Habilitation Thesis Reviewer's Report

Masaryk University	
Faculty	Faculty of Informatics
Procedure field	Informatics
Applicant	RNDr. Radek Ošlejšek, Ph.D.
Applicant's home unit, institution	Faculty informatics, Masaryk University
Habilitation thesis	Data-Driven Exploratory Interactions and Visual Analysis
Reviewer	Prof. Dr.-Ing. **Jörn Kohlhammer**
Reviewer's home unit, institution	Fraunhofer Institute for Computer Graphics Research IGD & Technical University Darmstadt, Germany

The habilitation thesis in front of me is separated into two main parts: the commentary sections that summarize the contributions of the applicant; and the selected papers originally published at various conferences. The commentary introduces the two main research areas of the applicant: interactive exploration of images, and visual exploration and analysis in cybersecurity. The two areas are quite different, linked mainly by a shared general relation to exploratory computer graphics, and are also chronologically separated with the main current research of the applicant in visual analytics for cybersecurity.

The applicant's earlier work on the interactive exploration of images moved from a focus on disabilities over e-learning towards dialogue systems and dialogue-based exploration. In the publication *Creating Pictures by Dialogue* the applicant specifically worked on supporting blind users of information systems that require a natural language description of objects in a picture. As a prerequisite to this, he addresses a decomposition of the scene graph into described elements. The publication on *GATE* further supports this by suggesting a framework for the integration of image annotations and ontologies with SVG, which enhances the accessibility of these techniques for blind users. This publication also introduces the What-Where-Language (WWL) that is further explored in later publications. The applicant's paper on *Information Retrieval from Images* extends the user focus on a broader range of special needs, including elderly people and groups with low technological literacy. By means of the WWL, users can begin a dialogue via the GATE system to get further information about an image. In a further extension of the GATE framework, the applicant also explored possibilities to sonify color images in *Hybrid Approach to Sonification of Color Images*, again using WWL for a hybrid dialogue processing of graphics. In the course of this research, the applicant also introduces a semantic color model to allow the speech interpretation of colors.

The applicant further extended his scope to target applications in e-learning. In his work on *Annotating and Describing Pictures*, the earlier work on graphical ontology construction had to enhanced and optimized to be useful for more general e-learning tasks, as well as web applications and electronic text books. The final publication in this thematic area, *Integrating*

Dialogue Systems with Images, can be seen as a summary to the different contributions over the years in this respect. It outlines the basic principles of dialogue systems for describing pictures, but going further into detail, e.g., in the dialogue construction and communication analysis. All of these earlier publications focus more on conceptual contributions and less on technical descriptions or evaluations of the described techniques.

There is a major shift of focus also in the latter respect in 2013, when the applicant concentrates on cyber-security and eventually on cyber defense exercises that are enhanced with visualization to give the participants feedback during the exercises. At the center of the work and several publications is the KYPO Cyber Range, an environment for training scenarios in cyber security. The first paper in a series of publications introduces the tool and the KYPO architecture. It is the basis for different views and visualizations, but mainly a shared collaborative environment to use certain resources, data repositories, and sandboxes. The publications on cybersecurity were submitted at increasingly renowned conferences and had a stronger emphasis on evaluation. The ICSOFT paper on *KYPO Cyber Range: Design and Use Cases* is in my view the strongest paper in this series, with a thorough comparison with related cyber ranges, a rationale and introduction of the architecture and platform approach, and the idea behind the user interfaces and interactions with the platform and the users between each other via the collaborative platform. This paper also sets the scene, so to say, for the three following papers.

The paper on *Lessons Learned* from the defense exercise in the KYPO Cyber Range goes a bit into more detail on the nature of the complex cyber defense exercises, how exercises are planned with objectives, scenarios, and participant roles. The paper reports on the lessons learned from each of these steps in the five phases of an exercises ranging from preparation to repetition. The second paper in this batch of publications focuses on the *Timely Feedback* that is given to exercise participants over the course of the exercise. The applicant and his co-authors developed an extended line chart that shows the points gained or lost for each team along a timeline. The evaluation of this feedback chart signaled, among other results, that the visualization could show more complex information for the participants, an aspect that points at possibilities for future extension of the approach.

Finally, the paper on the *Evaluation of Cyber Defense Exercises using VA* draws the connection to the title of the habilitation thesis by discussing Cyber Defense Exercises (CDX) in the context of the knowledge generation model as introduced by Keim et al. (2014). The KMG is mainly a descriptive model, i.e. it clarifies what VA is and what the processes are on the machine side and the human side that might generate knowledge. Section K.2 evaluates whether the VA model can be *applied* to CDX, which means it tests whether it is a fitting prescriptive model. In addition, while the KMG describes processes at run-time of the analysis (and mainly by one human and one display system), CDX organizations seem to require several months, include several human teams, and different system views. In any case, the KMG is also a way to think about *intended* analytical processes, which the authors of Paper K conclude themselves. Nevertheless, I suggest also taking a look at an important preceding publication that the KMG draws on: the sense-making loop as introduced by Pirolli and Card (*The sensemaking process and leverage points for analyst technology as identified through cognitive task analysis*, Conf. on Intelligence Analysis, 2005). I see parallels and probably better applicability here, since intelligence analysis has aspects that are common with cyber security analysis and CDX, it seems. Most importantly, it has a similar analytical and organizational timeline.

In summary, the applicant describes an interesting journey through two scientific areas and various application fields, moving towards cyber security and visual analytics. The habilitation thesis has been very well prepared. Fitting to the role of the applicant, he has advised and supervised almost 150 students along the way and worked in different research teams. Over the course of the last 13 years that are in the focus of this review and especially since he became involved in the area of cybersecurity, the applicant has published in increasingly higher-rated conferences. While the earlier publications reported mainly conceptual, these later publications show more extensive evaluations with the users of the developed techniques. Overall, I see the expectation of a habilitation thesis fulfilled and have outlined a few further questions for the defence.

Reviewer's questions for the habilitation thesis defence (number of questions up to the reviewer)

- Some of the early work in image exploration is conceptual, but still characterized by techniques. At least looking at the papers, these approaches were not evaluated in its entirety. Has this nevertheless led to demonstrators and proofs of concept that you can further elaborate on?
- Related to this, it must be difficult to get enough evaluation subjects to analyse these results in a very specific area. How did the applicant make sure that the applicability or benefit of the approaches was given?
- In the paper on sonification of color images, it did not become completely clear to me, how blind persons would benefit from this in certain situations or in general. I very much see the technical achievement, but how can the blind use such techniques?
- There is a chronological and thematic separation of the two main research areas in this thesis. Can you further highlight the relation and the role that your earlier work played in the team of different researchers working on the KYPO cyber range?
- In Paper H, I read with interest the related work section including different cyber ranges and testbeds available. Maybe I missed it, but where do you position KYPO here, and what are open issues where KYPO has further potential in the future?
- Paper K evaluates whether the components of the KMG of Keim et al. fit to the general processes and resources of cyber defense exercises. One conclusion was that there is a lack of VA tools integrated into cyber ranges. For which data, user, and tasks do you see the largest potential for VA tools and what techniques could be beneficial?

Conclusion

The habilitation thesis entitled "*Data-Driven Exploratory Interactions and Visual Analysis*" by Radek Ošlejšek *fulfils* requirements expected of a habilitation thesis in the field of Informatics.

In Darmstadt on March 29th, 2019