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Micro Point

- Non super-sampling aliasing free algorithm -

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Abstract There are many rendering techniques using point-based super-sampling. With super-sampling, more sampling gives more quality. But how many samples do we need? We can only estimate this from statistics. In this research, we introduce a new concept called a Micro Point. Using Micro Points, we get aliasing free images without super-sampling.

1. Introduction

In point based rendering techniques, more super samples in a pixel area give lower variance. In other words, we expect improved quality of the image with super sampling. But we can not always estimate the required number of samples, for example in the case that there is an extremely bright extremely small region at a pixel.

In this research, we introduce a new concept for rendering called a Micro Point which was inspired by from quantum mechanics. Micro Points handle high frequency components in a scene correctly without super sampling. Today it takes much computational cost to render stars in the night sky, hair, or objects whose area is smaller than a pixel by existing methods. By using Micro Points, the calculation cost will be improved tremendously for such cases.

2. Previous works

A lot of methods for dealing with high frequency components have been proposed by many researchers.

2.1. Super sampling and pixel division

There are many method which are based on super sampling or pixel division [1,2,3,4,5,6]. We can only know statistically about appropriate number of samples.

2.2. Area sampling

There are several area sampling methods: For example, considering the coverage of polygons or lines at pixel on rasterization [7], beam tracing [8], or cone tracing [9]. The first method has a problem concerning how to handle depth information and shading for anti-aliasing a pixel. The latter two methods have the problem that the implementation is too complex for practical use.

3. Micro Points

3.1. Fundamental concept

From the uncertainly principle, we cannot measure position and momentum simultaneously under the Planck constant. This is a basic principle of quantum mechanics. A fundamental concept of the Micro Point is to substitute a pixel size for the Planck constant, an alpha value for momentum, coverage rate at a pixel for position.

In the concept of a Micro Point, we equate the following two situations: a triangle in a pixel with alpha=0.1, and coverage=50%, and a sphere in a pixel with alpha=1.0, and coverage=5%.

Intensity, normal vector, tangent vector, UV, dU, dV, etc. are defined dependent values that describe the features of shape in the existing rendering method. By the Micro Point, there are no certain shapes in the pixel. These parameters – intensity, normal vector, tangent vector, etc are defined by independent probability distributions in a pixel.

3.2. Normalization

In the Micro Point method, coverage and alpha are normalized such that the coverage is always 100%, with an appropriately adjusted alpha. In the above case, the alpha will be 0.05 and the coverage will be 100%. Therefore, there are no miss-samplings and super sampling will not be needed. This scheme will be expanded to texture mappings. Each texel will be similarly normalized.

3.3. Sampling theorem

By the sampling theorem, each Micro Point will be defined on sub pixels; we currently divide a pixel into 2x2 sub pixels.

4. Rendering by Micro Points

4.1. Dicing

Using object's local properties (intensity, normal vector, UV, etc.), an object will be diced into object fragments (if a object is a polygon, a polygon will be diced into polygon fragments). Each object fragment's local properties should be well sampled by dicing. Thus we don't need arbitrary techniques such as mipmaping [10].

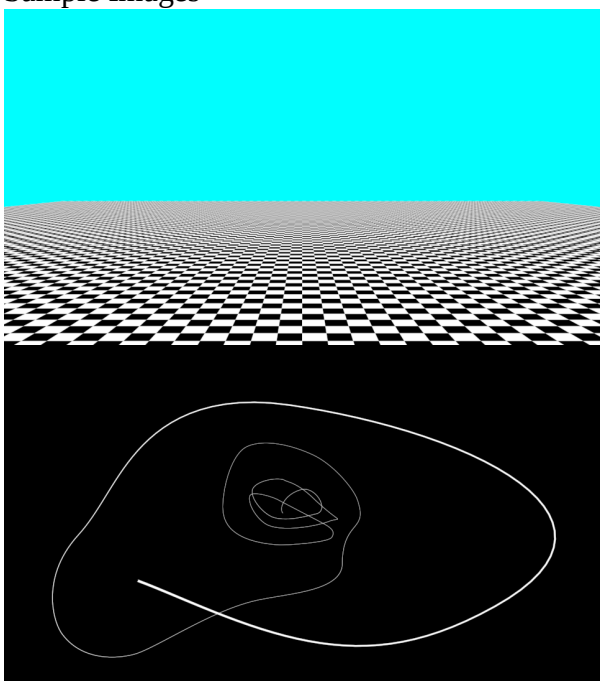
4.2. Micro Point generation

All object fragments are transformed into view coordinates, and then each transformed object fragment is converted into Micro Points on the image screen. On Micro Point generation, additional information for shading and depth min/max are bound to the Micro Points.

4.3. Determine color and alpha from Micro Points

In general, each pixel has more than one Micro Point. If two Micro Points' depth ranges overlap, these Micro Points are merged into one Micro Point. After this merge process, pixel color and alpha is determined by alpha blending from front to back.

Sample Images



Note: Please check these image at a magnification of 6 times.

5. Result and further discussion

By using Micro Points, we are able to correctly handle high frequency components whose size are less than a pixel. And we also confirm that aliasing, which has roots in high frequency components, is removed without super sampling.

The implementation of Micro Points is similar to the implementation of micro polygons, and it also has a high affinity with point clouds. We have easily found several extensions of Micro Points for deep shadow maps, depth of field, ambient occlusion, color bleeding, motion blur, SH, VPL, etc.; these methods are used for movie production [11-15].

6. Future tasks

When we were investigating the Micro Point method, we got an impression that the removal of moirés which are generated by interference of high frequency components is difficult by existing methods. This problem should be tackled.

7. Closing

Quantum mechanics is a milestone that is the door from classical physics to modern physics. Likewise Micro Points have a potential to be a milestone to progress from classical rendering to modern rendering. By speeding up by a GPU, restructuring of the production pipe-line, ... etc., on the road of Micro Points, we see infinite possibilities for rendering. Micro Points are placed as a royal road for rendering research.

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