A panoramic image generation method reproducing size perception in human vision

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***Abstract*— In computer graphics, it is common to generate images from models in 3-D space using perspective projection. However, it is known that perspective projection images cannot reproduce the sense of size that humans perceive in real space. This is also true for panoramic images. A magnification function expresses a sense of the size of objects in relation to the viewing distance. In this study, we propose a method to generate images by applying a magnification function to panoramic images. This method makes it possible to reproduce the human impression of a real space as an image, even in a panoramic image.**

I. Introduction

When observing 3-D computer graphics images drawn by perspective projection, we often feel a sense of discomfort because the size relationship of objects with different viewing distances differs from that in real space. Human vision reconstructs space in the brain using "distance and depth cues" from the two retina images. Perspective projection cannot fully represent human perceptual characteristics. Panoramic images allow wider areas than perspective images to be captured in the images. However, the relationship between the sizes of objects with different viewing distances in the same direction is basically the same as in the perspective image.

Nagata et al. [1] investigated the relationship between perceived size and distance in real space and proposed a magnification function:

$$f(D) = e^{A}, \quad A = \frac{\alpha N_0 D^{\alpha}}{\alpha + \lambda N_0 (D^{\alpha} - 1)} - C, \qquad (1)$$

where D is the observation distance, and α, λ, and C are parameters to adjust for individual differences. The images generated by using this magnification function were closer to the impression of real space than the perspective projection images in the one-point and the two-point perspective landscapes. This study proposes a method to generate panoramic images by applying this function.

II. Image Generation Method

The procedure for generating a panoramic CG image using the magnification function is shown below. The 3DCG software Blender 2.90 (Blender Foundation) was used for implementation.

1. Crop a portion of a landscape as a long, narrow vertical image. For this purpose, a virtual camera with a sensor size of 5.3mm x 24mm is prepared. This corresponds to a vertical angle of view of 77 degrees and a horizontal angle of view of 20 degrees. Then, define the direction of the center in the landscape (called the image center)
2. Prepare a lot of clipping areas in the depth direction in the virtual camera, and generate 229 images by perspective projection method by dividing the clipping areas from 2 m distance to 110 m distance from the camera position. For each image, the distance d from the camera to a drawing area and the angle b from the image center to the drawing area are recorded. The angle b is 0 degrees at the image center, minus means the left side and plus means the right side.
3. Repeat the step 2 10 times for 200 degrees, changing the camera angle horizontally by 20 degrees. A total of 2280 images are generated.
4. Prepare an image buffer large enough. The center of the buffer is the center of the panorama image, where angle 0 is set. For each of the images generated in the step 3, calculate the magnification rate f from the distance d from the camera according to Eq. (1). Scaling the image data according to the magnification factor f and recorded in the image buffer. The horizontal position of the image data is the position $b \times f$ in the image buffer. Figure 1 shows a normal panoramic image and an image generated by the proposed method.

Fig. 1 ordinary panoramic image (top) and an panoramic image generated by the propsed method (bottom)

References

[1] K.Nagata, A. Osa, M. Ichikawa, T. Kinoshita, and H. Miike, "Magnification rate of objects in a perspective image to fit to our perception," Japanese Psychological Research, Vol.50, No.3, 2008, pp.117-127.

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