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OPPONENT'S REVIEW OF A DOCTORAL THESIS

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Title: Advanced Moment-Based Methods for Image Analysis
Opponent: Radovan Jiřík, Ph.D.

The topic of the dissertation is moment-based image analysis. It is focused on rectangular decomposition algorithms for faster calculation of moments and on design of new moment invariants. The topic is very interesting and timely in the image-processing field, with the main applications being image compression, filtering, image description and recognition. The proposed methods contribute to lower computational and memory demands and to more reliable image recognition methods.

The text of the dissertation is very well structured. It starts with a comprehensive introduction to image analysis and image recognition and continues with an introduction to image moments and invariants and summary of the current research trends in this field. Subsequently, the main goals and structure of the thesis are stated. The introductory part links the content of the dissertation logically together. The following chapters summarize, in a structured way, the four journal papers which are the core of the dissertation. The text is written in a very good English and contains very few mistakes and typos. The fact that the dissertation consists of four papers in peer-reviewed international journals with impact factor (one paper in the review process) shows a very good quality of the dissertation.

Paper 1, “Decomposition of binary images – a survey and comparison”, is a study comparing the most relevant methods for decomposition of 2D binary images into rectangular regions. The authors also suggest their own decomposition method, based on graph theory, providing division into the minimum number of rectangles. The methods are compared in terms of the number of rectangles, computation speed and memory demands. I see an important contribution in both the comparison study and the proposed decomposition technique.

Paper 2, “Close-to-optimal algorithm for rectangular decomposition of 3D shapes”, presents an extension of the original decomposition method of paper 1 to 3D. It decomposes 3D binary objects to a smaller number of rectangular blocks than the available 3D methods. The methods are compared in sense of the achieved number of blocks, computational and memory demands. I appreciate the online tool designed by the author to illustrate the implemented decomposition methods. The novel method outperformed the best existing method “3D Generalized Delta Method” by yielding slightly fewer blocks but is substantially more computationally demanding, roughly by a factor of 100. This makes it challenging to find an application that would benefit from the novel algorithm. The suggested applications are stated in a fairly general way as applications which prefer low number of blocks above the decomposition speed. Mentioning applications more specifically would strengthen the paper’s contribution. For example, it would be interesting to show under what circumstances the proposed method would lead to faster feature computation or faster convolution.

Papers 3 and 4 present novel theories of invariants for Gaussian blur and Gaussian noise in images. The invariants for Gaussian blur are based on so-called primordial images defined in the spectral domain by means of projection operators. They are inherently invariant also to translation and with a small modification to scale. The invariance was also extended to rotation. The proposed Gaussian-noise invariants are based on histograms. Both theories have been thoroughly evaluated in frame of blur- and noise-invariant image comparison and recognition. They form a strong contribution of the disertation.

In conclusion, the author has clearly proved his ability to work systematically on the given scientific topic and showed a good potential for further work in research. The results presented in this thesis are of high impact for the image processing and analysis community. This is exemplified by the publications of the author. In my opinion, the author has qualified to be awarded the title Ph.D.

Questions:

1. Could you show an example under what circumstances the close-to-optimal 3D decomposition method would lead to a faster computation of features or a faster convolution, compared to the 3D Generalized Delta Method?
2. On the bottom of page 32 you write “The implementation of the library for the popular runtime environment Node.js3 has been inspired by our work presented in this thesis.” Could you explain this more specifically?

In Salt Lake City, November 26, 2017

Radovan Jiřík, Ph.D., opponent