Review of Dissertation Thesis

Title: Accelerated HDR Tone Mapping on FPGA

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I was given to review the above stated Ph.D. thesis dated from August 30, 2024. The thesis has 133 numbered pages and consists of six chapters (1 Introduction, 2 High Dynamic Range Imaging, 3 Acceleration of HDR Tone Mapping, 4 Goal and Contribution, 5 Applications and Future Work, 6 Conclusions).

The thesis is organized as follows. In Chapter 2, an introduction to high dynamic range imaging (HDR) is presented. Chapter 3 focuses, from a general point of view, on the possible hardware platforms for the acceleration of HDR tone mapping with the emphasis on FPGAs. The mentioned two chapters may be regarded as a general preparation for Chapter 4, which is a central chapter of the whole thesis since the scientific contribution is presented in that chapter. A bit surprisingly, the conference paper Nosko et al.: True HDR camera with bilateral filter based tone mapping (2017) is included into Chapter 3, which otherwise is devoted to general description of HDR acceleration tools. (If the author decided to present this paper in the thesis, why didn't he do it in Chapter 4?) In Chapter 5, the author shows how the results mentioned in Chapter 4 were used in practice (e.g. in traffic) or in various other projects.

The main fourth chapter is realised as a collection of three papers: [1] Nosko et al.: Color HDR video processing architecture for smart camera (2020), [2] Musil et al.: Smart camera for traffic applications (2023), [3] Musil et al.: De-Ghosted HDR Video Acquisition for Embedded Systems (2020). The participation of 40%, 10%, and 45% is declared in the thesis with the note that in the case of second paper, the author of the thesis focused mainly on the implementation and integration issues. The reformatted articles are accompanied with a short introductory text and a brief summary of scientific contribution in Subchapter 4.4 (one page).

In the fifth chapter, the use of author’s HDR chain in traffic and in several research projects is mentioned together with some thoughts about possible future work.

The whole chain of HDR video processing may be regarded as a topic of this thesis, including acquisition, deghosting, and tone mapping (as can bee understood from [1, 3]). The approaches that were used were influenced by the goal that the whole chain should be accelerated by using FPGA. The approach presented in [1] can be summarised as follows: In the acquisition step, the multiple exposure approach with camera response function (CRF) is used. Ghost detection is based on the prediction of pixel value, a ghostmap is created for this purpose. The tone mapping operator (TMO) is realised by bilateral filtering, a new computing scheme for Durand TMO is proposed. In [3], the attention is devoted mainly to the problem of deghosting. The approach is based on pixel value matching again. Although the method may be regarded as similar to some other methods that had been known before, the author emphasises quite different and improved processing which is based on creating certainty maps containing the values expressing the level of certainty that the individual pixels contain the same patch of the scene as the reference pixel. In the case of both papers [1, 2], experimental results are presented showing the usefulness of the approach. In this context, I should mention that I have managed to find nine citations for the paper [1] in Scopus (two citations for [3]). The way how the papers [1 and 3] are referred to in the citations shows that the approach gained respect in the community. For example, in the survey by Yafei Ou et al. (2022), the

algorithm [1] has been selected for comparison and has been evaluated as an efficient algorithm with high throughput.

The introductory chapters (Chapter 2 and 3) are nicely written. The main part of the thesis is created as a collection of three papers. In the case of papers [1, 3], the declared contribution (40%, and 45%, respectively) of the thesis author is significant. Both [1] and [3] were published in 2020, i.e. they are not “absolutely fresh”. With respect to this fact and with respect to the form that has been used (a collection of papers), I would welcome a little bit longer comments adding supplementary information to what was published in the papers. This could be done, for example, in Subchapter 4.4 describing the scientific contribution, which is now written as a one page text emphasising more or less only the high throughput and real-time performance of the proposed algorithm. I feel the content of that chapter as a bit minimalistic. It was possible to sum up also the main ideas (or main differences when compared with other methods) that are hidden behind those achieved results. It was also possible to discuss how important these ideas seem to be today, a longer time after publishing the papers [1, 3]. (What happened in the area during that time, would the solution be the same today?) Such a discussion could compensate for a certain time gap between 2020 and 2024 (I feel it like this with respect to a low value of authorship declared for [2]). Also, it would not be bad to relax almost exclusively focusing only on the FPGA platform, e.g. at least in the form of a certain basic information covering a broader context. For example, as a reader, I would welcome at least a rough information showing into which extent the proposed FPGA method could be compared with the methods intended for today’s GPUs or perhaps even also for smart phone cameras. (In Chapter 3, some possible platforms are briefly listed only.)

Summary: The thesis focuses on important and demanding topic. The author has proven his ability of research work. He proposed a solution to the problem that was opened in the thesis. The solution has been evaluated experimentally, the experiments have shown that the solution is useful and outperforming some other approaches. The solution was presented in journal papers. On the basis of all this, *I recommend the thesis for the defense*.

Ostrava, November 12, 2024

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