



OPINION

on a dissertation project for the awarding of the educational and scientific degree "Doctor" in professional field **5.1. Mechanical Engineering**, scientific specialty 02.01.52 - "Robots and Manipulators"

Thesis topic: **Design and control of a 3D-printed humanoid hand**

Author of the thesis: **Mag. Eng. Ivaylo Robertov Georgiev**

Member of the jury: **Assoc. Prof. Nina Foteva Valchkova, PhD, Eng.**

1. Scope of the dissertation.

The dissertation consists of a main part of 115 pages, structured into an introduction and 5 chapters, a list of main contributions, a declaration of originality, a list of publications related to the dissertation, reports, participation in projects related to the topic of the dissertation, 5 appendices, and a list of references. A total of 65 literary sources are cited, with corresponding Internet addresses are also provided. In connection with the work, five scientific publications are presented, all co-authored. The work includes a total of 53 figures and nine tables.

2. Relevance of the developed problem in scientific and applied terms.

The dissertation addresses and analyzes a current and relevant problem in scientific and applied terms, namely, the dependencies and basic characteristics of humanoid hands, which are undergoing rapid development supported by innovations in electronics, sensor technology, and control. Today, anthropomorphic hands are used in a number of fields in science, medicine, and industry.

In medicine, robotic arms are used as prosthetic replacements for hands. In telemedicine (remote surgery) and telerehabilitation of arms for remote treatment of patients. Humanoid arms are used remotely to perform precise movements in environments that are dangerous for humans.

The design of the humanoid arm proposed in the dissertation, the methods used for design, prototyping, and control enrich and build on the knowledge in this field. The dissertation is of major importance for the development of humanoid robotics in Bulgaria.

3. Degree and levels of relevance of the problem and specific tasks developed in the dissertation.

The relevance of the problem addressed is of high level, considering that humanoid hands aim to reproduce the human and to come as close as possible to its functionality, despite the difficulty of replicating the complex movements acquired over millions of years of

evolution. Studying humanoid robotic hands can contribute to a better understanding of human biology and provide better understanding of the dexterity and complexity of human hand movements. The aim of the dissertation is to design and create a 3D-printed humanoid robotic hand built on a modular principle, as well as to investigate its functional capabilities. Each finger of the hand is driven by an independently controlled motor. The modularity refers to the fingers and includes the hardware and software for their control. The stated objective is achieved by solving seven tasks.

4. Level of knowledge of the problem and creative interpretation of the literature.

The dissertation demonstrates an impressively high level of familiarity with the current state of the problem, as well as a very good creative interpretation of the literature review proposed in the first chapter of the work.

5. Consistency of the chosen research methodology and the set goal and tasks of the dissertation with the achieved contributions.

I consider that the goal and objectives formulated in the first chapter fully correspond to the achieved scientific-applied and applied contributions, and that the methodology used is fully adequate to the set goal.

6. Contributions of the dissertation.

These contributions are correctly divided into scientific-applied and applied contributions. An approach has been developed for creating assembled 3D-printed fingers for a humanoid hand. An innovative design has been proposed that allows the fingers to be printed as a single object with movable joints using FDM printing technology. The geometric and kinematic characteristics of the fingers of the human hand have been studied.

In terms of applied contributions, a prototype of a humanoid hand with modular fingers has been created, hardware and software for controlling and adjusting the 3D-printed modular humanoid hand has been developed, and software for reproducing signs from the sign-language alphabet has been created, which is implemented on the 3D-printed humanoid hand. Experiments have been conducted to confirm the functionality of the 3D-printed hand. These experiments include object grasping and sign-language reproduction.

In terms of their significance, the contributions to practical implementation play a key role in the implementation of 3D-printed fingers on a humanoid hand. That is why I fully accept the contributions formulated in the dissertation.

7. Assessment of the publications related to the dissertation.

Five articles indexed in Scopus and four conference papers presented at international conferences abroad and in Bulgaria have been published in connection with the dissertation. In my opinion, these publications and papers are entirely sufficient in terms of validating the results of the work. At the same time, the main ideas in the dissertation have been also defended in this way, as they are presented at highly prestigious scientific forums.

8. Opinions, recommendations, and comments.

Some remarks and recommendations can be made regarding the dissertation, which are primarily editorial in nature and in no way diminish the achievements of the work.

With the accumulated knowledge, the candidate can continue work on improving the developed humanoid hand and achieve results that could lead to a utility model and patent.

9. CONCLUSION

In conclusion, I give a **POSITIVE** assessment of the dissertation, which in terms of the significance of the proposed scientific and applied contributions, ranks among the most notable efforts to create a systematic approach to solving the extremely complex task of finding the optimal approach for the analysis and optimization of a 3D-printed humanoid hand.

The requirements of the Law on the Development of the Academic Staff in the Republic of Bulgaria, The Regulations for its implementation, the Regulations on the Conditions and Procedures for Obtaining Scientific Degrees and Holding Academic Positions at the Bulgarian Academy of Sciences (BAS), as well as the internal rules for the development of the academic staff at the Institute of Robotics at BAS, have been fulfilled with regard to the scope, volume, and quality of the dissertation.

Due to the above and on the basis of the positive results achieved in the dissertation, with full confidence I recommend that Mag. Eng. Ivaylo Robertov Georgiev be awarded the educational and scientific degree of "Doctor" in the professional field 5.1 Mechanical Engineering, scientific specialty "Robots and Manipulators".

Date: 10.11.2025

Member of the jury:

/Assoc. Prof. Nina Valchkova, PhD/