Photon Mapping for Photorealistic and Non-Photorealistic Rendering

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I. INTRODUCTION

The rendering equation, introduced by Immel et. al. [1] and Kajiya [2], is much better estimated by photon mapping than simple ray tracing; however, unlike ray tracing, photon mapping relies on Monte Carlo sampling techniques, meaning the more photons mapped, the more realistic the rendered image appears. Thus, the method is much more computationally expensive than ray tracing, but with this increase in computation comes the power to render more complex effects, such as indirect illumination and caustics.

Though indirect illumination is one capability of photon mapping, I chose instead to focus on rendering caustics and more specifically, rendering lighting effects through transmitting surfaces. Another feature of photon mapping is that once the photons are mapped, the view camera can move and view the same scene, since the photons, though randomly distributed, do not move when the camera is moved. This view-independence feature was my primary motivation for exploring the possibility of view-independent non-photorealistic (NPR) rendering, since many methods of rendering artistic styles, stippling in particular, traditionally rely on generating random noise, which is difficult to keep consistent across multiple views.

A. Motivation

I was personally motivated to explore the non-photorealistic rendering of these artistic effects because of my background in drawing and painting. I was hoping to explore the more possibilities of imitating brush strokes with photon mapping, but this was a pretty unexplored area in computer graphics research, likely due to its difficulty. I instead spent much more time improving the rendering of realistic effects and pencil effects once I got a working implementation of the photon mapping algorithm.

II. RELATED WORK

Photon Mapping was initially introduced by Jensen and Christensen [3] and my approach in this paper is primarily based on Jensen's algorithm. The photon mapping algorithm has seen a number of improvements, including adding a photon map for shadow photons [4], which I adapted to use as part of my implementation for rendering stippling effects.

Non-photorealistic rendering has been explored by a large number of computer graphics researchers. I am unaware of any research papers exploring the possibility of using photon mapping for stippling effects, though there has been plenty of research into rendering objects with this effect [5]–[7]. Li and Wang [8] utilized the photon mapping algorithm to develop a painterly rendering framework, using the the impressionist line integral convolution (ILIC) used by [9].

III. APPROACH

IV. RESULTS

REFERENCES

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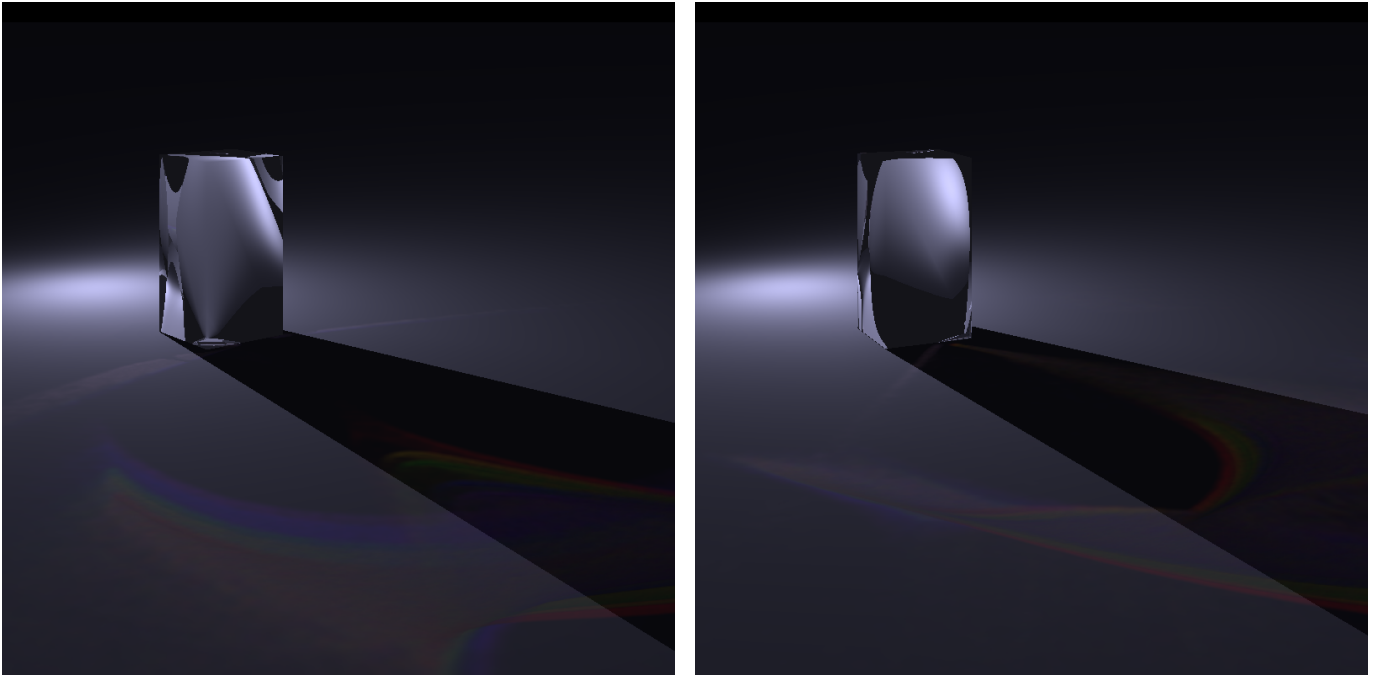
Fig. 1: Prism rendered at two different angles. The bands of light are more separated on the left, and they combine at the right. Rendered with 90000 photons. 5 wavelengths were sampled.
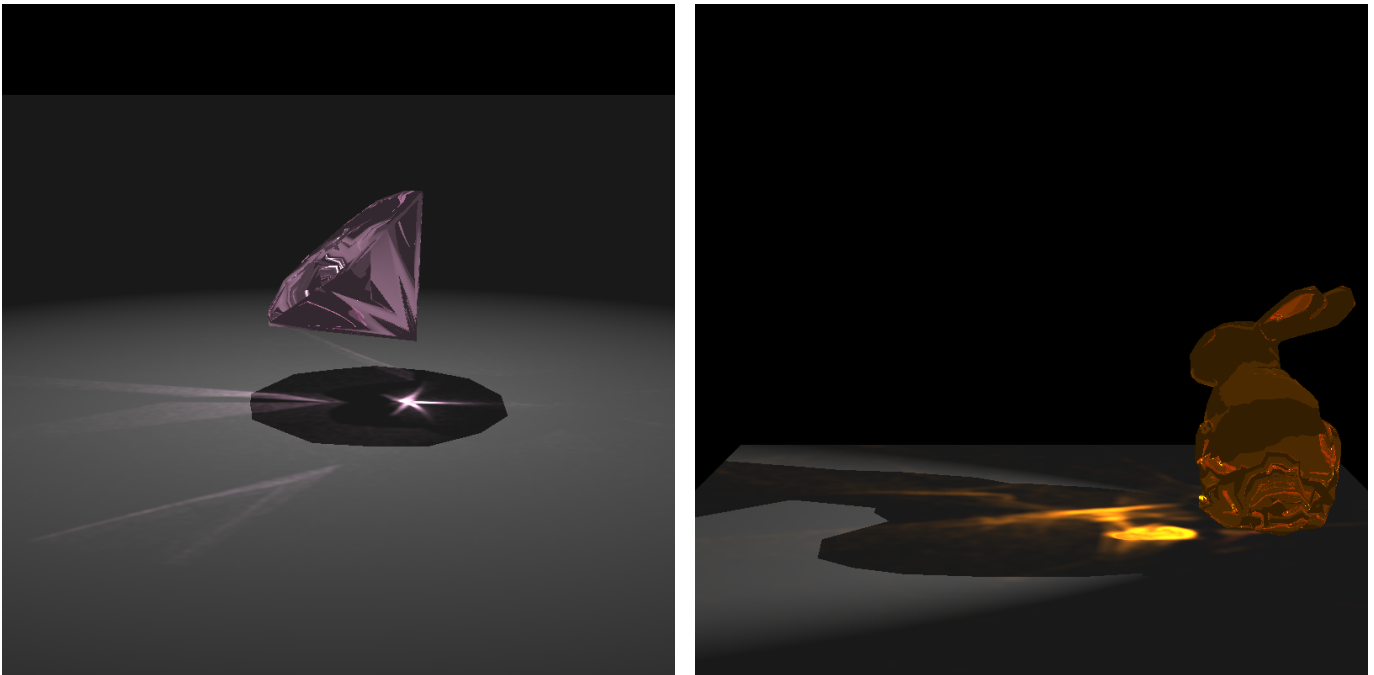

Fig. 2: The color of caustics can be estimated estimated very accurately.

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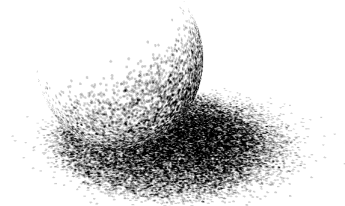
Fig. 3: Layering of transparent surfaces shown by a wine glass and wine. Rendered using 100000 photons.

(a) Stippling effect on a sphere with a spotlight

(b) Stippling effect on a sphere with an area light

Fig. 4: The difference in the choice of lights to render the stippling effect

dragon_stippling.png

(a) Stanford dragon rendered with a spot light. 50000 photons were used

(b) Bunny rendered with an area light. 30000 photons were used. Notice that the shadowed side of the bunny has much more shape than the lit side

Fig. 5: more complex geometries are handled quite nicely by the stippling effect using photon mapping