Takua Render: Physically Based Pathtracer

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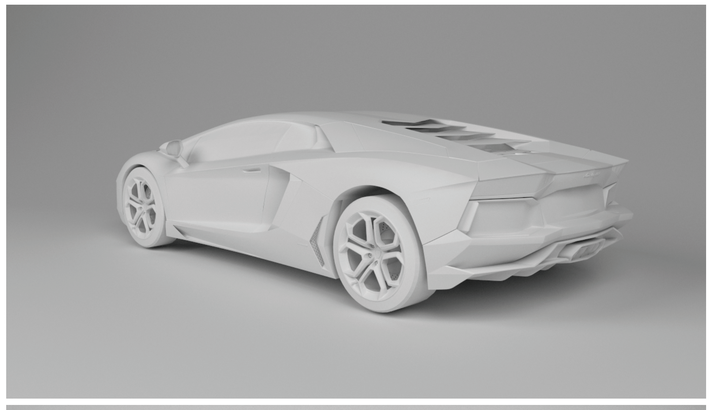
ABSTRACT:

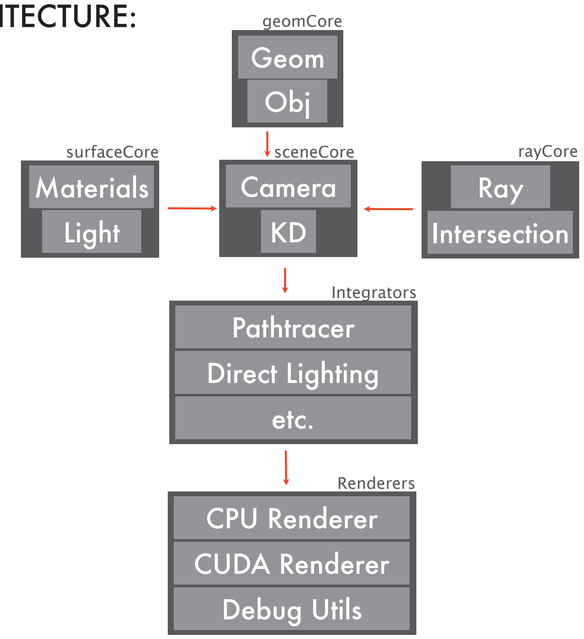
Takua Render is a massively parallel, GPU based physically based pathtracing renderer designed to produce photorealistic, film quality images.

MOTIVATION:

Historically, photorealistic rendering has necessitated a tradeoff between speed and image quality. In recent years, the emergence of general purpose GPU based compute through languages such as CUDA has allowed for enormous, multiple orders of magnitude speed increases for data parallel tasks such as pathtraced rendering. As a result, Takua Render can cheat the quality-speed compromise.



ARCHITECTURE:

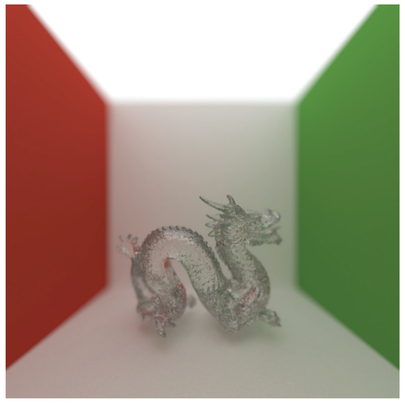


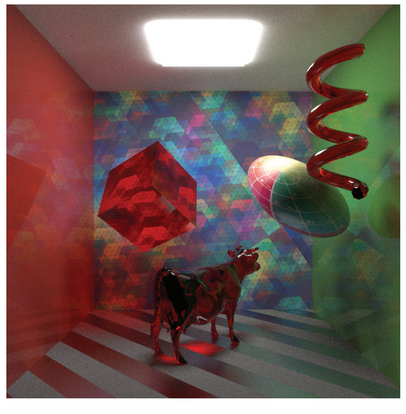
RENDER EQUATION:

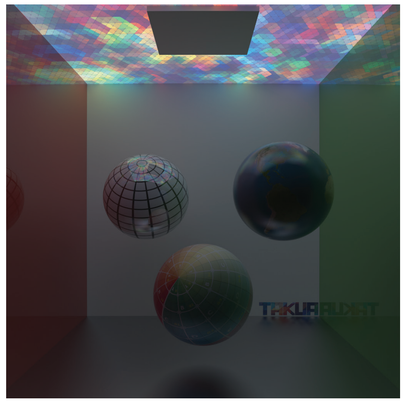
$$L_o = L_e + \int_\Omega L_i \cdot f_r \cdot \cos\theta \cdot d\omega$$

SELECTED FEATURES:

-Global illumination via Monte-Carlo pathtracing
-Physically based BRDFs such as Lambertian diffuse, specular/reflective, Fresnel reflection/refraction via S-P polarization, Schnell's law of refraction, and more.
-Brute force Monte-Carlo single scattering
-Custom memory manager and caching system allowing assets size to exceed available GPU memory
-Massively parallel CUDA based GPU rendering core AND multithreaded x86 CPU rendering core
-Texture and OBJ mesh support
-Direct lighting using multiple importance sampling

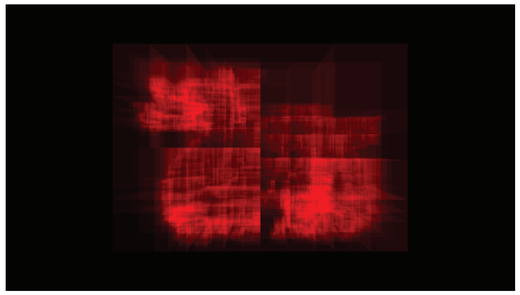




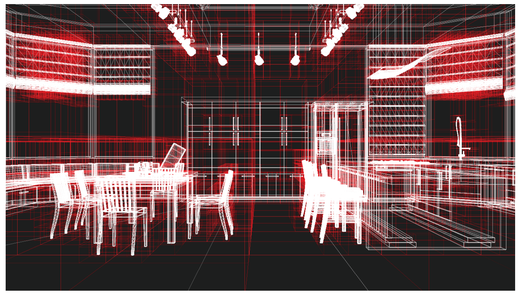


KD-TREE SPATIAL ACCELERATION STRUCTURE:

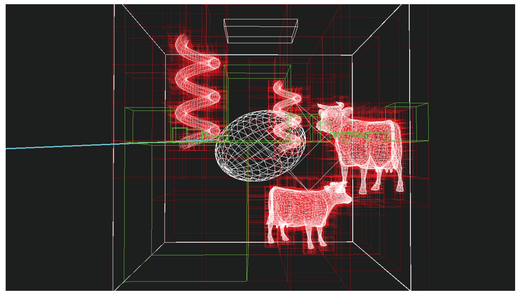
Takua Render utilizes a custom, highly optimized Surface-Area Heuristic based kd-tree for accelerated intersection testing. Construction takes O(nlogn), traversal takes O(logn) using an efficient, short-stack while-while based approach designed specifically for optimal GPU traverse performance.



Heat map showing traverse cost per pixel for the Stanford Dragon test model. Brighter colors indicate higher cost.



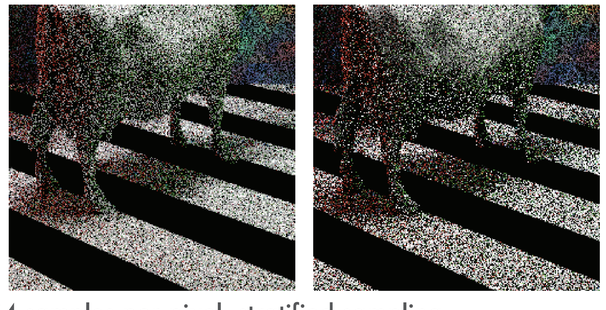
KD-Tree and wireframe for a complex kitchen scene containing approximately two million polygons. Takes under 1 second to construct.



Traversal path for a single ray through a scene. All geometry in red boxes were culled from intersection testing by KD-tree traversal, whereas green boxes contain geometry that had to be intersection tested.

SAMPLING TECHNIQUES:

Takua Render supports stratified sampling in addition to uniform random sampling in order to decrease variance for the same computation time.



Left side: 64 samples per pixel, stratified sampling.
Right side: 64 samples per pixel, uniform random sampling. Note the higher amount of variance in the uniformly randomly sampled image.