Posudek diplomové práce

Matematicko-fyzikální fakulta Univerzity Karlovy

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Text posudku:

The presented thesis investigates possibilities of integrating an industry standard raycasting framework — Embree — into a highly specialized, research oriented, rendering toolkit — ART — capable of rendering images with advanced spectral and polarization effects. The Embree library has been designed as an easy to integrate, efficient implementation of ray–triangle intersection and traversal of acceleration structures. It assumes scenes composed of triangle meshes, builds its own acceleration structure based on user hints letting the user focus on the actual rendering algorithm itself.

ART, on the other hand, is based around the Constructive Scene Geometry paradigm, where complex scenes are represented by a tree structure of Boolean operators working with 3D primitives defined by implicit functions. This makes ray–primitive intersection calculation easy at the expense of having to traverse the CSG structure. Naturaly, Embree doesn't look like a good fit for this approach, however, ART also supports polygonal meshes which would benefit from Embree.

The goals of the thesis are thus twofold: 1) proof of concept integration of the Embree library within ART framework, 2) assesment of its performance under different circumstances. Author begins by brief introduction to the offline rendering domain covering the fundamentals of raytracing, its acceleration strategies, various scene representations with their pros and cons, finishing with a brief introduction to Intel Embree.

Second chapter deals with technical details of both ART and Embree preparing ground for the third chapter. There he states design choices concerning his approach to tackle the first goal of the thesis. He continues with thorough description of three implementations he made. First one is a recreation of a previous work which proved to incur high performance penalty and was dismissed as unperspective.

Second one is the intuitive approach of treating each top CSG node (a scene can be composed of several CSG hiearchies creating complex models) as an Embree user defined geometry, i.e.,

Embree fits a whole CSG node with its bounding box into its own acceleration structures and when a ray hit is registered with such a node, user provided callback is invoked to calculate the custom intersection. Here, the CSG tree rooted at the intersected scene node needs to be traversed. A third approach builds upon the second one by building internal kD trees for each top CSG node.

The theorethical part of the thesis is well balanced, in my opinion, providing short refreshement for people from the graphics field and good enough introduction with plethora of references for people without the graphics background. The introduction, first, and second chapters are well written and easy to read. However, the third chapter could use some refactoring and polishing as it was confusing in some places. Overall, the thesis would benefit from at least one more round of proofreading to fix small formal mistakes, typos, and unreferenced figures from the main text.

I'd like to mention author's honesty when discussing some of the encountered and presented bugs in certain test scenes: instead of omitting them or speculating about their nature, he admits that he doesn't know where they come from — and it's not entirely fault of the implementation either, native ART seems to exhibit such a behaviour on its own.

The source code seems to be readable and well commented with detailed instructions how to compile and run it. The Embree intergration is well separated and can be toggled on/off both at compile time (obtaining native ART) and runtime (allowing for performance comparisons). That is a design decision that pays off in light of the presented results. Those show Embree having the upper hand in scenes composed of triangle meshes (Embree's home domain) and scenes with multiple top–level CSG nodes. On the other hand, scenes composed of a single large and deep CSG tree are much better handled without the Embree overhead.

Although the implementation is far from perfect, the thesis clearly shows benefits of integrating Embree even within a context of a renderer based mostly around non–polygonal scene representation. Author mentions outlook for multiple improvements regarding the future work to bring in better performance. I'll conclude my review by stating that all goals of the thesis were fulfilled. Despite my criticism of the third chapter, I do think this is a good thesis and I do recommend it for defence.

Práci doporučuji k obhajobě.

Práci nenavrhuji na zvláštní ocenění.

V Praze dne 19. 8. 2021

Podpis: