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No: 185/17 - Jiří Vorba

Report on the Doctoral Thesis by Jiří Vorba

The doctoral thesis of Jiří Vorba introduces two new key algorithms to light transport simulation. Both techniques are foundational and have had immediate impact to academia and industry. It is hard to imagine that any future rendering algorithm will not include at least part of the techniques introduced in the thesis, which impressively underlines the importance of the results. It has been my pleasure to review this strong piece of research.

With respect to the form, the thesis is self-contained and very readable in addition. We like to point out that chapter 2 is very useful and instructive. It is very compact and nevertheless includes subjects like for example zero-variance schemes that go beyond the classic introduction.

Beyond doubt, Jiří Vorba proved his ability for creative scientific work. All results are mathematically derived in complete form. Supported by extensive and solid experimentation, the new theoretical contributions are verified in practice and a new understanding of the light transport simulation problem is created.

It is especially refreshing that prior work from at least two neighboring disciplines (machine learning and neutron transport) has been profoundly reviewed - a rock-solid approach that is rarely encountered today.

Chapter 3 presents the first of two new contributions: Enabled by techniques from machine learning, light transport paths now can be guided towards where light comes from, which dramatically increases the efficiency of light transport simulation as the number of zero-contribution light transport paths is decreased by a large factor. The data structures and algorithms are elegant and absolutely practical.

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Chapter 4 then identifies and reasons about a consequence of the previous chapter. For a second time, the candidate proofs that he is able to identify open ends and to drive them to an impressive solution, while advancing the state of the art. In a very systematic approach, Russian roulette absorption and splitting are unified, which is made possible by taking advantage of the data acquired by machine learning beforehand. Again, the technology is very practical.

In summary, the doctoral thesis improves the efficiency of light transport simulation by introducing a new technology to guide light transport paths towards the light, which is complemented by balancing the number of paths for maximum performance.

I strongly recommend to accept this excellent doctoral thesis.

Best regards,

Alexander Keller 

A SET OF POSSIBLE QUESTIONS

ALEXANDER KELLER

(1) What is the key difference between your approach and Eric Lafortune's approach taken in "A 5D Tree to reduce Variance of Monte Carlo Ray Tracing" ?
(2) How can your results be applied to bidirectional path tracing ? What is the expected gain, if any ?
(3) Is multiple importance sampling still required ? What about the problem of insufficient techniques ?
(4) Argue about the mathematical concepts of consistency and unbiasedness !
(5) Argue about the stability and convergence of Equation (3.5) !
(6) How do you sample from a Gaussian mixture model as used in your algorithms ?
(7) How do Gaussian mixture models adapt to complex visibility, for example when light passes through trees in the wind ?
(8) Is there a plausible or even physical explanation to provide intuition for Equation (3.12) ?
(9) Would it be possible to avoid Russian roulette absorption at all ?
(10) How is splitting controlled in your approach in order not to become exponential ?