Annex 6: Habilitation thesis reader's report

Masaryk University
Faculty   MU Faculty of Informatics
Field of Habilitation   Informatics

Applicant   RNDr. Pavel Matula, Ph.D.
Affiliation   Masaryk University, Faculty of Informatics
Habilitation Thesis   Image Processing in Fluorescence Microscopy and its Utilization in Cell Biology Experiments

Reader   Professor Ulla Ruotsalainen
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Report Text (as large as the reader deems necessary)

The habilitation thesis of Dr. Pavel Matula concentrates on image processing and image analysis of fluorescence microscopy images especially for cell biology experiments. The topic is very timely because the amount of data in these experiments is exploding and at the same time more and more quantitative information is sought from the biological samples. The topic is also highly multidisciplinary. The broadness of the thesis from image acquisition till biological analysis has made the work challenging but might also have been interesting to complete.

I am looking this thesis from the following aspects:

- What is the quality of the publications
- What is the independent contribution in the publications by the applicant
- Gained visibility by other researchers
- Created opportunities for students
- Future potential for the research

Publications

The thesis is based on 26 publications of which 7 journal publications and 19 conference publications. The journal publications have been published in good or very good journals according to the impact factor (Web of Science) and ranking in Finnish Publication Forum project (http://www.tsv.fi/julkaisufoorumi/english.html). Two of the methodological publications were published in very high grade journals IEEE Transactions on Medical Imaging and Pattern Recognition Letters. Most of the conference papers have been presented in dedicated conferences that have not been classified. However, the publications have been evaluated as full papers and some of them have been published by the Lecture Notes in Computer Science that gives good visibility for the publications and ensures their quality.

The publications in the thesis form an excellent collection of actions needed for analysis of cells or their structures with microscopy imaging. The main focus in the work is in image analysis although also image acquisition and cell biology results were included. The publications that describe the developed methods are well written and at the time they were

published they were truly modern approaches. Later on all the methods: simplex meshes, level sets method and graph cuts have been used in different medical imaging applications. The choice of these methods shows excellent knowledge of the literature in the field. Especially noticeable is the work with spherical object reconstruction with simplex meshes which has been described with evaluations and extensions in three conference papers. These publications create a core of the thesis that continues with other methods to extract the three-dimensional objects and their shape. Although the methods developed during this thesis work rest on different approaches the aim in them is segmentation of microscopy images which often are suboptimal for the task e.g. because of noise and low contrast. Also in the development of the methods challenging optimization problems had to be solved. The goal of the developed methods has been robustness to noise and fast numerical computing. Both are indeed needed if the aim is to use the methods in real microscopy experiments.

It is very valuable that the thesis includes papers where the image analysis has been used in real microscopy studies of living cells and cell structures such as chromosomes. The developed microscopy image analysis software (Acquiarium) and the image segmentation methods were used in the true biological studies but also new methods for quantification of the imaging results were developed. The image analysis methods might be fundamental for the biological research although in the final publication they represent only a small part. It is clear that the work with methodology has built the basis to solve new problems in creative ways. The thesis is well balanced between the methodological development and applications in true microscopy images.

Independent contribution of the applicant

The contribution of the applicant in each publication has been expressed as percentages. Except those, clearly mostly done by the applicant (spherical object reconstruction and fast marching 3D reconstruction), it is difficult to evaluate the importance of the contribution instead of amount of contributions. This would have needed more text in the thesis to be really clear. I don't know the role of the summary text in the habilitation thesis but at least in this thesis the summary was made shortest possible way and only very brief explanation of the contributions was given. In the chapter 4 most of the description was quotation from other publications. For the reviewer the summary descriptions were helpful in reading the book but I am missing some kind of discussion of the whole work. It would have been interesting to see the applicant's opinion of the work.

Other notice that I want to make is the lack of journal publications where the applicant would be the first author. In certain fields of science, like in computer science, researchers have mostly published their results in good conferences. However, publishing in journals is essential because the reputation of a scientist depends very much of the quality of publications and where these publications have been published. I strongly recommend that in the future the applicant would try to publish his work in good journals. I am happy to see this kind of change occurring with the latest publications.

In Finland to achieve the docent degree, the habilitation, one has to publish twice the number of publications included in the doctoral thesis. This habilitation thesis clearly fulfills the criteria.

Gained visibility among other researchers

Researchers are often qualified by investigating their visibility among other researchers. This can be achieved by investigating the number of citations their publications have gained. Dr. Pavel Matula has got the h-index 7 (Web of Science & Scopus) with the publications collected in this habilitation thesis. I regard this very good taking into account that many of the publications have been published in conference proceedings that may have less visibility than journal publications.

Created new research directions for students

In the thesis it was not clearly stated which of the publications were done together with students. I assume that when the applicant is the second author in a paper he has been instructor for the student. Also the nice continuation of the research topics by the publication time shows how the research has evolved during the habilitation thesis work. This is why I consider that the applicant has produced new research topics for the students.

Future potential of the research

The work described in this habilitation thesis is important for high through-put studies in biology. These will become extremely important not only for basic research but also in health care. The automated microscopy image analysis increases the accuracy of the studies but also enables much more studies to be analyzed with improved repeatability providing better statistical power in the studies. The research field is challenging but at the same time extremely important. It requires deep understanding of the data acquisition, biological question and image analysis methodology. This habilitation thesis collects all these topics together which is remarkable achievement. On this basis very interesting new research can be anticipated in the future.

Reader's questions to answer to defend the habilitation thesis (number of questions is upon reader's consideration)

1. What would be the best (microscopy)image segmentation method of those developed during this habilitation thesis? How it compares to other existing methods?

2. Some of the developed methods were extensions from 2D to 3D image analysis. How would you describe the challenges in moving to 3 dimensions?

Conclusion

Pavel Matula's habilitation thesis of *Image Processing in Fluorescence Microscopy and its Utilization in Cell Biology Experiments does* meet the standard requirements for a habilitation thesis in the field of Informatics.

In Tampere on 27th August, 2012...........   Ulla Ruotsalainen ....(signature)