

360° Interactive Video Scenes with Multi-directional Moving Capability

Vajirasak Vanijja Susumu Horiguchi

Graduate School of Information Science
Japan Advance Institute of Science and Technology
1-1,Asahidai, Tatsunokuchi, Ishikawa, 923-1292, Japan
Email: {vanijja, hori}@jaist.ac.jp

Abstract

In this paper, 360° video clips of a sampled area are captured and merged together with an optimized method to extend the degree of freedom of the user's movements. This method allows the user to move freely in 8 directions from the current position. Any movement by the user causes the view image and the light condition to be synthesized by interpolated zooming of the camera's view to create a realistic virtual environment.

Keywords: Omni-directional camera, Interactive video, Image-based Virtual Environment, Virtual Reality, 360° panoramic image

1. Introduction

Virtual reality technology based on real photo images or video images is a highly effective of effective approach. An interesting commercial product, Quicktime VR 0 is a good example that utilizes this method. Quicktime VR enables the user to pan and zoom to view a section of a 360° cylindrical panoramic image of a real environment scene. Chiang *et al.* [1] implemented a Software Developer Kit to integrate photo-realistic 360° cylindrical panoramic scenes with 3D synthesized objects in a virtual environment. Nayar *et al.*[3][4] proposed an idea to capture the whole environment using one shot from a 360° camera. Peri *et al.* [5]described a new method for the creation of a perspective view of an interactive image scene from an image created by a 360° camera. Y. Onoe *et al.* [6] presented the online perspective image generation. However, their interactive image scenes have some limitations of movement within the virtual environment.

In this paper, we propose a multi-dimensional moving capability system where the users can control and move their view around a specific area in 360°

interactive video scenes. The view image and the light condition are synthesized by an interpolated zooming technique triggered by the user's movement. The proposed system is able to create interactive video scenes with less computation time compared to previous approaches because it only interacts only with 4 small video clips at a time. 360° interactive video scenes with multi-directional moving capability can be used for training systems and virtual tour applications for complex environments, such as a museum or rooms in a house.

2. 360° interactive video scenes

It is necessary to clarify the terminology used in this paper before describing the details of the system.

1) 360° interactive scene:

The scene is created from a 360° panoramic image[5]. The user can shift viewing direction to left or right as shown in Figure 1. The user can view only a segment of the panoramic image at any movement in time.

2) 360° interactive video scene:

The sequences of a 360° interactive scene are created from 360° panoramic video clips[5]. The user can control the video sequence to play forward or backward.

A 360° interactive video scene can present an image view in all directions of environment along the camera movement path. In this paper an approach to extending the freedom of movement in 360° interactive video scene is described.

Figure 2 shows the marked points, which are the positions of the user in each step of movement. In this paper, we adopt 0.5m as the step of distance. 360° video clips are captured in the vertical and horizontal directions and are combined together using the optimized method and allow the user to control their view and movement.

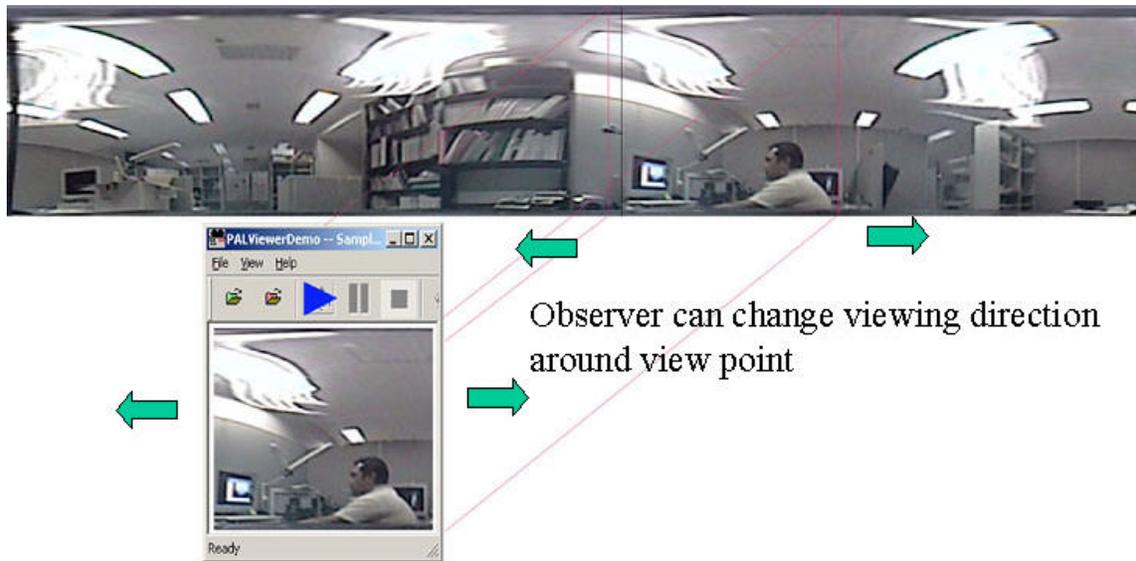


Figure 1: A 360° interactive scene in which the user can control the viewing direction

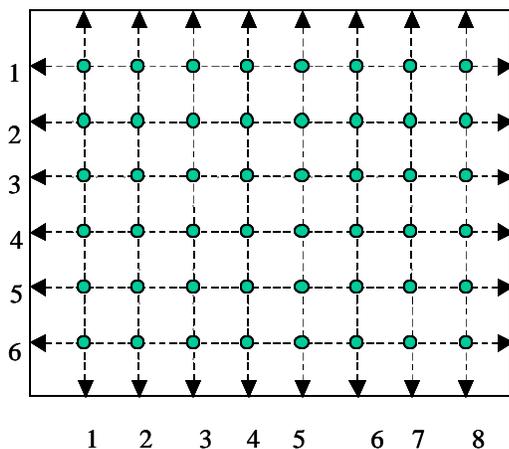


Figure 2: A specified area with the moving path of a 360° video camera (dashed line) and marked points position

3. Multi-Directional Moving Capability

360° video clips are captured in the vertical and horizontal directions, and then cut into segments. Figure 3 shows the multi-dimensional moving capability in which the user can move the view around specific area of 360° interactive video scenes. The combinations of 360° interactive video scenes at one position are shown in Figure 3. The black circle, at the center, is the current

position of the user. The dashed circles are marked positions in oblique directions. The solid gray circles are marked positions in the specific area. Big arrows in oblique directions are image frames, which are created by an interpolated zooming method to extend the moving capability in oblique directions. According to the viewing direction of the user, the 360° interactive video scenes are selected in the next step of the movement. The control display loop allows the user to move along vertical and horizontal directions. But for oblique directions, the interpolated zooming technique is applied to create image frames between the current position in the 360° interactive video scene and the adjacent scene in an oblique direction as can be seen in Figure 3 represented by the big arrows.

The control display loop starts by initialize the current user's position and then loading 4 clips from the 360-degree interactive video scene, which are indexed by marked points in the space. When the user moves to a new position in the space four new clips from the interactive video scene are loaded into memory and point index to the key frame. These relate to the new user's new position. Any time the user move, the graphics display loop will check the user's viewing direction to identify the next video clip in the sequence.

4. The Interpolated zooming technique

Let (x_1, y_1) be the current position and (x_2, y_2) be the target position in an oblique direction. These are shown in Figure 3. The interpolated zooming technique is used to create image frames between the current position and the next destination position in an oblique direction.

Figure 4 shows the relationship between the view planes of the current position and destination views. “ a_1 ” is the normal width of the view plane at the current position (x_1, y_1) and “ a_2 ” is the width of the zoomed image at the target position (x_2, y_2) . “ b_1 ” and “ b_2 ” are the angles’ edges of center view points at angle “ α ”. “ z ” is the zoom ratio of normal view plane “ a_1 ” to view plane “ a_2 ” to make the zoom.

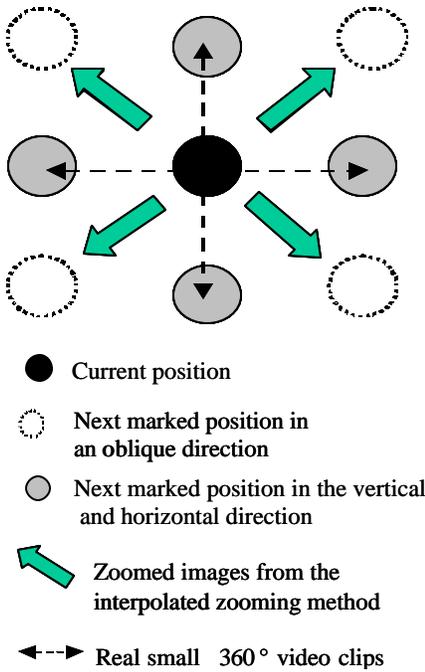


Figure 3 some marked positions and the relation of (x_1, y_1) and (x_2, y_2)

It is calculated by the following equations:

$$z = \frac{a_1}{a_2} \quad (1)$$

$$d = \sqrt{(\Delta x)^2 + (\Delta y)^2} \quad (2)$$

$$, \Delta x = (x_2 - x_1) \text{ and } \Delta y = (y_2 - y_1)$$

$$a = \tan^{-1} \frac{a_1}{2h} \quad (3)$$

$$z = \frac{a_1}{2\left(\frac{a_1}{2 \tan(\alpha)} - d\right) \tan(\alpha)} \quad (4)$$

In equation (4), when “ d ” = 0.707m, $\alpha = 20^\circ$ and $a_1 = 6m$, the zoom ratio will be 1.18. This “ z ” specifies the zooming ratio of the original image to the destination image. The interpolated zooming technique will zoom to the image of the oblique viewing direction by steps until z

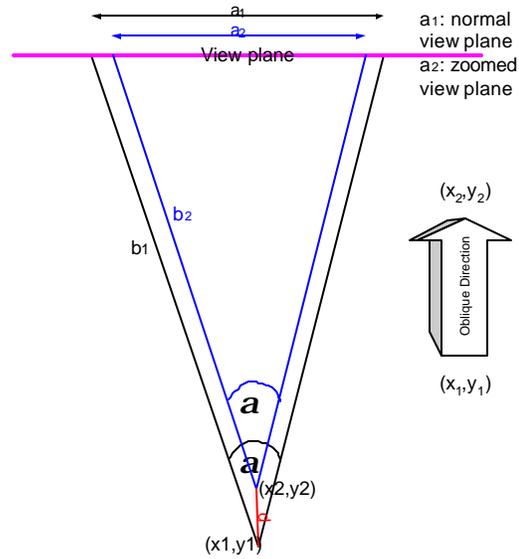


Figure 4 Relation between zooming ratio “ $z = a_1/a_2$ ” and distance “ d ”

= 1.18 and then stop and load new set of 360° interactive video scenes for the new position.

Figure 5 shows the interactive video scenes generated by the interpolated zooming technique. It is seen that the interpolated scenes between the original position and destination position are well synthesized.

This technique is designed to use with short distances. This method is not recommended for the case where the distance is longer than 1m because the distortion at the edge of the viewing image frame, captured by an omni-directional camera, will generate errors.

5. Experiment

In the experiment 360° video clips are captured from a room, with size 10.40x7.80 m², in vertical and horizontal direction as shown in figure 5. Moving paths

of the camera follow marked positions. The space between each point in vertical and horizontal is 0.5m.

Figure 6 shows the sequence of example images, which generated by Interpolate zooming technique at the position that shown in figure 5. Interpolated zooming technique is applied to the image frame in the direction of the arrow. Images in figure 6 are the result of the zooming, which simulate the view when the user moves close to the computer. The left-most frame is a segment of the image frame at the current position. And the right-most frame in figure 6 is a segment of the new frame at the destination position.

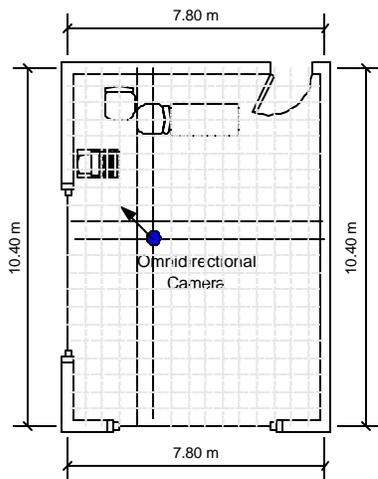


Figure 5 shows floor plan of the sample room

6. Conclusion

The 360° interactive video scenes have a high potential for application and expansion. The proposed multi-dimensional moving capability system allows the users to control and move their view around a specific area in 360° interactive video scenes. The proposed system can create interactive video scene with less computation time and memory, because the proposed system loads only 4 small 360° interactive scenes into memory at one time.

There is still need to find a proper technique for evaluating the quality of the interpolated zooming technique. The performance improvement by reduced computation time and extend the range of the moving direction, which are a continuing problems to be solved in future work.

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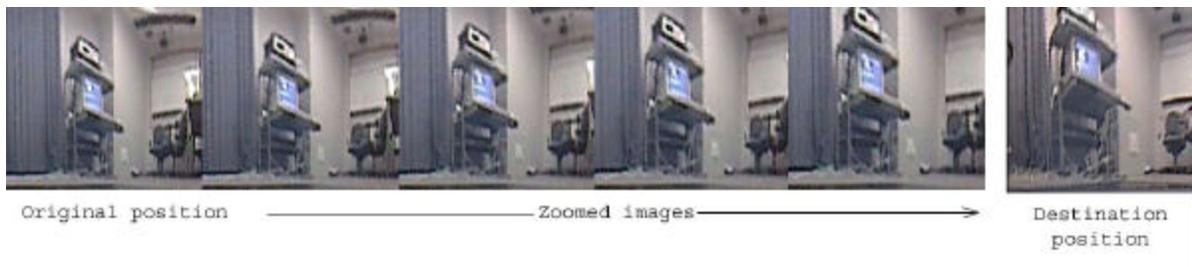


Figure 6 the zoomed images by Interpolated zooming technique from current position to destination position in oblique direction.