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Expertise of the doctoral thesis by Filip Krolupper

Dear Professor Zdenek Nemecek,

in his doctoral thesis entitled "Recognition of partially occluded objects" Filip Krolupper has dealt with a problem which is still unsolved in the area of object recognition: the visual recognition of objects under the complicated circumstance that parts of them are not visible in the image to be analysed.

Filip Krolupper concentrates on a class of recognition algorithms which utilize the contours of the objects. In chapter 1 he describes the background of his topic by giving a short overview of existing methods of object recognition (structural, fuzzy, and statistical). It concisely introduces the reader into the field. In addition, in this chapter he motivates his field of research by giving three examples of applications where a solution of the occlusion problem would be of great benefit.

Chapter 2 mainly summarizes the state-of-the-art with respect to contour-based object descriptions. Filip Krolupper distinguishes four standard methods, namely string features, important points, non-linear shape primitives, and wavelets. This overview is very carefully investigated and cites all relevant references. What remains unclear to me is the reason why the wavelet method is excluded from further consideration. The argument of a computationally expensive matching algorithm could be explained in more detail. In this chapter Filip Krolupper also describes in technical detail the methods his own algorithms are based on, namely the methods of Lamdan et al. and of Jia.

In chapter 3 the author explains the three main objectives of his thesis. The first objective is an improvement of Jia's method of contour approximation to eliminate some of its

disadvantages (error propagation, lack of robustness to occlusion, and suppression of details). These goals are achieved for hand-drawn contours of objects and are published in the first paper with Filip Krolupper as single author.

The second goal was the development of a polygonal contour approximation which is affine invariant as well as robust to noise. Such a method was developed and introduced in the second paper published together with Jan Flusser as co-author in *Pattern Recognition Letters* which is quite a distinguished journal. It has been shown that the new method meets these goals and even is able to represent contours in precise details and is comparable to Lamdan's standard method. This method is also tested on images of real objects.

As many contour-based recognition methods work in a divide-and-conquer fashion it is of benefit to find an algorithm which is able to split a contour into smaller segments and to do this in a stable manner. This was the last objective of the thesis. Filip Krolupper achieved this goal by the development of a method which is also affine invariant and needs only first derivatives. This method is introduced in the third paper, again with Jan Flusser as co-author, and tested on hand-drawn contours. The results of the tests show that Filip Krolupper's method again outperforms Lamdan's standard method. It would be interesting to see whether the same good results could also be obtained on images of real objects. In the chapters 4 and 5 the publications are given, and the thesis concludes with a short conclusion in chapter 6 and an extensive appendix with test data.

Summarizing, the following achievements can be regarded as the main new scientific results of this thesis: first the improvement of Jia's method, secondly the development of the first polygonal contour approximation method which is affine, and thirdly the development of the affine invariant contour cutting method. The importance of them for the area of object recognition lie in the fact that the problem of recognition of partially occluded objects based on their contours is still unsolved. The achievements of this thesis can be regarded as one step further to a solution of this problem. Possible applications of the proposed methods are robotics, optical character recognition, or conveyor belt applications in industry which all suffer from the occlusion problem. The thesis is written in a clear and lucid form. It is easily readable, and the main points as well as the technical details are presented in a comprehensible way. The verbalism of the thesis is appropriate and, besides of some typos, it is written in proper English.

The thesis proves Filip Krolupper's ability for creative scientific work.

Yours sincerely,

Gabriele

