In Prague
28/1/2021
Jiří Vorba

Questions:

1. Presented analog MC simulation follows the physical process of electron transport respecting the real mean-free paths. Due to low density of scattering events within the specimen, the simulation suffers from high noise levels and is thus inefficient. Is matching the noise levels from the real microscope important for application of your simulation or could you potentially increase the simulation efficiency by so called biasing of MC simulation while keeping the true expected values? (For example you could force many more scattering events within the specimen. Also one could potentially integrate transmittance through all the voxels instead of counting particles.)

2. How much time does it take to simulate say dose of 100000 on GPU?

3. What value have you used for maximum number of scattering events (ems_maxScatteringCount)?

RNDr. Jiří Vorba, PhD.

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Master thesis review

Title: Simulating image formation in an electron microscope by electron tracing

Author: Bc. Pavel Mikuš

Supervisor: Mgr. Tomáš Iser

Reviewer: RNDr. Jiří Vorba, PhD.

Author proposes and explores Monte-Carlo simulation of image synthesis in cryogenic electron microscope. From the point of light transport simulation applied in computer graphics, the proposed simulation is similar to analog light tracing collision estimator for heterogeneous volumes. However, while light tracing transports photons which interact with volume particles, electron microscope simulation requires tracing electrons interacting with specimen atoms and thus major difference is in the applied physical units.

Author faces several problems. He applies delta-tracking algorithm for tracing particles in heterogeneous volumes known from computer graphics and neutron transport simulations. To that end, he has to get familiar with image formation process in electron microscope and model appropriately parameters for electron MC transport like scattering coefficients and scattering functions.

Proposed simulation is implemented in C++/CUDA and capable of running both on CPU and GPU. Achieved results are very convincing. Method is thoroughly evaluated on real data and numerically compared to existing methods (multislice and transmittance methods) and to images acquired from real microscope. In terms of quality measured through cross-correlation, the method shows to outperform transmittance method and visually matches the multislice method. Contradictions from expectations are admitted and identified for future work.

Should I mention a weak point, I would welcome some time comparisons of the proposed method and competing methods, especially in comparison to the multislice method.

The subject of the thesis is interdisciplinary and highly non-trivial. Author shows very good understanding of the topic, capability of solving non-trivial problems and also very good programming skills. I would like to highlight the quality of the implementation which is very well engineered. **All in all, definitely, the work stands out of master thesis standards and I recommend it for defending.**

RNDr. Jiří Vorba, PhD.