学　位　論　文　内　容　の　要　旨

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学　位　論　文　題　名

A Study on Efficient Rendering of Reflections on Complex Surfaces
（複雑な表面における反射の効率的なレンダリングに関する研究）

Reflections on reflective surfaces with high complexity structure, such as sparkles of the sun dancing on ocean surfaces or glints of street lights catching on wet pavements, are tiny but important to the rendering's realism and quality. The reflections visually describe the surfaces' detail and material to the viewer.

However, these reflections are difficult to render accurately in a limited time. Because the traditional methods aren't suitable for a non-smooth normal distribution function like those of the complex surfaces, many brute force methods can solve the problem by increasing the samples until they are enough to represent the surface's complexity. But they have two critical issues. First, we cannot determine the number of samples enough for each surface and light complexity. Second, the increase in sample size also increases its computational time. If we prioritize an application's interactivity, we only have a few milliseconds to render and show the result.

Our goal is to render an accurate reflection from the complex surfaces efficiently. We approach the problem by improving the real-time rendering quality in three different ways: spatio-temporal anti-aliasing, adaptive supersampling, and micro-reflection rendering.

Real-time rendering methods such as conventional rasterization-based methods cannot capture sharp reflections from complex surfaces. The objective of our approach is to improve the reflection quality for the rasterization-based method. The traditional method uses smooth functions to approximate normal distribution functions of microfacets of the surfaces. These smooth functions cannot capture the sharp feature of the reflections.

Spatio-temporal anti-aliasing is important for rendering dynamic complex surfaces such as an ocean. The method accumulates temporal reflection results for an interval between rendering frames to create a higher quality reflection. The techniques also consider spatial aliasing by wave clamping and NDF compensating. Hence, our method can remove both spatial and temporal aliasing from the result.

Adaptive supersampling improves our Spatio-temporal anti-aliasing by preserving the sub-pixel geometric detail, which was removed by the wave clamping. Our method first renders an aliasing-free image by approximating the normal distribution for the sub-pixel details with a Gaussian distribution. Then, our method detects the pixels that include significant high-contrast reflection by the sub-pixel geometry and renders sub-pixel reflections by supersampling.

Micro-reflection rendering increases the reflection quality of a simple surface, which we did not consider in the above methods. The problem usually arises when the lighting is evaluated at only the center of a pixel. An intense highlight can occur in a small area that is not at the center of its pixel. We propose a method that renders in real-time a sub-pixel specular-highlight. Our approach finds a reflec-

tion vector for each pixel that creates the brightest highlight by interpolating between four reflection vectors at the pixel corners. Then we compute the lighting with the reflection vector and multiply the result by an appropriate weight to account for a fraction of the pixel area that reflects the light source.
Also, we introduce our glittery surface rendering method, which is our work in progress. The technique creates a glittery effect on surfaces by storing multiple tiny surface orientations in one variable. Our process efficiently generates sparkles and glints on the surface in real-time; however, we still currently evaluate the method's effectiveness.
Our approaches show an improvement over the conventional methods in an area of complex surface reflection rendering.