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Review of PhD thesis "Shadowing and Lightning Acceleration" (by Tomáš Milet)

The PhD thesis describes a lot of relatively incremental improvements of the already existing algorithms for shadows rendering. **Shadow rendering belongs to current topics in Computer Science**.

From the formal point of view, it is written as a textbook in good English. Its many figures and algorithms in pseudocode help readers to understand the presented topic. The text is structured into twelve chapters, out of which the most important are chapters 4-7 and 9-10. These chapters seem to be written independently. As a result, they often start with the unnecessary repeating of some information regarding what shadow mapping and shadow volumes methods are. Also, the presentation of the experimental results is inconsistent. For example, FPS is used in the tables and figures of chapters 4 and 5, in Chapter 6 has the values in milliseconds. I consider this to be a drawback that disallows a quick comparison of the improvements proposed by the author.

Chapter 4 describes an extension of the algorithm by Kim et al., 2008 to produce shadow volumes for an arbitrary triangular model (including non-manifolds) without visual artefacts caused by the limited precision of floating-point arithmetic. The solution is relatively straightforward: remove the triangles parallel to the light plane. I miss the detailed explanation of the first column in Tables 4.1-4.3. What is CPU, AVX+OMP, GS, OpenCL? The reader can only guess. It contrasts with the level used in Chapters 1-3. What versions of OpenMP and OpenCL have been used for the experiment? Table 4.2 is not referenced from the text. What it demonstrates? It would have been better to use some chart instead of tables to communicate the information better.

Chapter 5.2 proposes an additional extension by introducing a reference edge to compute multiplicity only once for each opposite vertex whilst retaining the robustness of the calculation. I do not understand what sign(A-B) in Algorithm 6 is. If A and B are vertices, they are vectors of at least three components, in which case A-B is also a vector. How the function sign(X), $X \in R^d$ is defined?

While the algorithms in Chapters 4 and 5 exploits the geometry shader, Chapter 6 presents a shadow algorithm for WebGL, which supports vertex and fragment shaders only. Multiplicity computation is, therefore, done in the vertex shader. It is stated that the shader must receive six times maximal potential multiplicity vertices per edge, explaining that one side of the shadow volume is composed of two triangles and six vertices. Why? Four vertices should be enough. I very much appreciated the level of the experiments performed. It is a pity that Figures 6.7 and 6.8 and Figures 6.12 and 6.13 do not have the same scale on the y-axis, which would allow easy cross-platform comparison of the results. Despite that, some relatively significant differences in the trends of SV between GeForce GTX 980 and Radeon R9 290X are observable. What could be the possible reason for it?

Chapter 7 describes a method that performs an octree space partitioning to reduce the number of silhouette edges tested in the shadow volume algorithm. It is not clear to me why octree has been chosen. In my opinion, a k-d tree would be easier to build, traverse, and due to its lower memory

requirements, it would better fit cache and thus outperform octree. The split could be chosen at the median of x, y, or z coordinates of primitives, ensuring that the structure would be balanced. Is there any particular reason why octree should be preferred?

Chapter 9 focuses on the shadow mapping technique, whereas the state-of-the-art in the field of shadow mapping is given in Chapter 8. My understanding is that the new algorithm is the RTW algorithm, where the warping functions are constructed differently, and MFS is used to accelerate the shadow mapping process. The second proposed algorithm (denoted as new-DV) then replaces MFS with DV. I miss the comparison of RTW with the novel algorithm with neither MFS nor DV acceleration, i.e. I would like to see the influence of the different construction of the warping functions on both the quality and the performance.

Chapter 10 presents unpublished experiments with the illumination of scenes containing many light sources with limited spatial influence. Although it shows, together with Chapter 11, the probable research direction of the student in the future, I found this chapter somewhat irrelevant to the rest of the thesis.

From the above-described, it should be apparent that **the thesis exhibits a lot of novel ideas, though many of them have relatively incremental character**. **However, the contribution of the student is not clear** since the described methods and algorithms were published in papers having multiple authors (not counting his supervisor A. Herout and the dean of the faculty P. Zemčík). I believe that the most significant (and original) contribution of the student lies in the development of a shadow algorithm for the WebGL 1.0 platform, described in Chapter 6 of the thesis and published in the conference paper:

MILET Tomáš, TÓTH Michal, PEČIVA Jan, STARKA Tomáš, KOBRTEK Jozef and ZEMČÍK Pavel. Fast robust and precise shadow algorithm for WebGL 1.0 platform. In: ICAT-EGVE 2015 - International Conference on Artificial Reality and Telexistence and Eurographics Symposium on Virtual Environments. Kyoto: Eurographics Association, 2015, pp. 85-92. ISBN 978-3-905674-84-2.

The work presented in the thesis was sufficiently published in 6 conference papers, whereas in 4 of them, the student is the first (corresponding) author. One was published as a full paper at the SCCG student conference in 2013, another one as a poster at the WSCG conference (CORE B) in 2014, the other two as full papers at the WSCG conference (CORE B) and ICAT-EGVE conferences (CORE B) in 2015. Even though it has been a relatively long time since their publishing (6-8 years), there is no citation of it from the research community, save for self-citations. Surprisingly, there is not a single publication from the period 2016-2018. I wonder why? The student must have had enough material five years ago for a journal paper summarizing his work, after the publication of which he could write the thesis and submit it for defence. The most recent relevant publication was published at the WSCG conference in 2019, with the first author being J. Kobrtek. T. Milet is also co-author of a recent journal publication (2021): Chlubna, T., Milet, T. & Zemčík, P. Real-time per-pixel focusing method for light field rendering. Comp. Visual Media (2021). https://doi.org/10.1007/s41095-021-0205-0. However, the topic of the paper is different from the topic of the thesis.

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Nevertheless, **the list of publications demonstrates the student ability to perform research. It is also supported by an impressive list of research projects in which the student has been involved.**

CONCLUSION: The student has demonstrated his ability to participate in research activities. However, I am not convinced about his preparedness for independent research because his authorship contribution measured using standard methods is lower than typical in the field. Nevertheless, **as the thesis complies with the acknowledged requirements for the PhD degree, I recommend it for defence.**

During the defence, the student should clarify his contribution. He could also discuss a possible extension of his methods for soft shadows computation.

Plzeň, Czech Republic 13.5.2021

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