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REVIEW

on the dissertation on the topic: "ANALYSIS OF THE SIGN SYSTEM AND THE CONTENT OF WEB MAPS"

author of the dissertation: Eng. Nikoleta [redacted] Nikolova

for the acquisition of the educational and scientific degree "doctor"

professional field: 5.7. Architecture, construction and geodesy

scientific specialty: Cartography (incl. thematic geographic mapping)

Reviewer: Prof. Dr.S. Eng. Andrey [redacted] Andreev – National Military University of Applied Sciences "Vasil Levski", Email: andreev_an@abv.bg

The review was prepared in accordance with the requirements of the Law on the State of the Republic of Bulgaria and the Regulations for its implementation and on the basis of the order of the Rector of UACEG for the appointment of a scientific jury (Order No. 299 / 27.03.20206) and the decisions of the jury taken at its first meeting.

1. General information about the procedure

Eng. Nikoleta [redacted] Nikolova was enrolled as a full-time doctoral student at the Department of "Photogrammetry and Cartography" by order of the Rector of the UACEG No. 115 / 27.02.2023 with a study period of three years (2023 -2026). By the same order, Prof. DrS. Eng. Stanislav Vassilev was appointed as the doctoral student's scientific supervisor. The doctoral student passed his specialized exams and the English exam with excellent results. Eng. Nikolova was dismissed with the right to defend by order of the Rector of UACEG No. 83/02.02.2026 based on a decision of the Faculty Geodesy. At a meeting of the Department of "Photogrammetry and Cartography" after an internal defense, a proposal was made to open a procedure for an official defense.

The following materials were submitted for the defense procedure:

- CV;
- Order for enrollment;
- Order for dismissal;
- Order of the Rector of UACEG for the appointment of a scientific jury;
- Dissertation work for the acquisition of the ONS "Doctor";
- Abstract of the dissertation for the acquisition of the ONS "Doctor";
- Copies of the publications on the dissertation.

2. Information about the candidate

Eng. Nikoleta [redacted] Nikolova graduated from the UACEG in 2022, where she obtained the educational qualification degree "Master" in "Geodesy", professional qualification "Engineer in Geodesy, Cartography and Cadaster". From 2023 to 2026 she was a full-time doctoral student at the Department of "Photogrammetry and Cartography" in the scientific specialty "Cartography (incl. thematic geographic mapping)". In February 2026 she was discharged with the right to defend.

Eng. Nikoleta [redacted] Nikolova has versatile computer skills for working with Microsoft Office products, Sketch Up, Unity, PostgreSQL, AutoCAD, ProgeCAD, QGIS, ArcGIS Pro, ArcGIS Online, ArcGIS Storymap, ArcGIS Survey 123, ArcGIS Experience Builder, etc.

She is fluent in English and German.

His scientific and publishing activities are related to the topic of the dissertation.

3. Analysis of the dissertation work

The dissertation work is designed in a total volume of 182 pages, - table of contents, introduction, eight chapters, conclusion, list of used literature and 27 appendices. The work contains 133 figures and 19 tables.

The layout of the entire dissertation work is at a very good aesthetic and publishing level.

Relevance of the problem

The relevance of the problem considered in the dissertation work is related to the growing interest in creating and using web maps. This requires increasingly effective and intuitive sign systems.

In this regard, visual variables (color, size, shape, orientation) play a key role in the correct perception and interpretation of spatial information. Their inappropriate application leads to cognitive difficulties, misinterpretations and reduced efficiency when working with web maps.

In addition to the choice of effective cartographic visualizations, the structure of the legends, as well as the navigational-functional design of a web map, are also important. Their precise analysis ensures better communication with the cartographic web product.

All this proves the relevance of the research conducted in the dissertation.

3.1. Goals and objectives of the development

The relevance of the problem, the main goal and the tasks set are clearly formulated in the introduction to the dissertation.

The main goal of the dissertation is: to analyze the effectiveness of cartographic signs through a combination of different graphic variables and to evaluate the interactive elements in some of the most famous web maps and geoportals in Bulgaria in the context of cartographic communication.

To achieve the goal, the author has identified the solution of the following tasks, which are formulated in the following sequence:

1. Analysis of the effectiveness of web maps: To consider the general theory and basic definitions of effective and efficient content in web maps and to expand their classification in the modern cartographic context.

2. Detection of problems with web maps in Bulgaria: To analyze in detail the most famous geoinformation portals currently in Bulgaria to identify areas of web maps that cause problems or difficulties with their understanding and efficient use.

3. Analysis of interaction with web portals and menus: To study the most used interactive elements of a web map through real user data, providing a method for "capturing" user interactions and preferences, as well as the time for orientation in navigation elements and menus in web maps through programming.

4. Evaluation of cartographic symbols and legend types: To use eye tracking systems in cartography to determine how the perception of cartographic symbols and legends in a web environment occurs. The evaluation of two different types of legend structuring for signs with double articulation is important for improving both the design of cartographic signs and the legends themselves.

5. Development of recommendations and final cartographic product: Conducting two experiments (in Bulgaria and in the Czech Republic) for visual search (related to the structure of the signs) and for user interaction (related to the interactive elements of the web map and legend) to determine recommendations for a qualitative understanding of spatial information on a web map and creating a final cartographic product based on them.

The object of the dissertation research is web maps and their sign systems and content.

3.2. Content of the dissertation

Each of the chapters in a logical sequence solves a certain problem from the field of application of the dissertation and seeks in it the implementation of the research tasks. The structure of the dissertation should clearly distinguish between the theoretical, empirical and applied parts.

The first chapter is devoted to the analysis of the essence and effectiveness of cartographic products. Existing classifications of web maps and eras in web mapping are considered. The topic of interaction design is considered in the areas of human-computer interaction, information visualization, usability research and visual analysis. The graphical user interface in the work between the user and the software product (web map) is analyzed. It is concluded that one of the most important issues in cartographic design is its adaptation and perception for the needs of users, analyzing: differences between age groups; intercultural differences; differences in color perceptions; differences according to cartographic education and experience. Attention is paid to collecting user opinions through questionnaires and online interviews.

In chapter two, the meaning of the sign and the sign system in web cartography is analyzed. The following are examined: the essence of the sign, cartographic semiotics, types of signs. Cartographic communication is analyzed and the conclusion is made that it is necessary to include a group of web map users, listen to their opinion, record the frequency of interaction and areas of interest, for the successful creation of a cartographic product. Special attention is paid to cartographic visualization and static and dynamic visual variables are examined. The effectiveness of the sign system is assessed, using criteria for readability, clarity and clarity.

In chapter three, eye tracking systems in cartography are examined to establish the readability of maps. The following are analyzed: optical systems, software and hardware for studying the gaze.

In chapter four, a classification scheme of methods for studying the quality of web maps is compiled. The methods for content evaluation are presented as layers of information (metadata) in contrast to the classic content of maps. The level of detail of the information is analyzed, assessing whether the signs are sufficient, clear and visible for the specific purpose. Usability evaluation is presented as a process of analyzing and measuring the quality of interaction between the user and a given system, product or service. The author concludes that the analysis of the usability and effectiveness of web maps in relation to their technological and functional characteristics is of crucial importance for creating an intuitive and effective tool for users. Visual - cartographic methods are presented as the visual design and aesthetics of web maps: analysis of the sign system, analysis of data presentation and aesthetic analysis. In conclusion, the author analyzes the methods for ensuring the security and confidentiality of data processed by a web map.

In chapter five, an analysis of the effectiveness of the structure of cartographic signs is carried out. Test tasks that consider the main aspects of graphic visual variables and their application in the modern context are experimentally studied. Additionally, it is investigated whether there is a relationship between the dominance of some visual variables - between color and size and whether the spatial arrangement of signs affects the primary perception. The author concludes that cognitive load is mainly influenced by the speed of decision-making and it is a reliable indicator when compiling a sign system.

In chapter six, an analysis of usability is made in relation to technological and functional productivity. The geoportal of the Ministry of Defense, the KAIS of the AGKK, the geoportal of GIS Sofia, the geoportal of the MRDPW are examined and analyzed, and the strengths and weaknesses from the point of view of web maps are presented.

In chapter seven, an efficiency study was carried out using a gaze tracking system in cartographic design and legends. A test web map was developed, through which user perceptions are analyzed in two main directions: assessment of the intuitiveness of icons/buttons for frequently

used functionalities (distance measurement, moving, returning to a previous view and retrieving information about an object), with the focus on elements with an established non-intuitive design; Application of the principle of double articulation to cartographic signs and the way they are presented in the legend, analyzing the impact on reading through eye tracking. Experimental data were collected from participants from the Czech Republic, previously informed about the objectives of the study and the way of processing the information. In conclusion, the author concludes that the analysis of data from the eye tracking system Pupil Labs Neon allows for the assessment of the visual behavior of participants through fixations and time spent on individual areas of interest (legend and map). These data make it possible to analyze the cognitive load, visual search strategy and task difficulty.

Chapter eight presents recommendations for improving cartographic design and signs on web maps. A cartographic design was designed to improve the interface of the GIS portal of the Ministry of Defense by creating a new interactive web map design of the existing web map. A list of recommendations and cartographic designs for an improved cartographic interface was prepared. A comprehensive methodological framework for evaluating and analyzing the functionality and cartographic design of web maps was developed. The specific recommendations serve as a basis for standardizing web cartographic content in Bulgaria.

In the conclusion, the author summarized the research and analysis carried out in the dissertation work and presented summarized conclusions.

The dissertation work used scientific methods fully related to proving the working hypothesis adopted by the author. The solution to the specific tasks is achieved through the following analytical research methods: historical-logical analysis; synthesis and analysis; modeling; comparison; induction and deduction; abstraction; logical analysis; idealization and formalization.

3.3. Literature sources

The literature reference contains 127 titles, of which 15 are in Cyrillic and 112 are in Latin, including Internet addresses.

The content of the literature reference shows that the doctoral student has tried to become familiar with the problems of the dissertation in a variety of ways.

3.4. Knowledge of the problem

The content of the work and the analysis of existing methods show the very good knowledge of the problems being developed by the doctoral student and his ability to choose an appropriate methodology depending on the source data used and the chosen field of application. The proposed technological schemes can be used both for research developments and when solving practical problems.

4. Contributions and significance of the development

The author's main claims for contributions are formulated as scientific, scientifically applied and applied.

Scientific contributions:

Contribution 1. A systematized classification of methods for assessing the quality of web maps is proposed, which includes: methods for evaluating content, methods for analyzing usability and user experience, technological-functional methods, visual-cartographic methods and additional methods.

Contribution 2. A combined approach for analyzing user behavior when working with web maps is introduced, through: registering real user clicks and interactions, measuring execution time and errors made, and a questionnaire survey integrated into the web environment to collect

subjective evaluation. The aim is to investigate the relationship between objective user behavior and subjective perception of speed and difficulty.

Contribution 3. For the first time, two types of structured legends for non-scale signs and linear signs with double articulation have been experimentally studied, through practical tasks in a web map:

- a legend with a separate presentation of the structural basic and additional elements;
- a legend with a combined presentation of the signs in the form in which they function on the map.

Contribution 4. Eye tracking systems were applied to analyze the visual perception of the legend and the map, and the following were studied: the number, frequency and location of fixations on the legend and the map. The obtained indicators reveal dependencies that cannot be established through traditional assessment methods.

Contribution 5. A study was conducted with a large number of participants, aimed at analyzing the visual variables in web cartographic visualization - color, size, shape, orientation and their combinations. Based on the results, experimentally substantiated generalizations were derived for the most effective visual solutions for web maps, which lead to fewer errors when working with them. A dependence was established between the dominance of the visual variables color and size, as well as the influence of spatial location on the initial visual perception for detecting objects.

Contribution 6. A structured typology of difficulties in working with Bulgarian geoportals was prepared.

Contribution 7. An updated classification for types of web maps was created, which integrates modern trends in cartography. It complements the existing classifications in the literature by introducing new technical and functional capabilities that reflect current user needs.

Contributions of a scientific and applied nature are:

Contribution 8. A comparative analysis of the interactive, navigational and sign elements of national geoportals was made, in order to assess their functionality, cartographic engagement and usability.

Contribution 9. Scientifically based recommendations were formulated for increasing the effectiveness of web maps, based on an integrated analysis of cartographic signs, legend structure and interactive navigation design. Unlike existing studies that consider these elements separately, the dissertation evaluates the web map as a complete system and offers practically applicable guidelines for optimizing cartographic communication and user interaction.

Applied contribution:

Contribution 10. A new web cartographic design of an existing Bulgarian GIS platform was developed, based on the results of the experiments and analyses conducted. The new design was empirically tested with 37 participants, with the results showing increased efficiency compared to the initial version. Applied contributions are:

I acknowledge the claims of the doctoral student for the contributions and believe that they are his personal work.

5. Abstract

The text of the abstract corresponds to the dissertation and reflects the main points of the problems considered in the work. It contains 74 pages, of which 69 pages present key points of the dissertation. The abstract also includes a table of contents, a list of cited literature, and a list of publications related to the dissertation.

6. Evaluation of publications on the dissertation work

The doctoral student has submitted 6 publications related to the dissertation work.

All publications are independent and are in the period 2024 - 2025. The publications are in:

- Journal "Geodesy, Cartography and Land Management" - 1 issue;
- XXXIV International Symposium "Modern Technologies, Education and Professional Practice in Geodesy and Related Areas", SGZB - 1 issue;
- The Yearbook of UACEG - 1 issue;
- 9th International Conference on Cartography and GIS, July 2024, Nessebar, Bulgaria, Cartography and Geoinformation 2025, Croatian scientific and professional journals – HRČAK Kartografija i geoinformacije – 3 issues.

The issues addressed in them give reason to conclude that they are the work of the author.

7. Citations and use of results

The doctoral candidate has submitted a statement that there is no data on known citations of the articles to the dissertation "Analysis of the sign system and content of WEB maps" as of April 2026.

8. Critical remarks and recommendations

The work is excellently designed. I have no substantive comments on the research and the essence of the work.

My recommendation is that the author continue his research and prepare a monograph on the issues addressed in the dissertation so that they become available to the geodetic community.

9. Personal impressions of the candidate

I do not know Eng. Nikoleta [redacted] Nikolova, but the results of the dissertation give me reason to believe that she is a well-rounded young scientist with theoretical and practical experience in the field of applying modern web maps and cartographic technologies.

10. Conclusion

The results obtained in Eng. Nikoleta [redacted] Nikolova's dissertation, the design of her work and the publications show that she has the abilities for scientific research and the ability to offer original solutions.

Considering the above, I propose to the esteemed Scientific Jury to award Eng. Nikoleta [redacted] Nikolova the educational and scientific degree "Doctor" in professional field 5.7. Architecture, construction and geodesy, scientific specialty "Cartography (incl. thematic geographic mapping)".

Shumen
20.07.2026

Reviewer:.....
(Prof. DrS. Eng. Andrey Andreev)