GPU Accelerated Interactive Integral Photography System Using Extended Fractional View Method

Kazuhisa Yanaka and Sho Kimura
Kanagawa Institute of Technology

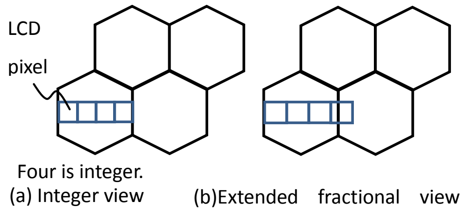

Figure 1 Integer view vs. fractional view

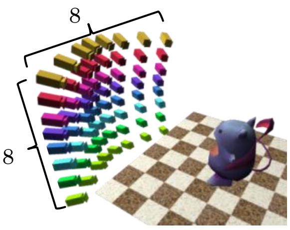

Figure 2 Multi-viewpoint rendering

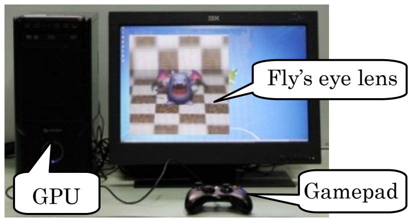

Figure 3 GPU Accelerated interactive integral photography system

Abstract

We developed a novel system of interactively displaying 3D images, in which integral photography images with the method of extended fractional views both with horizontal and vertical parallax could be rendered much faster by using a graphics processing unit (GPU). Therefore, displayed auto-stereoscopic 3D computer graphics (CG) objects could be moved very smoothly with a gamepad.

1 Motivation

Integral photography (IP) is an ideal system to display 3D images because not only horizontal but also vertical parallax can be obtained without having to wear special glasses. The simplest IP system can be made by placing a fly's eye lens on a liquid crystal display (LCD). The pitch of a fly's eye lens in the past strictly had to be an integer multiple of the pixel pitch of the LCD, as shown in Figure 1 (a). However, this restriction was removed in the extended fractional view (EFV) method [1] shown in Figure 1 (b). Therefore, almost unrestricted combinations of fly's eye lenses and LCDs became possible, both of which are inexpensive ready-made products. Another advantage of EFV is that the quality of auto-stereoscopic images is considerably higher even if relatively low-resolution LCDs are used. Therefore, EFV can be used, for example, for auto-stereoscopic CG animation using digital photo-frames [2] where real-time rendering is not necessary. It has been technologically difficult to apply EFV to real-time interactions, on the other hand, because only very low frame rates could be achieved because numerous computations were required [3].

2 Method

We solved this problem by introducing GPU processing. Although GPUs have the potential of tremendously accelerating processing speed, we must be careful because they have basically been designed for "embarrassingly parallel" problems. The multi-viewpoint rendering in Figure 2 can suitably be applied to GPUs, but existing algorithms being used to synthesize IP images cannot be applied because the processing of pixels is dependent on other pixels. Therefore, we developed a new algorithm that was more suitable for GPUs, in which any pixel position was mapped into an equivalent point within a rectangle near the origin, by making use of the periodicity of a fly's eye lens. In addition, the 8 × 8 images captured from cameras in Figure 2 were connected together to form a single image to avoid restrictions where a maximum of 16 images could be read by the shader.

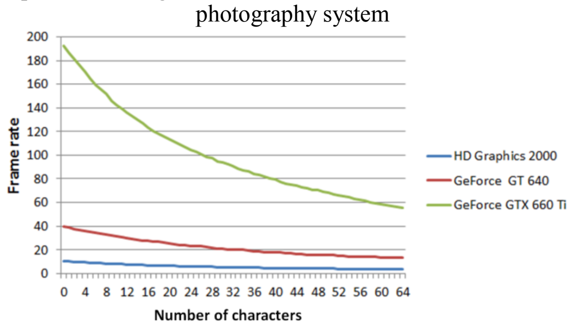

Figure 4 Frame rate vs. number of characters

3 Experimental Results

Figure 3 has a photograph of the experimental system that consisted of a high-resolution LCD (IBM T221 and 3840×2400 pixels), a fly's eye lens (Fresnel Technologies No. 360), and a PC with an upper midrange GPU (GeForce GT660Ti which had 1344 CUDA cores). More than 60 fps were secured even with large IP images.

The relation between the number of characters and the frame rate obtained by one of three kinds of GPUs is plotted in Figure 4. Here, 512 × 512 LCD pixels were assigned to an IP image, and a character called "CatBatDeamon" had 956 polygons. The processing speed was sufficiently fast to animate characters quite smoothly, provided that there were not too many characters even when the GPU (6 EUs) embedded in the CPU was used.

4 Conclusion

Real-time processing became possible by introducing a GPU, and the rendering speed of the IP images improved sharply. Generally speaking, the higher the performance of a GPU is, the smoother the motion of an object becomes, and this becomes more suitable for applications such as games and virtual reality systems that require excellent image quality and rigorous real-time processing.

References

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e-mail: yanaka@ic.kanagawa-it.ac.jp

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