REVIEW

by Prof. Dr. Stanimir Nedyalkov Stoyanov,

Paisii Hilendarski University of Plovdiv

of a dissertation for awarding the educational and scientific degree 'doctor',

in the field of higher education: 4. Natural sciences, mathematics and informatics

professional direction: 4.6. Informatics and Computer Science

doctoral program: Informatics

Author: Christian Nedelchev Milev

Topic: "Intelligent Personal Tourist Guide"

Scientific supervisor: Prof. Asya Stoyanova-Doycheva, PhD

1. General description of the presented materials

By order No. PD-21-906 dated 26/04/2024 of the Rector of the Plovdiv University "Paisiy Hilendarski" (PU) I have been appointed as a member of the scientific jury to ensure a procedure for the defense of a dissertation work on the topic "Intelligent Personal Tourist Guide" for the acquisition of the educational and scientific degree "Doctor" in the field of higher education 4. Natural sciences, mathematics and informatics, professional direction 4.6. Informatics and computer sciences. The author of the dissertation is Christian Nedelchev Milev - a full-time PhD student of study at the "Computer Systems" department of the Faculty of Mathematics and Informatics (FMI) of the PU with scientific supervisor Prof. Asya Stoyanova-Doycheva, PhD.

The set of materials presented by Christian Nedelchev Milev is in accordance with the Rules for the Development of the Academic Staff of the PU and includes the following documents:

- application form to the rector for opening a procedure;
- resume in European format;
- protocol of the preliminary discussion in the department;
- abstracts in Bulgarian and English;

- declaration of originality and authenticity of the attached documents;
- certificate of compliance with the minimum national requirements;
- list of publications;
- dissertation work;
- opinion of the scientific supervisor on readiness;
- copies of the publications on the subject of the dissertation work;
- a document for the fee paid according to the tariff.

2. Brief biographical data for the PhD student

In 2012, Christian Milev completed his bachelor's degree in informatics at the FMI of the PU, and in 2014 his master's degree in software technologies at the FMI of the PU. In the period 2019 – 2022, he is a full-time doctoral student in the Computer Systems department of the FMI of the PU. In March 2022, she was expelled from doctoral studies with the right to a defense. He has practical experience as a programmer in various companies.

3. Relevance of the topic and appropriateness of the set goals and tasks

The problem investigated in the dissertation is of increasing relevance. The development of specialized personal assistants (in the case of tourism) aware of the physical environment and delivering various intelligent services is a little researched area and the results obtained would have wide practical applications.

4. Knowing the problem

From the presented materials and my personal impressions, I can conclude that the doctoral student knows the state of the issue in detail, is able to creatively evaluate literary sources related to the construction of cyber-physical systems providing intelligent services. Proof of this is also the appropriately selected and up-to-date publications referenced in the dissertation, as well as the achieved research results.

5. Research methodology

Although I do not find a clearly presented methodology in the text of the dissertation, from the formulation of the objectives and tasks of the dissertation, from the structuring of the dissertation

work, as well as from the results achieved, I can conclude that the research was conducted according to a properly selected and effective approach.

6. Characterization and evaluation of the dissertation work

The dissertation is 112 pages long, consists of an introduction, three chapters, a conclusion, a list of publications on the dissertation, a bibliography and a declaration of originality of the results. The referenced 126 literary sources are up-to-date and appropriately selected in accordance with the nature of the research. In my opinion, the dissertation is structured logically correctly and coherently presents the conduct of the research. Each chapter ends with a summary of the main results and conclusions.

In the introductory part of the dissertation, the need to conduct the research is motivated. It is emphasized that research in the field of digitization of cultural and historical heritage is extremely relevant, especially in the context of using new technologies such as the Internet of Things and the Internet of Services, as well as the emerging new field of research and practical applications of the Internet of Cultural Things, which aims to introduce a new way of promoting and disseminating cultural heritage worldwide. The purpose of the research is clearly and comprehensibly formulated and tasks for its achievement are specified. In my opinion, the tasks are an expedient specification of the goals and contribute to the successful planning and conduct of the research. The structure of the dissertation is briefly presented.

In the first chapter, an overview of the state of the issue is made. Mainly examined are various systems operating as tourist guides. I think that despite the huge number of such systems, those that have a direct connection with the subject of the research presented in the dissertation have been selected expediently and motivated. Recommender systems in tourism, interactive tourist guides, agent-based tourist systems and e-tourism are presented and analyzed in detail. Based on the overview at the end of this chapter, the main characteristics of a modern information system that fulfills the function of a personal tourist guide are derived, thereby proposing the framework of the study, which is detailed in the following chapters.

The second chapter presents the architecture and business functionality of the developed personal tourist guide. In general, the architecture is an adaptation of the reference architecture for building a virtual physical space called ViPS. A brief overview of this reference architecture is given. An architecture built on the basis of microservices is proposed especially for the tourist guide. The main main characteristics and advantages of architectures using microservices compared to monolithic architectures are shown. Based on the main advantages of microservices-based architectures, taking into account the ViPS reference architecture and the proposed functions of the

tour guide, the architecture includes eleven components arranged in the following three layers: representative, microservices, and for storing the specialized knowledge of the tour guide. The chapter describes in detail the three operational layers of the architecture. The main service provided by the tour guide is assisting tourists in choosing a desired tourist route, taking into account their interests, opportunities (such as time at their disposal) and the physical and administrative features of the cultural and historical sites included in the route. These tourist itineraries can be generated in two main variants – virtual itineraries and real-time itineraries. The routes are generated using an algorithm implemented on the basis of two concepts for structuring information objects and knowledge - ontologies and environments. Another basic intelligent service offered by the tour guide is recognition of Bulgarian folk costumes and folk embroidery. The service uses neural networks, which makes the proposed prototype even more attractive. To provide and support the basic services, various support services are built into the architecture of the tour guide. For example, services for interaction with system users are integrated in the representative layer, realizing opportunities for conducting surveys to establish the wishes and possibilities of tourists and for visualization of tourist routes. Also in this layer there is a service for presenting the results of costume and embroidery recognition. In the service layer, mainly operational (system) services are integrated, supporting those in the representative layer, for accessing, selecting and extracting data and knowledge from the tourist guide's repositories. In the third layer, functions serving the four main repositories of the tourist guide are implemented: a database for storing user profiles, the ontologies of a cultural-historical topic, metadata for presenting objects as environments and a database for storing digitized images.

In the third chapter, the implementation of a prototype of a personal tourist guide with the architecture given in the previous chapter is presented. For the implementation of the prototype, an integrated technology was proposed, including the following development tools: React Native (a mobile application framework for both IOS and Android platforms), Firebase (an application development platform that uses the three services firebase auth, firebase analytics and push notifications), Redux (predictable state container for JavaScript applications), Google Maps, Geolocation (for retrieving user location information) and Haversine formula (for calculating distances according to spherical geometry). The purpose and use of the individual components of the integrated technology are described in detail in this chapter. Details related to the implementation of individual services are presented. To demonstrate the functionality of the realized prototype, a virtual walk is presented in detail, including cultural and historical sites with different locations. An attractive mobile user interface is also demonstrated.

In the conclusion, the results of the study are summarized in two large groups - results related to the construction of the system architecture, and results related to the implementation of the

prototype. The relationship between the results, the objectives, the structure of the dissertation work and the publications are presented in a table. Brief formulations of four possible aspects for future continuation of research on the topic of the dissertation are presented.

Summarizing, I want to emphasize that the dissertation work has been prepared very thoroughly. The style of the dissertation is very good, clear and easy to read, which helps the correct understanding of the text. The models, algorithms and methods are illustrated with very well-designed diagrams and charts. I am impressed with the business functionality of the tourist guide.

7. Contributions and significance of the development for science and practice

I think that the objectives of the dissertation and the tasks specifying them have been fully achieved. I would summarize the contributions of the research presented in the dissertation as scientific and applied. Among the first, I would consider the proposed architecture of the tourist guide as an intelligent system built on the basis of microservices. Also using neural networks to recognize traditional Bulgarian folklore objects. As a non-trivial contribution, I would also define the use of a large number of ontologies, representing specialized knowledge, to fulfill tourists' requests. I would also define the possibilities of customizing the tourist routes as an original contribution of the dissertation work.

8. Evaluation of publications on the dissertation work

The PhD student has indicated four publications reflecting the results of the dissertation. One was referenced in WoS, three in SCOPUS and one was published in a journal, which significantly exceeded the requirements for publication activity of doctoral students. All publications are co-authored and in English.

9. Personal participation of the PhD student

From the materials presented to me for review and from my personal impressions, I can claim that the results of the conducted research were mainly obtained with the personal participation of the PhDl student.

10. Abstract

The abstract is carefully prepared and summarizes the results of the dissertation work. Its volume is the usual size.

12. Personal impressions

I have personal impressions about the PhD student. I think he consistently pursued the goal of the dissertation and thoroughly solved the tasks. The rich practical experience of the PhD student allowed him to create software tools of good quality.

13. Recommendations for future use of dissertation contributions and results

I agree with the PhD student's views on continuing work on the dissertation topic. In addition to them, I think it will be appropriate to think about using different methods of machine learning, which will make the system even more attractive, up-to-date and usable by tourists.

CONCLUSION

The dissertation contains scientific-applied and applied results, which represent an original contribution to science and meet all the requirements of the Law on the Development of the Academic Staff in the Republic of Bulgaria (ZRASRB), the Regulations for the Implementation of ZRASRB and the relevant Regulations of PU "Paisiy Hilendarski". The materials presented and the results of the research in the dissertation fully correspond to the specific requirements of the Faculty of Mathematics and Informatics, adopted in connection with the Regulations of the PU for the application of ZRASRB.

The dissertation shows that the PhD student Christian Nedelchev Milev possesses in-depth theoretical knowledge and professional skills in the scientific specialty of informatics (development of intelligent systems), demonstrating qualities and skills for independent conduct of scientific research.

Due to the above, I confidently give my positive assessment of the conducted research, presented by the above-reviewed dissertation work, abstract, achieved results and contributions, and I propose to the honorable scientific jury to award the educational and scientific degree "doctor" to Christian Nedelchev Milev in the field of higher education: 4. Natural sciences, mathematics and informatics, professional direction: 4.6. Informatics and Computer Science, PhD Program: Informatics.

20.05.2024 Reviewer: .....

(Prof. Stanimir Stoyanov)