Informatics and computer science.

Date: 20.04.2023

Reviewer:

/Prof. Stefka Fidanova, PhD/

**ADASRB - Act on Development of the Academic Staff in the Republic of Bulgaria*