

## *Review of a Doctoral Thesis at FIT BUT*

**Doctoral thesis:** End-user Cobot Programming in Augmented Reality

**Name of the doctoral student:** Ing. Michal Kapinus

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**Name and institution of the reviewer:**

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### **I. Doctoral Thesis**

#### Appropriateness and Relevance

The issue of collaborative robotics is alive and effective cooperation of humans with collaborative robots (cobots) is still in the development stage. The safety of the coexistence of a robot and a human worker can be solved by appropriately limiting motion velocity and acting forces, respectively, by applying suitable anti-collision sensors on the robot's body. The more significant challenge is simplifying human-robot interaction from the point of view of programming the performance of technological operations or their control in real-time, which will make it possible to implement this technology even in small-scale production.

#### A summary of the Contributions of the Thesis

Mr. Kapinus has set in his thesis four goals:

- definition of visualization and interaction methods suitable for human-robot interface
- design of program flow in the form of visualization
- definition and visualization of the program's 3D spatial parameters
- evaluation of the proposed methods

All of the listed goals have been completed, extensively evaluated, and carefully documented.

#### Novelty and Significance:

The novelty of the results lies in the design and implementation of interactive methods of selecting objects of interest by an operator in augmented reality and defining the prescribed movement scheme and technological sequence of operations performed by the robot arm. The mentioned human-robot interaction methods are not a standard part of industrially supplied solutions. We can understand them as an addition to existing systems to ensure the ability of the worker-craftsman to program and cooperate with the robot even without extensive knowledge in the field of robotic systems and their programming.



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### Evaluation of the Formal Aspects of the Thesis:

The dissertation is logically segmented into reasonably large chapters and subsections. As a not native English speaker, I can only tell that I would similarly write most of the formulations and that my checker Grammarly had only a few suggestions for stylistic and grammar corrections.

The author wrote the accompanying text with insight; some sentences in the style "Moreover, humans have very versatile end-effectors, also known as hands" were witty.

Hypertext links to literary sources or abbreviations used in the PDF document are helpful for the reader.

The dissertation contains no mathematics and only a single classic block diagram. The absence of mathematics is fine in principle; however, the transformations of the coordinate systems connected to the worktable, robot or AR observer could have been formalized, and several described procedures could also have been expressed in graphic form.

The work, written in a pleasant typographic design, contains enough own or reprinted illustrative images that match the textual explanation, as well as several tables with the evaluation of the success of the experiments.

### Quality of Publications

In the period 2016-2022 there were published 9 articles in (and only in) IEEE or ACME/IEEE International Conferences and Symposia, which have been listed in Web of Science. In 3 of them, Mr. Kapinus is named as the first author. All publications have, along with WoS database, together about 50 citations, which is a good result. Scopus database provides almost the very same results. The achieved results would also deserve their presentation in suitably focused foreign magazines.

## **II. Candidate's Overall Achievements**

### Overall R&D Activities Evaluation:

Doctoral thesis of Mr. Kapinus contains, besides introductory parts 6 different experiments, including the complete implementation of the workplace, the construction of the experiment, and its evaluation with the participation of dozens of participants. It was obviously the author's attempt to capitalize on all the work done during its solution and its materialization in one place. It is, of course, commendable, but even half the thesis volume would be sufficient for its successful defense. In any case, the volume and quality of the research work carried out by Mr. Kapinus testify to his erudition in theory and implementation of alternative ways to create convenient human-robot interfaces and evaluate their specific properties based on extensive experiments.

As part of international activities, it is possible to note his participation in a research project within the Center for Human-Computer Interaction, University of Salzburg, Austria.



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### III. Conclusion

The submitted dissertation and the student's results to date meet the generally recognized requirements for the award of an academic degree (in accordance with § 47 of Act No. 111/1998 Coll. on Universities).

In Bratislava, 18.03.2023

Signature of the reviewer:

