Panoramic Image Representation for Immersive Projection Display System

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Abstract: CAVE uses projection displays for user to feel high immersion of virtual reality. We can make more immersive environment using a panoramic image representation which surrounds users by the real images. In this paper, we make the panoramic images from the real environment using a digital camera and a panoramic tripod head and apply them to the K-CAVE system to increase user's immersion.

Key Words: *Virtual Reality, Panorama, Immersive Projection Display, CAVE*

1. Introduction

The CAVE [1] is a widely used display system in virtual reality. It uses projectors and screens for users to feel high immersion. It surrounds users with artificial objects, avatars, background and etc. To feel more realistic, the CAVE can use real image or model of them. A real background can be used just as users see in real world and a panoramic image can be viewed like this because it can surround user in the whole direction. If a panoramic image representation which surrounds users by the real images, we can make more immersive environment.

In this paper, we develop a panoramic image representation for CAVE to increase user's immersion. First we shot background photos of real world using a panoramic tripod head, a digital camera and a tripod. Then we stitch them to produce a panoramic image for background. Finally we make a panoramic image representation for CAVE using these images.

2. Panorama image representation

2.1 Panorama image format

There are two main formats of panorama image [2] which show 360 degree field of view in the vertical and horizontal directions. One is the equirectangular format and the other is cubic. The equirectangular format is also called the spherical format. It contains a single image of the equirectangular projection and it’s ratio is 2:1. The cubic format is made of six face images of cube that surrounds user.

2.2 Panorama image representation in CAVE

We use the equirectangular format to produce representation. Because the images are located with 3 dimensions in CAVE, the images of the cubic format are distorted in the corners of vertex. We make a virtual sphere which contains the whole hexahedron of CAVE screens. Then we project the equirectangular image to the inner face of the virtual sphere. This projection is implemented using the texture mapping technique.

3. Panorama image photographing

3.1 Panorama photographing

When we take a panoramic image, it must be considered to stitch together later. We can turn the camera on a no-parallax point, which is also called a nodal point, to eliminate parallax between images. A panoramic tripod head is used to rotate the camera on the no-parallax point.

While we take a picture, there are some conditions which were kept in mind. The exposure value, the f-number, the focal length and the shutter speed must be fixed through all images. We can take pictures in this condition using manual mode. Large f-value is preferred to get generally clear image.

3.2 Photograph calculation

Photographing for a panoramic image is not so easy. To get good quality images, we must move a tripod which is not so

light to carry and take dozens of pictures. If we pre-calculate how many and what directions images we take, we can do photographing more efficiently.

For the width w(mm), the height h(mm) of CCD in the camera and focal length f(mm) of camera lens, the field of view fv_h(degree) in horizontal direction is as follows.

$$fv_h = 2\tan^{-1}\left(\frac{w}{2f}\right) \qquad (1)$$

If we want to overlap l(%) between the adjacent images, we need n_0 images to fill in horizontal direction as follows.

$$n_0 = \left\lceil \frac{360}{fv_h \times (100-l)/100} \right\rceil \qquad (2)$$

Using similar calculation with the height of CCD, we can get the number k_0 of images to fill in vertical direction. The unit tilt degree difference d between the adjacent images in vertical is as follows.

$$d = \frac{360}{m} \quad m \text{ is a multiple of } 2 \text{ and } m \geq k_0 \qquad (3)$$

We take pictures of tilt degree d, $2d$, $3d$, and so on until 90 degree. The number n_g of needed images with tilt degree g is as follows.

$$n_g = \left\lceil \frac{360 \times \cos g}{fv_h \times (100-l)/100} \right\rceil \quad g < 90 \qquad (4)$$

4. Results

We take images using Nikon™ D70 digital camera with Nikon™ 18~70mm DX lens which is not the fish-eye lens. Fanotec™ NN3-II is used for the panoramic tripod head. We take 12 images in 0 degree, 8 in 45 and 1 in 90 as shown as Figure 1. We stitch these images to a panoramic image using Autodesk™ Stitcher Unlimited 2009 software.

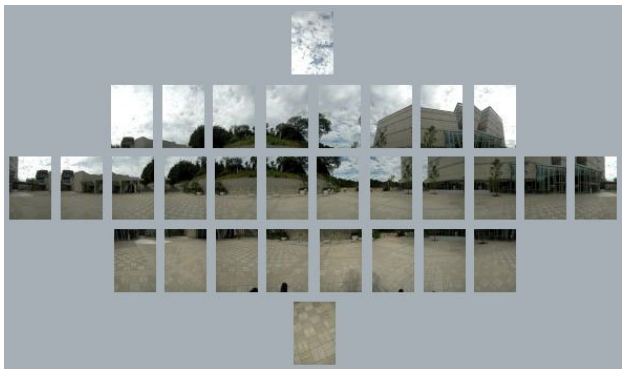

Figure 1. Raw images of each tilt degree

The K-CAVE [3] is a CAVE-clone display system at the Keio University. It consists of 4 screens, 8 projectors, 8 Linux based PCs, a magnetic position sensor and a joystick. Stereo feature is achieved by circular polarization filters and all experiments are developed using OpenCABIN Library [3]. We implement a panoramic image representation in K-CAVE as follows.

Figure 2. Panoramic image representation for CAVE

5. Conclusion

We make the panoramic images from the real environment using a digital camera and a panoramic tripod head and apply them to the K-CAVE system to increase user's immersion.

Our contributions are as follows. We formulate the calculation of panoramic image photographing and we can take images efficiently. And we construct panoramic representation for CAVE to improve user's immersion.

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