CS 557 -- Winter Quarter 2021

Paper Analysis Project -

Practical Parallax Occlusion Mapping

for Highly Detailed Surface Rendering

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I.   Introduction

1.   The purpose of the paper

The general theme of the paper I read is related to how to bring more real visual enjoyment to people by using different ideas. Depending on the history of visual art, the evolution is from two-dimension to multi-dimension and it has been keeping going to develop more realistic scenes. The title of this paper means that we can get the dynamic lighting of surfaces by applying a per-pixel ray tracing algorithm. It showed that the reduction of the scene can be improved a lot including texture, depth, or lighting and so on.

Even though we can derive a not bad result from the basic mapping method, but there still exist some defects. In this class, we learn a method called normal mapping. It can generate a nice realistic brick picture. However, it cannot make each light from each angle perfect and the shadow is also defective. (see Figure 1.)

Figure 1. The result of normal mapping

The thing that the researchers are trying to do is to figure out a way to render a complex surface topology with high performance and to be more realistic. The old rendering method requires a higher computation performance but the lower quality is received. Thus, the problem they are trying to solve is to reduce the cost of computation including

vertex transform, memory footprint, depth of all angles, and so on. In addition, a better quality of rendering will be made.

2. Background of the author

The author of the paper "Practical Parallax Occlusion Mapping for Highly Detailed Surface Rendering" is Natalya Tatarchuk, who is the Vice President of Graphics at Unity Technologies. In addition, she earned an S.M. in computer science from the Harvard John A. Paulson School of Engineering and Applied Sciences and Graduate School of Arts and Sciences in 2008. She grew up in an engineering family; thus, the technology-related topic is very common around the dinner table. However, Tatarchuk's major is not computer science but physic when she first studied at Boston University. Until she met computer programming, she became hooked on it, especially in computer graphic field. Tatarchuk really enjoys the difficulties and challenges which computer graphic brings.

"Ultimately, we want to make it easy for people to create," Tatarchuk said. For her, the most significant achievement is not to figure out a kind of powerful algorithm but to help game creators to get ahead. For example, a group of professional engineers definitely know how to set up an appropriate VR environment; however, it is a challenge for a group of normal people. Thus, the goal of Tatarchuk is - how do software developers make it easy so the users are not suffered from the technology and can reach their crazy and amazing vision.

II. Methodology and Result

1. Classic method of mapping

1.1 Normal-mapping:

Compared with bump-mapping and displacement-mapping, normal-mapping does not contain any height information but angle information. The most significant point is that the angle information can be utilized to generate a beveling effect. It definitely cannot be finished with only height since the render has no idea which

direction the edge should be bent. Thus, the information o angle is relatively important here. But the detail still cannot be present well like correct depth at each angle.

2. Improved method

2.1 Dynamic Parallax Occlusion Mapping with Approximate Soft Shadows

It applies an efficient algorithm to the per-pixel ray tracing for the inverse displacement-mapping. In addition, it can do the interactive rendering of displaced surfaces with self-occlusions, motion parallax, dynamic lighting, and soft shadows. (see figure 6.) Compared with the result of the normal mapping, the outcome of the parallax occlusion mapping is more detailed and realistic in the part of grooves, bumps, even scratches.

Figure 4. Parallax occlusion mapping versus normal mapping

In addition, it also applied the soft shadow to deal with bold shadow. In general case, it probably is fine if we use hard shadow; however, the most shadow in the world is influenced by lots of factors like refraction and scattering of light. If the object, which produces a shadow, called blocker is close to the ground then the penumbra will be pretty small. Under this case, the shadow is hard. Relatively, we will get soft shadow. By computing the ratio of blocker and receiver, we can get more realistic situation of shadow by the distance between the object and light source.

III.   Discussion and Conclusion

In this paper, we can see that dynamic parallax occlusion mapping with approximate soft shadows conquer several weak points other mappings have including memory usage, computation consumption, the quality of image. The data provided in the paper shows that there are 1,500,000 polygons and a total of 45 Mb buffer used when normal mapping is applied. However, there are only 1,100 polygons and totally less than 14 Mb buffer used when parallax occlusion mapping is running. In the end, the points that the paper made are the render of the complex surface with detail in real-time, precise lighting effect, a better memory footprint, highly interactive rendering use, and the render of height field in a dynamic way.

IV.   The insight I got from the paper

One thing that I can almost understand and be interested is the discrepancy between the hard and soft shadows. Before I read this paper, my original idea of generating a shadow is like hard shadow. However, it is not a quite suitable choice sometimes. In my opinion, the soft shadow will be produced when the object is far from the ground. (see Figure 5.) The soft effect is stronger if the partially shadowed area is bigger. This theory is like lens effect.
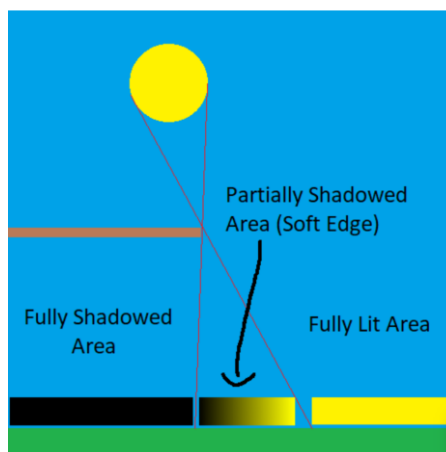

Figure 5. Shadow generation

On the other hand, the hard shadow will be produced if the object is close to the ground. Under this situation, the partially shadowed area will be smaller. In addition, the distance is not the only one factor which can affect the type of shadow. Another factor that can affect the type of shadow is the size of light. (see Figure 6.)
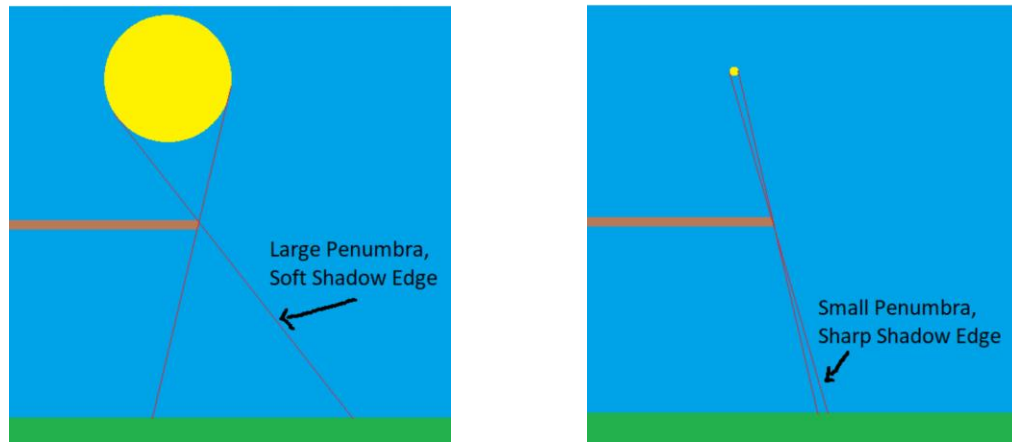

Figure 6. The discrepancy of the size of light

I think the soft shadow will be frequently used because the effect that the soft shadows create is more realistic than the hard shadow does. The soft shadow considers the ratio of blocker-to-receiver; thus, it can precisely calculate the exact size and type the shadow should be.

V. The thing I want to try I were researcher

I would like to combine bump mapping and displacement mapping to improve the model and scene. For example, I will add the true relief to a landscape by using displacement mapping then add the extra noise to it. In this way, it reduces the weight of computation from the displacement mapping then accelerates the performance.

Reference

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