REVIEW
of a foreign research advisor on the dissertation
of Arailym Zhanbolatkyzy Orazova
with the title "Application of nonlinear methods to control a multi-link robotic arm", submitted for the degree of Doctor of Philosophy (Ph.D.)
in the educational program 8D07101 – "Automation and Control"

Currently, robotic manipulators are widely used to automate and improve the efficiency of processes in various manufacturing sectors; consequently, tasks related to the control of these robots are highly relevant, and new approaches to addressing them remain a focus for researchers worldwide. The dissertation addresses a topical and practically significant subject within the framework of two projects funded by the Science Committee of the Ministry of Science and Higher Education of the Republic of Kazakhstan: AP19679327 "Methods of machine learning for tasks of automatic control and inertial navigation of mobile robots" and AP13068317 "Development of new robot-manipulator control algorithms for 3D scanning technologies and additive microplasma spraying of coatings".

In the dissertation, Arailym Orazova has developed and tested new models and approaches, as well as a nonlinear robust control law for the linearized dynamics of a multi-link robotic manipulator; these offer advantages over existing solutions by enabling improved control accuracy.

The validity of the developed models and the nonlinear control law has been verified in practice through computer simulation methods. The soundness of these approaches is confirmed by the high caliber of publications on the research topic.

The main new scientific results of the dissertation work are the following, proven in the dissertation and in the publications of Orazova A.Zh.:

1. A serial robotic manipulator is presented as a specific type of differentially flat control system; a generalized computed-torque method and a linearization approach for the manipulator control system have been developed.

2. A geometric interpretation of the manipulator’s dynamics is provided, along with linearization via static state feedback.

3. A nonlinear robust control law has been developed for the linearized dynamics of a multi-link robotic manipulator. This control law ensures stability and improves the accuracy of trajectory tracking in the presence of parametric uncertainties, mathematical model inaccuracies, and external disturbances. Conditions for the stability of the closed-loop control system and the convergence of the trajectory-tracking error under the proposed nonlinear robust control law have been derived.

The title of the dissertation corresponds to the passport of the specialty and its content. The dissertation and the results obtained in it are characterized by internal unity: the goals and objectives of the study are clearly formulated, and it is shown that each result was obtained during the implementation of a specific task and serves to achieve the set goal of the study. All results are logically interconnected, that is, they are achieved consistently and are necessary. The logic is clearly traced,

reflecting the unity of the theoretical constructions of the dissertation author and the practical results of the work.

The research results presented in this dissertation were obtained by the author independently. It should be noted that part of the research on modeling and control of the robotic manipulator was carried out and discussed in the laboratories of the Research and Innovation Center (EKIK) of Óbuda University, Budapest, Hungary during two doctoral student research internships from 15 to 29 November 2023 and from 14 to 28 May 2024.

Thus, the author's personal involvement in obtaining the results presented in the dissertation was comprehensive - from participation in the planning of the experiment and its implementation, to the formulation and discussion of the research results.

The main results of the dissertation, supporting its scientific findings and conclusions, have been published in peer-reviewed scientific journals and international conference proceedings.

Thus, the dissertation of Orazova A.Zh in terms of scientific novelty, completeness and significance of the obtained results meets the requirements of Chapter 2 of the "Rules for Awarding Academic Degrees" of the Committee for Control in the Sphere of Education and Science of the Ministry of Science and Higher Education, presented to works submitted for the degree of Doctor of Philosophy (Ph.D.) and is recommended for public defense. Arailym Zhanbolatkyzy Orazova deserves to be awarded the Ph.D. degree in "Automation and Control."

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