Cybercity Walker - Layered Morphing Method -

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1 Introduction

We are aiming at reconstructing a broad city area in a computer (Hirose, et al. 1999). Usually, traditional CG techniques are used to describe and present a virtual space. However, the CG techniques based on geometrical models can not draw images having photo-realistic quality in real time.

Image-Based Rendering (IBR) is another promising method to describe a virtual environment. We have already developed a method to generate interpolated images without any distortion (Endo, et al. 1998) based on one IBR method called View Morphing (Seitz and Dyer 1996). This method makes it possible for an observer to freely walk around a plane, which is defined by three points where three base images are taken. However, this method has some limitations because the problem of occlusion still exists and it can not present an object having complex outline.

This paper proposes a new morphing method called Layered Morphing and explains about a system called Cybercity Walker that is an implementation of this method.

2 Approach

Our Layered Morphing Method consists of two kinds of processes. One is a process to separate a base image into layered images and the other is to perform the morphing of images layer by layer.

The first process is to separate a base image into layered images. Suppose there is a base image in which one object is in front of another object keeping a part of it out of sight. In this case, if you perform morphing without separating it into layers, the resulting image can not present observers a part hidden by another object even when they change their position. This gives an observer a sense of incongruity. To solve this problem, we tried to separate the objects into their own layers so that the appropriate parts of them are seen when an observer changes his/her point of view. Note that because we can designate an outline of the object in the layered image using a two dimensional paint tool, it is possible to deal with the situation when one object hides another even for objects having complex outlines.

The second process is to reconstruct any image seen from other viewpoints than those used to take the base images. The observer can not observe a continuous view if only images actually taken are presented to him/her. Therefore it is required to reconstruct an interpolated image seen from any other point using morphing method in order to present an observer a smooth and continuous view.

The next section explains this method.

3 Layered Morphing Method

3.1 Producing Layered Image

First we have to determine the number of layers. The basic strategy is to separate objects into layers when a jump edge is found where occlusion occurs. When the number of layers is determined, simply copy the set of three base images into each layer as an initial image set.

Then, fill out any area other than the object for that layer with black. If some parts of the object are hidden by some other objects, retouch those parts using a two-dimensional paint tool available in the market (figure 1).

Finally, generate interpolated images for each layer by applying the morphing algorithm stated in the next subsection. The algorithm should be applied from the layer with furthest object to that with nearest object. You can deal with the situation where some parts of object are hidden by other objects if you treat the black parts of each layer as transparent.

3.2 Morphing Method without Distortion

We have already developed a morphing method to generate an interpolated image without any distortion from a set of three base images with position and orientation data (Endo, et al. 1998). In this method, every corresponding point in the base image set is tied using triangular meshes. An image seen from any point in the plane including three points used to take the base images is reconstructed by applying two steps of algorithm. Before applying the

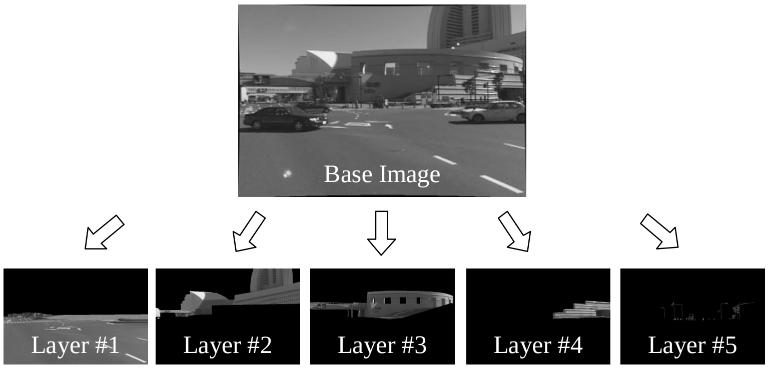

Figure 1: Producing layered images

interpolation algorithm, the base images are rotated so that they satisfy conditions not to produce distortion, thus the resulting interpolated image has no distortion regardless of the camera position used to take the base image. While applying this morphing method repeatedly according to the position and orientation of an observer, it becomes possible to give an observer a feel that he/she is walking through a three dimensional world.

Note that the area for an observer to walk-through can be expanded by changing the images in the base set of three images according to the view position of the observer. Also note that an observer can freely look around by changing the images in the base set according to the orientation of the observer.

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3.3 Result of Image Reconstruction

Figure 2 shows the result of applying our morphing method to the images of a city taken by our data capturing system (Hirose, et al. 1998). As shown in the figure, an observer can change his/her viewpoint freely in the two dimensional space.

4 Experiment System

We have built a system implementing our Layered Morphing Method explained in “3. Layered Morphing Method” of this paper. We call it Cybercity Walker system.

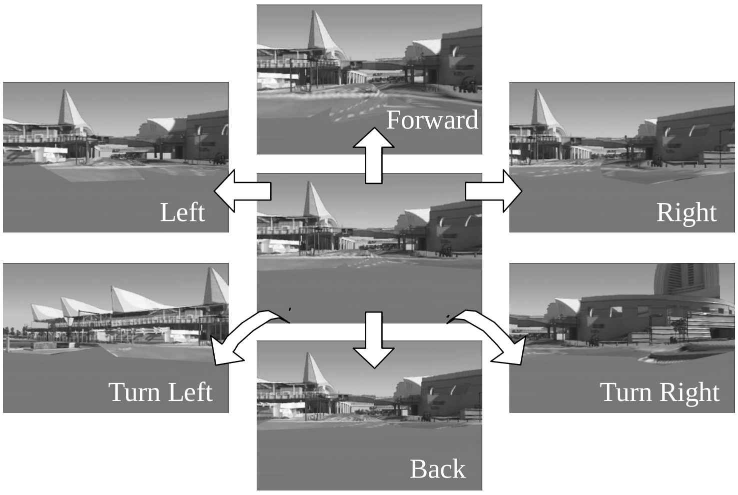

Figure 2: Result of image reconstruction

Cybercity Walker is a system built by combining the Layered Morphing Method and the panorama switching method. The panorama switching method is a method to give an observer freedom to look around him/her while moving along the path where images were taken (Endo, et al. 1998). In this method, a panoramic image is produced by stitching images of various directions taken by our data capturing system. The system switches panoramic images thus created according to the position of an observer to allow him/her to move along the path while looking around. By combining these two methods, we can effectively build a walk-through system, in which an observer can move and look around with a certain level of freedom. The resulting walk-through system selectively uses the panorama switching method for the situation where an observer only moves along a predefined path such as going through a road, and the Layered Morphing Method when an observer can move in a certain area as when he/she is in an open space.

The system configuration is the same as that of (Endo, et al. 1998) (figure 3). The morphing method is applied to two places giving an observer freedom to move around the area of approximately 10 meters square. In one of these places, a broad viewing angle of approximately 180 degrees is given to an observer by changing the base image set according to his/her viewing direction. The base image sets are separated into approximately five layers and the total size of the required data is around 40 Mbytes. Of course it is possible to render the required images in real time.

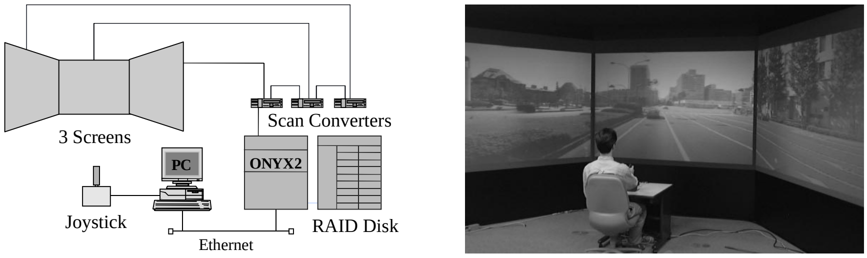

Figure 3: System configuration

In this system, an observer can move around approximately 600m x 500m of Minatomirai area, district of Yokohama, which is given by the panorama switching method and the Layered Morphing Method. As many as 9,000 panoramic images are used and the total size of the data is approximately 12 Gbytes.

5 Conclusion

This paper explains about a new approach to generate photo-realistic images seen from any point of view. Note that we can present complex shaped objects while avoiding the problem of occlusion. The feasibility of implementation is also stated as the experimental system called Cybercity Walker. In the present stage we have to separate the base image set manually into layers and it requires a lot of effort. The next goal of our research will be to automate this process.

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