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To the
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Referee Report on the Habilitation of RNDr. Martin Madaras, PhD

Dear Habilitation Committee,

I have been asked to write a letter in support of Martin Madaras's evaluation for habilitation (Docent in Informatics) at Comenius University Bratislava, to give an assessment about the scientific and educational achievements in his career. Since this is the first letter I have written for this sort of evaluation, I have attempted to organize it into three primary areas: 1) How I know Martin Madaras; 2) A brief review of the body of work as presented in the habilitation thesis; 3) A general summary and recommendation. I hope this will be a satisfactory effort for addressing your purposes.

I have first met Martin Madaras in October 2016 as head of the Virtual Reality Group and Senior Scientist at TU Wien. Martin had finished his PhD a year before and contacted me to ask about working in my group as a PostDoc for 6 months. I quickly saw his enthusiasm for his research and welcomed him into my group. He worked on a project combining optical and inertial sensors to improve motion capture, funded by "Action Austria-Slovakia". Martin did excellent work and made exciting progress during his stay from 1.10.2016 to 31.3.2017.

His habilitation thesis with the title "Towards Hybrid Methodology in 3D Computer Vision" summarizes the research that Martin did within the last 7 years.

The thesis is structured in a classical way. The first chapter, Introduction, describes the personal scientific journey of the author from the time of finishing his PhD thesis up to now. While working at university he also founded a company and worked with a range of other companies in the area of motion capture and 3D data capture. His original interests were in

finding analytical solutions to solve problems revolving around motion capture (skeleton extraction, skeleton tracking, pose estimation, etc.). However, data driven methods based on machine learning (specifically deep learning) were on a steep rise in 2D computer vision in the last decade and proved to be applicable to 3D computer vision problems as well. Therefore, the author started working on deep-learning data driven methods. While their results are often less precise than analytical approaches, they can be applied to a more diverse set of input data and show higher robustness to data variability. Last but not least, the author started to study hybrid methods, combining data driven with analytical approaches, where neural networks are used to provide initial solutions while analytical methods refine precision of the outcome.

The related work section explains the shift from analytical to data driven and finally hybrid methods. It shows the huge advancement of the field in the last decade. The reader sometimes gets a feeling of ancient history, when reading about some analytical methods that were common until a few years ago, in contrast to the latest data driven and hybrid approaches. However, the problems of using data driven methods, especially related to the need and generation of training data, are also very well described. This section provides a very good overview over state of the art and is very well written. It demonstrates overall expertise, is easy to read and the writing style allows even non-experts to understand the state of the art.

In chapter 3 the author categorizes his work into three main areas: (1) skeleton-based extraction and applications, (2) optical approaches for body motion tracking and pose estimation and (3) applications and pipelines for 3D scan processing in the industry. In the following, detailed explanations are given how the nine submitted papers fit into these three categories. The individual papers are well described and details are provided what Martin Madaras contributed to each paper.

Chapter 4 focuses on future challenges. This section is short but shows the enormous potential for future research. It becomes clear that data driven and hybrid methods have enriched the toolset of 3D computer vision researchers and future applications on mobile devices might lead to decentralized, distributed training and inference setups. It would have been interesting to learn more about Martin's ongoing and future research plans but that would go beyond the scope of this thesis.

The conclusion (chapter 5) summarizes the difficulties of synthetic data generation for data driven and hybrid methods and raises research questions how data generation can better reflect real sensor data or how classical computer graphics approaches can be used to generate better training data.

The appendix consists of nine publications of the author and constitutes the main part of the thesis. All included publications are of very high quality, have been peer reviewed and the main author of the habilitation thesis had major contributions in each one. Papers 2, 3, 4 and 7 have been published in very high quality journals, while papers 5, 6, 8, and 9 were published at the very well-known "International Joint Conference on Computer Vision, Imaging and Computer Graphics Theory and Applications" (VISIGRAPP). In summary, they fulfil all criteria for excellent publications that I would expect in a habilitation thesis.



The author has started his research on skeleton extraction during his PhD and continued pursuing questions related to (human) motion capture in a very clear directed way. Despite nowadays' difficulties of getting research funding, he was able to work in a very driven way. He founded a company, consulted and worked with multiple other companies, and acquired research grants to find the necessary resources in order to push his research forward. This driven approach is admirable and the skill to acquire funding for ones research is necessary in today's academic world.

In addition, Martin has taught courses at Comenius University since 2018, supervised over 20 Masters and Bachelor students and supported PhD students.

With that said, I give you my highest recommendation for approval of Martin's thesis for Habilitation. He is an intelligent and insightful person of high scientific principles, approaches his work with both rigor and enthusiasm, conveys knowledge clearly, and I expect him to continue to be a major contributor to the field. He is also a good, kind and trustworthy person and those characteristics when added to his academic skills make for a very special asset to have as a colleague. If it were my decision to make at TU Wien, I would endorse his advancement vigorously.

If you would like further input on this matter, please feel free to write or call and I would be glad to expand on my evaluation in further detail.

I explicitly suggest promotion of Martin Madaras to the title Docent.

Sincerely,

Univ.Prof. Mag. Dr. Hannes Kaufmann