CZECH TECHNICAL UNIVERSITY IN PRAGUE
Faculty of Civil Engineering
Department of Science and Research
Thákurova 7, 166 29 Praha 6

e–mail: obhajoby@fsv.cvut.cz tel.: 2 2435 8736

Opponent's review of the Doctoral Thesis

Candidate Karel Pavelka

Title of the doctoral thesis Using VR and AR in modern geomatics methods

Study Programme Geodesy and Cartography

Tutor Assistant Professor Jan Pacina, PhD

Opponent Prof., Dr. Sc., Roman Shults

e-mail roman.shults@kfupm.edu.sa

Topicality of the doctoral thesis theme

Commentary: The application of VR and AR technologies is a common trend in the modern world. Geomatics cannot be ignored in this process. Especially, when the geospatial contribution is one of the essential parts of VR/AR technologies. Therefore, the selected scientific theme aligns with cutting-edge concepts such as BIM, Digital Twins, Smart Cities, and IoT. The work demonstrates the significance of geospatial technologies and highlights the idea of multiple data fusion and their integration with contemporary achievements in computer vision. Implementing the obtained results will facilitate the architectural design processes, management of civil engineering projects, facility management, cultural heritage preservation, and education.

☒ excellent	☐ above average	☐ average	☐ below average	☐ poor

Fulfilment of the doctoral thesis objectives

Commentary: Based on the author's topics, one may define the following objectives that were rationale and achieved in the doctoral thesis.

11. The study of the integration capabilities of geospatial technologies, including GIS, close-range photogrammetry, UAV photogrammetry, and terrestrial laser scanning, with VR/AR to improve the structure documentation procedure.

2. The research of GIS capabilities in managing and analyzing spatial data and their incorporation into VR/AR environment.

3. The development of workflows to improve the integration process between geospatial data and VR/AR approaches.

4. The spatial accuracy exploration of geospatial data concerning their integration into VR/AR platforms.

☒ excellent	☐ above average	☐ average	☐ below average	☐ poor

Research methods and procedures

Commentary: Validity and reliability are ensured by a detailed analysis and theoretical developments, which are confirmed by the results of immense experimental research. The author has refined, studied, and applied different methods and approaches to achieve the thesis's goals. Powerful research methods were used, including mathematical statistics, geospatial analysis, and computer vision. The thesis presents a significant amount of experimental observations to confirm the theoretical results obtained by the author.

☐ excellent	☒ above average	☐ average	☐ below average	☐ poor

Results of the doctoral thesis – dissertant's concrete achievements

Commentary: 1. The analysis of visualization methods for 3D model creation using close-range photogrammetry, UAV, and terrestrial laser scanning.

2. The analysis of the possibilities of converting 3D models into VR/AR techniques and offering the model optimization for visualization.

3. The development of geospatial data fusion workflows taking into account further VR/AR visualization requirements.

4. The creation of the optimized workflow for converting 3D models to VR/AR environments.

☐ excellent	☒ above average	☐ average	☐ below average	☐ poor

Importance for practice and for development within a branch of science

Commentary: The primary practical value of the work is the development of valuable recommendations and technological workflows. All practical results relate to the functional improvement of the various geospatial data fusion with focus on VR/AR visualization, the following hands-on achievements should be noted:

- Creation of a prototype of a virtual museum using the Unreal game;

- Apply the debugged processes of geospatial data conversion to cartography within the Geoharmonizer project.

- Design and prepare the design and functions of the associated AR application for the Geoharmonizer project.

- Creation of 3D models for VR and AR from the documentation and reconstruction of miscellaneous cultural heritage objects.

The critical applications of the work include architecture, archaeology, cultural heritage, and civil engineering. The doctoral thesis results can be primarily recommended for implementation in the work of the state services in charge of cultural heritage preservation, restoration, and urban planning. Another valuable contribution in practice is the application of the obtained results in social studies and education.

☒ excellent	☐ above average	☐ average	☐ below average	☐ poor

Formal layout of the doctoral thesis and the level of language used

Commentary: I do not have any remarks regarding the thesis formal layout. The work is well-structured. The scientific language and English particularly are understandable and clear. The application of scientific terms and definitions is correct.

☒ excellent	☒ above average	☐ average	☐ below average	☐ poor

Statement on compliance with citation ethics

The results presented in the thesis are fully covered in peer-review publications. Two or more publications with identical content are missing. I have not noticed any violations of citation ethics.

Remarks

1. I would prefer the author present the developed workflow as a flowchart to clarify the data processing flows (including different data sources, i.e., TLS, drones, photogrammetry, etc.).

2. The author uses the term "ground photogrammetry" without definition. The more frequently used term is "close-range photogrammetry," which is scientifically accepted and refers to photogrammetry with distances up to 300 m.

3. What was the rationale for using cloud-to-cloud comparison for change detection? What critical value was assigned for which the changes may be treated as significant?

Final assessment of the doctoral thesis

Based on the study of the doctoral thesis, I believe that the dissertation of Karel Pavelka, "Using VR and AR in modern geomatics methods" is a completed scientific work devoted to solving an important and topical scientific task of close-range photogrammetry data processing for VR and AR tasks. The carried out studies have scientific novelty and practical value. The dissertation corresponds to the topics and scientific directions of the study program "Geodesy and Photogrammetry", and its author, Karel Pavelka, deserves the Doctor of Philosophy degree award.

Following a successful defence of the doctoral thesis I recommend the granting of the Ph.D. degree		
	yes ☒	***no*** ☐

Date: 09/03/2025

Opponent's signature: .....