REVIEW

of the dissertation thesis
for the award of the educational and scientific degree Doctor
in the field of higher education 5. Technical Sciences
professional field 5.3. Communication and Computer Engineering
doctoral program "Automated Information Processing and Control Systems"

Author: Victoria Tsvetanova Velkova
Title: Development and Research of a Service for Delivering Personalized Content for Visitors of Open-Air Museums

Reviewer: Prof. Desislava Ivanova Paneva-Marinova, PhD, Institute of Mathematics and Informatics, Bulgarian Academy of Sciences

1. Subject and Relevance of the Dissertation

The dissertation presents research results related to the development of technological tools supporting personalization and personalized experience in museums. Specifically, it aims at the design, development, and experimental implementation of a system for delivering personalized content to visitors of open-air museums by means of modern positioning, identification technologies, and AI. The topic and the work are timely and of significant scientific and applied interest.

2. Literature Review

The reference list comprises 158 titles, distributed as follows: 5 in Bulgarian (3 books and 2 articles); 153 in English (3 books, 104 journal articles, 36 papers from international conferences, and 10 websites). Notable among them are publications in high-impact IEEE journals such as IEEE Internet of Things Journal, IEEE Systems Journal, and others. Based on the cited literature, it is evident that the doctoral candidate is well acquainted with the state of research in the field. On this basis, the author defines the main research objective and tasks, thereby building upon existing achievements.

3. Research Methodology

The methodology applied in the study is based on established practices in the field.

4. Understanding of the Problem

Achieving the stated research objective requires profound theoretical knowledge and practical skills. From the presented dissertation, it is clear that the doctoral candidate possesses the necessary theoretical preparation and broad knowledge of modern technologies essential to attaining the research goals. She demonstrates good understanding of the research object and consistently follows specific tasks leading to results. The conducted studies are presented and substantiated with convincing analyses and conclusions.

5. General Characteristics and Evaluation of the Dissertation

The dissertation contains 239 pages, structured into table of contents, preface, four chapters, conclusion (including scientific, scientific-applied, applied results, and directions for future research), bibliography of 158 sources in English and Bulgarian, a list of the author's publications on the dissertation topic, analysis of those publications, citations of the author's works, and three appendices.

The **research aim and tasks** are formulated at the end of **Chapter 1 Review of the Available Literature**, as a natural outcome of the extended analysis of the state and development of modern technologies, approaches, techniques, and tools applied in "smart museums" to enable personalization, personalized content delivery, and personalized experience.

Chapter 2 is devoted to analyzing and comparing software architectures suitable for implementing services/systems for delivering personalized content to visitors of smart museums, with the aim of selecting the most appropriate for this study. It presents in detail the architecture of the proposed service, the technology stack, selected microservices, communication methods between microservices, personalization algorithms, and the mobile application as a key component of the service. Economic aspects of the development and deployment of the proposed service and its components are also analyzed.

Chapter 3 focuses on methods for classifying museum visitors in order to provide adaptive content (additional information, personalized routes, customized experiences, etc.). It examines segmentation methods, their specificities and criteria, and presents user profile analyses based on surveys and OAuth authorization from social networks. A methodology and practical guidelines for hybrid segmentation of museum visitors applicable to personalization of content are proposed. The chapter further discusses issues, standards, and recommendations related to personal data protection in open-air museums.

Chapter 4 proposes technological solutions for localization of museum visitors, integrating artificial intelligence for content personalization. A system is developed using NFC tags, BLE beacons, and GPS/NFC geofencing. A mobile application delivering museum content through push notifications is presented. Additional developments include a web service for geofence description using GPS maps, and a mobile application for geofence specification in real environments. All proposed systems, services, and mobile applications have been experimentally tested and validated.

The **Conclusion** provides summaries of the obtained results and highlights the main contributions of the research. Directions for future studies are also proposed.

The dissertation is carefully elaborated, the problem domain is competently and critically analyzed, and the presentation of the developed technological services, algorithms, and tools is detailed and analytically substantiated.

6. Contributions of the Dissertation

The dissertation contains **scientific, scientific-applied, and applied results that constitute original contributions to the research field.**

The scientific and scientific-applied contributions may be outlined as follows:

- Analytical study of modern technologies and methods for delivering personalized content in the museum environment.
- Development of a methodology for hybrid segmentation of museum visitors, combining surveys, OAuth profiling, and BLE/GPS tracking.

- A proposed algorithm for personalized content delivery in open-air museums, which integrates a multi-layer visitor profiling system with energy-efficient sensor management and intelligent notification handling. The algorithm provides dynamic generation of personalized content through integration of generative artificial intelligence.
- A proposed microservices-based architecture integrating geofencing, NFC technologies, and artificial intelligence.
- Design and development of a service for personalized content delivery employing microservices and geofencing.
- Creation of a prototype and minimum viable product of the mobile application ExhibitExplorer, part of the proposed service.
- Design and implementation of multiple microservices, including: interfaces for generative AI-driven personalized content delivery, visitor profile management, personalized notifications, analysis of visitor data, and generation of personalized recommendations.
- Development of a methodology for system validation.

7. Publications and Citations Related to the Dissertation

The author's publications on the dissertation topic include 8 titles, 5 of which are indexed in Scopus and/or Web of Science. All are in international conference proceedings, and one article is published in a ranked scientific edition (Digital Presentation and Preservation of Cultural and Scientific Heritage, 2024). All publications are in English. In four of them, Victoria Velkova is the first author; two are sole-authored, while six are co-authored. The works have received 10 citations. Based on these data, it may be concluded that the results of the dissertation have been sufficiently disseminated and discussed.

8. Authorship of the Results

Having reviewed the dissertation and the accompanying materials, I consider the scientific and applied results to be the author's own contribution.

9. Summary

The Summary consists of 45 pages and accurately reflects the structure of the dissertation, the obtained results, and the conclusions. It complies with the requirements of the Law on the Development of Academic Staff in the Republic of Bulgaria, its regulations, and the Rules of the Technical University of Gabrovo for the acquisition of academic degrees and academic positions.

10. Comments and Recommendations

The dissertation is well structured and written. The conducted research is sufficiently thorough. I have no critical remarks.

The dissertation demonstrates that doctoral candidate Victoria Velkova possesses profound theoretical knowledge and professional competence in the area of automated information processing and control systems, as well as the ability to conduct independent scientific research.

11. Conclusion

I am convinced that the presented dissertation **meets the requirements** of the Law on the

Development of Academic Staff in the Republic of Bulgaria. The achieved results provide sufficient grounds **to recommend** the award of the educational and scientific degree Doctor to Victoria Tsvetanova Velkova in the field of higher education 5. Technical Sciences, professional field 5.3. Communication and Computer Engineering, doctoral program Automated Information Processing and Control Systems.

04.09.*2025 *г. **Reviewer:**
/ Prof. Desislava Paneva-Marinova, PhD /