Posudek diplomové práce

Matematicko-fyzikální fakulta Univerzity Karlovy

Autor práce	Bc. Tomáš Iser
Název práce	Dimensional measurements from a limited set of X-ray projections
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Studijní program	Informatika **Studijní obor** Počítačová grafika a vývoj počítačových her

Autor posudku	doc. Ing. Jaroslav Křivánek, Ph.D. **Role** Oponent
Pracoviště	KSVI

Text posudku:

In his diploma thesis, the candidate deals with the problem of contactless measurements of physical objects' dimensions using X-ray imagery. While this is not a new idea, the existing computed tomography methods rely on a high number of X-ray projections, yielding even full 3D reconstructions. This, however, may not be necessary in the manufacturing practice, where the general shape of the fabricated part is known, and the measurements only serve to verify that certain key dimensions of the part are within allowable tolerances. This is the scenario addressed in the proposed work.

The method developed by the candidate relies on a low number of X-ray measurements in an easy-to-calibrate setting. The necessary regularization of the problem is achieved through a tightly constrained parametric model of the part to be measured. The resulting measurements show sufficient accuracy, while using significantly fewer projections than previous work.

Overall, I was truly impressed by the work and especially by the exceptionally systematic approach to the system design and its verification. As in any engineering task, the candidate faced a series of specific design decisions, and had to work around the limitations of the available hardware (finite focal spot diameter, X-ray scattering on the detector, noisy measurements, etc.) and software (imprecise ray-triangle intersections, limitations of optimization algorithms) technology. The effect of all of these is thoroughly investigated, validating the overall system design.

Overall, the thesis provides evidence of exceptional maturity attained by the candidate as a systems engineer, and I do recommend the thesis for defense.

I have several questions and comments. These should not be taken as criticism but rather a result of my genuine interest in the topic and the candidate's work. The major ones should be addressed during the defense:

- The work is motivated by the CT perhaps being an overkill for dimensional measurements in engineering applications, but I missed a summary of the practical impact of the proposed method in the measurement practice: What is the realistic speedup to be expected by using your method over a full CT scanner? What are the savings in terms of hardware setup cost, and cost of operation? What is the timing breakdown of the entire measurement session: How much time does it take to set the measurement up, how long to measure each object once everything has been set up, etc.?

- Please provide rendering performance measurements: ray casting vs. loss function calculation. What is the achieved number of rays-per-second on your hardware? Are there any transfers between the CPU and GPU in the optimization cycle that could be a bottleneck? If

so, how can they be eliminated?

- Please provide a breakdown of time spent on the various optimization stages. Isn't the 4k resolution in the final stage an overkill? Could one use adaptive sampling of areas that are most relevant (edges, corners)?

- Differentiable rendering has recently been demonstrated for full physically based light transport simulation in the work:
Differentiable Monte Carlo Ray Tracing through Edge Sampling.
Tzu-Mao Li, Miika Aittala, Frédo Durand, and Jaakko Lehtinen
ACM Trans. Graph. (Proc. SIGGRAPH Asia 2018) 37(6), 2018.
Please review the above work and discuss if it provides all the necessary building blocks that one would need to apply gradient-based methods in the optimization step of the proposed method.

- On Page 78, the thesis says that Gaussian blurring with large kernels is too slow and cannot be used to simulate the effect of on-detector scattering. In fact, there are several real-time methods for applying Gaussian filters of arbitrary sizes, and these are routinely applied for various post-effects, such as defocus blur, etc. One reference to follow would be:
Real-Time Screen-Space Scattering in Homogeneous Environments
Oskar Elek, Tobias Ritschel, Hans-Peter Seidel
IEEE Computer Graphics and Applications 2013

Práci doporučuji k obhajobě.

Práci navrhuji na zvláštní ocenění.

Pokud práci navrhujete na zvláštní ocenění (cena děkana apod.), prosím uveďte zde stručné zdůvodnění (vzniklé publikace, významnost tématu, inovativnost práce apod.).

Práce vyniká svou inovativností, extrémně pečlivým zpracováním a důkladnou validací navrženého přístupu. Výsledky práce jsou přímo aplikovatelné v průmyslové praxi a zároveň mohou vést k vědecké publikaci.

Datum 20. August 2019 **Podpis**