Beata Medyńska-Gulij, prof. dr hab.
Adam Mickiewicz University, Poznań, Poland
Department of Cartography and Geomatics

REVIEW

The habilitation thesis "The Evaluation of Cartographic Visualization Methods and Interactive Map Interfaces Through Eye-tracking Technology" of RNDr. Stanislav Popelka, Ph.D. in the field of Geoinformatics and Cartography at the request of the Faculty of Science of Palacký University Olomouc

Scientific subject

There are currently many methods for researching the effectiveness of maps to understand the underlying cognitive reasons behind user behaviors, perceptions, and interactions. Dr. Stanislav Popelka corectly refers to the classical foundations of scientific communication in cartography and invokes cartographic communication models. He definitely directs his considerations on the evaluation of mapping techniques and interactive interface maps to eye-tracking technology. Experiments in cognitive cartography are crucial for him in identifying barriers and problems in cartographic communication from the perspective of both the map creator and the map reader.

The research problem is placed in the broadly understood geovisualization and focuses on the achievements developed by two commissions of the International Cartographic Association: Designing the User Experience Commission and the Commission on Cognitive Visualization. The candidate takes up interesting global research issues according to the trends identified by the scientific communities of their own and from these commissions. On the one hand, the problem touches on the theoretical nature of user aspect of maps, methods of evaluating map effectiveness, and their optimization.

Knowledge of the principles and application of eye-tracking is crucial in these habilitation studies and it is not surprising that there are also enormous technical approaches to the possibilities of the equipment and applications. The identification of fixations and saccades with appropriate statistical data are key data for the candidate.

Generally, it should be stated that the topic taken up in this habilitation is current and scientifically important.

Goals

Dr. Stanislav Popelka has well formulated three goals of his habilitation, which fit into the current trends of research on the usability of visualization methods in cartography. The aims of his considerations focused on: evaluation and comparison of cartographic visualization methods; assessment of interactive map interfaces, and design and development of eye-tracking analysis and visualization tools.

A clear, extensive diagram representing methodological connections and case studies contained in eleven articles is worth noting. All articles were published in the years 2013-2024 in leading and good scientific journals related to cartography, geoinformation and human-computer interactions. In five articles, Dr. Popelka is the first author with a contribution of 70 to 25 percent. In the other six articles, he is the second author with a contribution of 40 to 50 percent. The titles of ten articles contain the term "eye-tracking". Dr. Stanislav Popelka conducts research with scientists from many research centers also involved in cognitive research in cartography.

The research methods in the habilitation are interdisciplinary from cartography, geoinformatics, psychology and cognitive science. Among the methods, the candidate considers the most appropriate term Usability thanks to quantitative studies collect data indirectly through measurement. Therefore, in this habilitation we see the application of eye-tracking to evaluate and compare map visualizations and interactive map interfaces. Dr. Popelka realizes that such simplification of quantitative data must be supplemented by other methods, such as think-aloud protocols, interviews, or questionnaires.

The strength of statistical analyses in each study described in the articles are the mandatory statistical tests for comparing visualizations. Among the analytical methods based on scientific visualization, it is worth noting the candidate's attention maps (heat maps) and maps of areas of interest.

In general, the methods used in this habilitation should be considered adequate and up-to-date, with particular emphasis on the author's care in searching for and testing new technological solutions for the evaluation of cartographic products.

Results

Following the coherent sequence of eleven articles, it can be stated that Dr. Stanislav Popelka in the first phase of his research focused on evaluating cartographic visualization methods, while in the second phase he focused more on exploring the usability and evaluation of interactive map interfaces.

Appreciating his extensive experience with successive eye-tracking tools since 2013, we today recognize him as an expert in this technology in global research in cartography and geoinformation. The most important results achieved by the candidate include the following: — evaluation of a tool for analysing eye-movement data and in detail for cognitive cartography experiments and evaluation of user behaviour during map reading process; — visual values of glyphs in geovisualization: multivariate-symbol maps and grid plots; — high capabilities for evaluation of the cartographical quality of urban plans by eye-tracking; — users worked with web maps in the simplest form and they did not look for hidden functions in the menu or attempt to find any advanced functionality; — verification of cartographic communication models using map reading strategy detection based on eye movement recording; — use of the same strategy as the map author used might be a prerequisite for users' proper understanding of a map reflected by the overlap of the author's and users' realities in Koláčný's model; — indication that multiple view in interactive interfaces is a better method of map comparison than swipe, especially in a task which compares four maps; — highly specialized specialists such as geologists tend to concentrate more on the map content than the other groups and generally spend less time completing tasks; — indication that standard eye-tracking systems offer good evaluation techniques for static stimuli when it

comes to geovisualization products; and — recommendations for better-designed dashboard interfaces that can transfer information appropriately.

Conclusion

The habilitation thesis "The Evaluation of Cartographic Visualization Methods and Interactive Map Interfaces Through Eye-tracking Technology" consists of eleven articles published in peer-reviewed journals with significant scientific impact. The presented series of articles should be considered as an appropriate flow of a coherent research process subordinated to the evaluation of cartographic products using eye-tracing.

Eye-tracking experiments with attention to obtaining quantitative and qualitative data from each participant of the experiment – user of the map, mapping technique or map interface – are definitely favored. The candidate used static and animated as well as interactive maps. Each of the conducted studies with users had very good preparation in the field of experiment's design and met the requirements of other experiments. This is important because the obtained evaluations were possible to compare with other results already published by other researchers.

Dr. Stanislav Popelka represents an experimental approach, where hard quantitative data, knowledge of equipment and applications are important. He has solid technical knowledge, which he can use to study the cognitive efficiency of users for various mapping methods. He is undoubtedly a recognized expert in the scientific community as a technology expert and undertakes many studies. He skillfully uses methods known from experiments in cognitive cartography, psychology, and geoinformatics. Valuable individual co-authored studies published in good journals are a strong point of this habilitation, as the candidate has demonstrated the application of his theoretical and applied knowledge in many cartographic and cognitive topics.

The scientific value of this habilitation is high due to the visible beneficial authorial progress in the development of methods for the evaluation of currently functioning interactive and web geovisual forms. In almost every article, the candidate draws attention to the pragmatic dimension of his research, i.e. his intention is to contribute to the improvement of map design and map applications. Therefore, a certain lack of directly formulated recommendations for designers of maps, geovisualizations and other cartographic products is aroused in this habilitation. The benefits gained from these studies will be extended to future challenges undertaken by the candidate, who has already demonstrated a high level of openness to problems to be solved.

Based on the above mentioned evaluations and findings of my review I fully recommend Dr. Stanislav Popelka to be promoted as an associate professor.

Poznań, 04.04.2025.