A Proposal for Rendering Translucent Materials

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I. Summary of Technical Problem

FOR our project we plan to extend ray tracing to render materials with interesting physical properties. This will include some simpler goals such as capturing the mirror and distortion affects of glass objects, and contains the final goal of realistically rendering static fluids. To do this we will need to implement the refractive and reflective properties of transluscent materials, and a model for subsurface scattering. Once these are done we also hope to implement some features to allow us to extend this to more complicated scenes. These features may include an acceleration data structure, bouncing rays off of an interpolated normal so we can render triangle meshes well, placing an image behind the camera to be reflected, and rendering to an image file. We would also ideally like to use photon mapping to capture caustics.

II. Relevant Research Papers

A. A Practical Model for Subsurface Light Transport

This paper details how to implement a dipole model for subsurface scattering. This will be the technique that we will implement in our project in order to produce more realistic looking liquids that are not completely translucent.

B. Global Illumination using Photon Maps

In order to add an additional element of realism we hope to utilize photon mapping to generate caustics in our images. This paper explains the generation of the photon map, as well as a method for gathering the photons for ray tracing.

C. Correlated Multi-Jittered Sampling

This paper details a sampling method developed by pixar which provides random access to the samples without precomputation, and in which samples can be ordered or shuffled. We may implement this sampling method into our application if we have time remaining.

D. On building fast kd-Trees for Ray Tracing, and on doing that in O(N log N)

In order to increase the speed at which our ray tracer runs, we may implement the kd-Tree outlined in this paper, which was developed specifically for ray tracing. Throughout the paper a few different methods of building kd-Trees are mentioned, and then the improved version is presented and explained.

E. Distributed Ray Tracing

Last of all we may implemented the depth of field ray tracing technique which was explained in Pixar's distributed ray tracing paper. This addition would be for the added visual effect, with no significant addition to realism.

III. Methods of Testing

A. To test the reflection and refraction of transluscent materials we will use three scenes:

- A non-perfect glass pane capturing the reflection of a sphere
- A hollow sphere distorting the scene behind it and capturing some of the scene in front of it
- A cup of water disorting scene behind it

B. To test subsurface scattering we will use these scenes:

- Spheres of various sizes to see if the sense of scale is captured
- Glasses of different milks
- A glass of some transluscent fluid such as wine

IV. Assignment Timeline

1) **Reflection & Refraction** *core*: Person.
2) **Subsurface Scattering** *core*: Person.
3) **Photon Mapping** *optional*: Person.
4) **kd-Tree** *optional*: Person.
5) **Multi-Jittered Sampling** *optional*: Person.
6) **Normal Interpolation for Reflection** *optional*: Person.
7) **Rendering Directly to a File** *optional*: Person.
8) **Depth of Field** *optional*: Person.

Once the core features are complete, the initial goal is to complete feature number three. Then features four to seven can follow in any order, followed by feature eight.

V. Conclusion

Our primary goals are to accurately capture the refractive and reflective properties of transluscent materials. Things we will work on given time include photon mapping to capture caustics through fluids, smooth renderings of triangle meshes, reflecting an image from behind the camera, getting a KD tree implemented for ray tracing, rendering to an image file, and lastly capturing depth of field.

References

[1] Robert L Cook, Thomas Porter, Loren Carpenter: "Distributed Ray Tracing". Proceedings of SIGGRAPH'1984.

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[5] Andrew Kensler: "Correlated Multi-Jittered Sampling". March 5, 2013.

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