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Brno University of Technology
Faculty of Information Technology

SUBJECT: PhD thesis evaluation report

PhD Candidate: Tomáš Goldmann

Thesis title: Research in the Field of Biometric Detection and Recognition of Individuals Using Facial Image Data

EVALUATION REPORT

Overall Assessment

The thesis » Research in the Field of Biometric Detection and Recognition of Individuals Using Facial Image Data« submitted for evaluation by PhD candidate Tomáš Goldmann falls into the general area of computer vision and biometrics and addresses different problems related to the detection and recognition of individual from facial images. Two research goals are defined for thesis, where the first focuses on the generation of (synthetic) face datasets for evaluating face detection and recognition models, while the second aims at designing light weight face recognition models capable of running on embedded devices. The problem of generating synthetic datasets is very timely as many of the existing datasets commonly used in face-recognition research are associated with ethical issues due to (often) missing consent. Additionally, having control of the characteristics of the test data is important to have insight into the performance of existing methods under specific circumstances. The second problem, i.e., optimizing models for edge devices, is more applied but equally important. While most recent solutions for face detection and recognition build on computationally heavy deep learning models, deploying this on hardware with limited

computing resources is challenging and requires lightweight model designs together with other adjustments (e.g., quantization) to facilitate this task. Overall, both research goals are timely and interesting and warrant PhD-level research.

For both goals, the PhD candidate presents reasonable solutions that demonstrate his ability to carry out independent research work and contribute to the field. This ability is further shown in the publications of the candidate that were submitted together with the thesis. The candidate has published 7 research papers so far, mostly in mid-tier venues. He published one paper as a first author and contributed to the rest as one of the co-authors. The candidate also produced multiple utility models during his PhD studies, 1 international patent and multiple products. One of his research papers also presents the basis for one chapter of the PhD thesis submitted for evaluation.

The thesis itself is written in English and consists of 162 enumerated pages and a preface that contains the abstract, keywords (in English and Czech), an acknowledgement section, the table of content and a list of figures. The main part of the thesis is organized into 6 chapters. In the first chapter, the candidate provides a very brief introduction with a motivation for the work and describes the main research questions and thesis goals. In the second chapter, he then presents the theoretical background for the doctoral work and discusses various topics meant to introduce the reader to the broader field of biometrics and, more specifically, to the field of face recognition. These topics include basic background knowledge, some historical perspectives on face detection and recognition, and discussions on existing standards and performance measures. In the third chapter, the candidate then reviews more modern work, based mostly on deep learning. This chapter provides information on various datasets commonly used in the studied area, existing models and solutions and some basics on devices for neural network acceleration. Jointly, Chapters 2 and 3 present a comprehensive survey of relevant areas and provide the reader with sufficient knowledge to understand the main contributions, described in the following two sections. Chapter 4 is one of the main components of the thesis and describes research aimed at addressing the first goal of the doctoral work. This is done with the introduction of a model-based procedure towards synthetic data generation. Here, the candidate first introduces a sensor for capturing 3D information on facial appearances and then presents a procedure to place such projections under different transformation into existing background scenes. This process allows for the generation of facial images of various poses in unconstrained settings and for the evaluation of existing detectors and recognition models on the synthetically generated data. Experiments are presented on multiple datasets to demonstrate the feasibility of the proposed procedure. In the next chapter, the candidate then addresses the second research goal of the thesis and first introduces a custom embedded device for running face recognition models. He then proceeds to optimizing multiple models towards the constraints of the developed device (and similar edge devices with limited computing resources) and finally investigates the trade-offs between performance and space/time complexity using various datasets. Additionally, some experiments with a preprocessing filter, aimed at removing the impact of shadows, are also presented in this chapter. The thesis concludes in Chapter 6 with a summary of the main contributions and some directions for future work. Following the concluding chapter is a bibliography with 239 entries and 6-part appendix with some additional results.

The overall technical quality of the thesis is suitable. The methodology used is in line with the standards used in the biometrics literature and at a reasonable level for a PhD candidate. All experiments and results are presented in enough detail for the expert reader to be able to reproduce the evaluations and validate the findings. One aspect I was missing was a more explicit discussion of the limitations of the proposed procedures that could help the reader to understand what can further be improved, but this is a minor aspect. While the technical language used and the mathematical rigor are at the expected level, I found many of the figures of somewhat poor quality. The figures, especially in the first two chapters, are readable, but I would prefer to have seen vector format images, especially for simple diagrams that can easily be redrawn instead of being borrowed from existing publications.

The technical contributions are at the expected level and exhibit a certain level of originality.

All in all, this examiner finds the thesis of sufficient quality and originality for the degree of PhD. The PhD candidate has in my opinion demonstrated the ability to conduct independent research work and contributed to new knowledge with a couple of scientific contributions that are also summarized below.

Original contributions

The main scientific contributions identified by this examiner are:

- A novel sensors for 3D face acquisitions and corresponding procedure for generating synthetic views of the face that can then be inserted into various images capture in unconstrained setting..
- A dedicated embedded device for face recognition and corresponding light-weight face recognition models optimized for operation on such a device.

Conclusion

Given the contributions outlined above, the technical quality of the thesis and my personal evaluation, I find the thesis **worthy of being defended for the PhD degree** and suggest proceeding with the next steps in the process.