A SURVEY ON PANORAMIC VIDEO METHODS

[1]Mohd Hanif Mohd Ali , [1]Fakhrul Anuar Aziz and [2]Abd Razak Yaakub
[1]Faculty of Information Technology
[2]Faculty of Management of Technology
Universiti Utara Malaysia, 06010, Sintok, Kedah

Abstract: Panoramic Video (PV) is an enhanced of Panoramic Image (PI) in virtual environment. PV is 360-degree of video where user can control the video sequence (play forward or backward) while PI is create from a 360-degree of image where user can change viewing direction to the left or right. The issues are PI cannot contain any moving object because it will distort and blur the image after stitching it. Stitching is a process to joint seamlessly the images into panoramic image. PI also not as real as PV because it just contains static movement (image) while PV can contain movable objects (video). The purpose of this paper is to compare the three methods to build a panoramic video system and decide the best method to capture 360-degree video without sacrifices the image resolution and quality. The three approaches are Catadioptric System with Perspective Lens (CSPL), Catadioptric System with Orthographic Lens (CSOL) and Multiple Cameras. CSPL uses mirrors and perspective lens to enhance the field of view (FOV). CSOL also uses mirrors but the lens is orthographic. This is because, orthographic lens can simplify the calibration and computation. Multiple Cameras is a method that will use multiple (at least four) Digital Video cameras to capture a 360-degree of video. It is important that each camera view is overlapped each other so it will be reduced the parallax effects. Each of the construction methods, advantages and disadvantages will be revealed and discussed.

Keywords: Virtual Reality, Panoramic Video, Multiple Camera, Catadioptric, Omnidirectional, 360-degree video

INTRODUCTION

Nowadays, Virtual Reality (VR) playing a major role in the Virtual Environment (VE). A key component in most VR systems is the ability to perform a walkthrough of a virtual environment from different viewing positions and orientations. As stated by Ivan Sutherland [6], VR is to make that (virtual) world in window look real, feel real and respond realistically to the viewer's action.

There have been many ways to recreate the situation of real sense of being there. For example a virtual presence that let user explore (freely move) certain places interesting in an interactive (using mouse and keyboard), expletory style and choose where to look. PV is a new technology that can capture 360-degree of video. It evolved from PI. PI can be made using three methods cylindrical projection, spherical projection and cubical projection. However, the easier way to do PI is using cylindrical projection. Nevertheless, the main constrain in this method is limitation to look up and down (vertical FOV) [1]. PV overcomes the passive and structured limitations of how video imagery is present and perceived [4]. It also produces quite high FOV. Unlike conventional imaging, the systems are low on FOV.

METHODS

There are three major methods in creating a 360-degree video. First are CSPL and then CSOL and finally Multiple Cameras. This paper will be discussing about the construction, advantages and disadvantages of each method.

Catadioptric System With Perspective Lens

Catadioptric are imaging sensors built with combinations of mirrors (catoptrics), and lenses (dioptrics). It uses reflecting surfaces (curved mirror) to enhance the FOV [3]. Figure 1 shows example of catadioptric sensor.

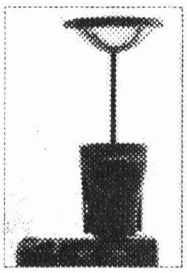


Figure 1: Example of catadioptric sensor

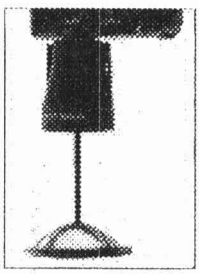
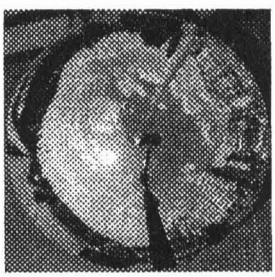


Figure 2: Upside down of CSPL sensor

Construction: There is various types of mirrors that can be use in this system. For example, conical mirror, spherical mirror, paraboloidal, ellipsoidal and hyperboloidal mirror. All of these mirrors used perspective lens in front of their camera. Although it is easy to construct a configuration that includes one or more mirrors to increase the FOV of this system, it is harder to keep the viewpoint fixed in space [3]. Figure 2 shows that it does not matter whether you place the mirror up and the camera down (refer Figure 1) and vice versa (refer Figure 2), as long as the system is in stationary place (vertical).

Advantages and Disadvantages: The main advantage of this system is common center of projection (COP). Therefore, this system requires no complex stitching [7]. The disadvantages are blurring. It occurs because of the reflecting surfaces. It also suffers from large locus of viewpoint and low resolution [3, 7]. Figure 3 shows before and after warped image (notice some blurring at the top of the image after warping).



Before warped

After warped

Figure 3: Before and after warped image.

Catadioptric With Orthofraphic Lens

CSOL is same as CSPL (using paraboloidal mirrors and lens) but the main factor that differentiates between them is CSOL use orthographic lens. According to Nayar [3], orthographic lenses will simplify the calibration and computation of perspective images. Therefore, the stitching process is a lot easier than CSPL.

Construction: There are many ways to achieve orthographic projection. One way is by using an inexpensive relay lens in front of the shelf of the perspective lens [3]. Figure 4 shows example of CSOL. This system uses a 1.1-inch diameter paraboloidal mirror; a Panasonic GP-KR222 color camera and Cosmicar/Pentax C6z1218 zoom and close up lenses to achieve orthography. The transparent spherical dome minimizes self-obstruction of the FOV.

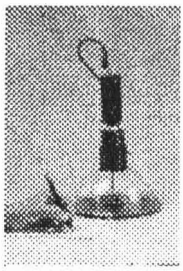
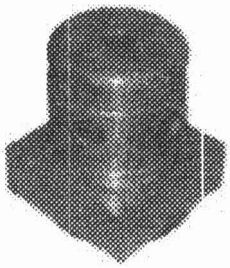


Figure 4: Example of CSOL sensor



Ladybug (MSR)

Figure 5: Example of Multiple Cameras sensor (Ladybug)

Advantages and Disadvantages: Same as CSPL, the main advantage of this system is common COP. Because of the usage of perspective lens, it will simplify the calibration and the stitching method than the CSPL method. The disadvantages are also same as CSPL except large locus of viewpoint. Nevertheless, the resolution is higher than CSPL.

Multiple cameras

Multiple Cameras used various cameras to capture a 360 degree of video. It does not matter which camera do you use as long as the entire camera in the system are the same and produce a high-resolution image. It will not use any mirrors to enhance the FOV. The main idea is, each camera are put as close together so each view of the camera are overlapped each other so the video can be stitch. The purpose of stitching is to create a seamless panoramic image from a set of overlapping pictures. A 50 percents overlap seems to work best because the adjacent picture may have very different brightness levels [1].

Construction: Figure 5 shows Ladybug as the multiple cameras sensor. Point Grey Research constructed Ladybug and used by Microsoft Research (MSR) to capture 360-degree video. This camera was build by using six cameras (Sony ICX204AK color CCD). Five are configure in a horizontal ring and one camera is pointing vertically. The system also has a storage unit that can record up to 20 minutes of full frame, raw, uncompressed video. The storage unit use notebook hard disk (four 40GB Ultra ATA 66) to store the video. Any IEEE-1394 device can be use to preview or control the system. It also retrieves and process previously record data. The system weighs only about 2.5 kilogram. This system is 360 degree x 80 degree (vertical) in FOV.

Figure 6 show FlyCam as the multiple cameras sensor. FlyCam was build by using five-miniature color board camera. Although the systems are mounted as close together, they do not share a common COP [2, 7]. The cameras are mounted on the faces of an octagon and each camera is angled 45 degrees to its neighbor. Octagon was chosen because it is easy to construct. Much other geometries and configurations are possible and might well improve the current design.

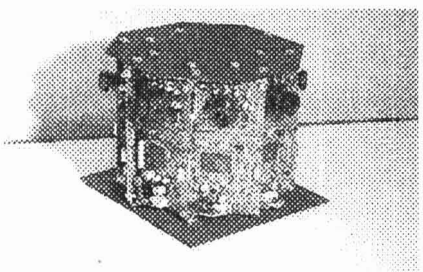
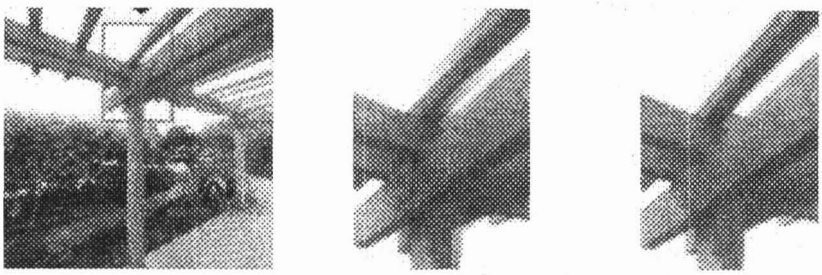


Figure 6: Example of Multiple Cameras sensor (FlyCam)

Advantages and Disadvantages: The main advantage in this method excels in the resolution output. This method ranked one followed by CSOL and CSOP. The images are the sharpest among others methods. The vertical FOV are much higher than other methods. The major drawback of this method is no common COP. The stitching process will require a more complex technique. Because of no common COP in multiple cameras, it will generate parallax effects. Parallax is apparent shifting of an object when viewed at different angles. It can be solve using Multi-Perspective Plane Sweep (MPPS) technique. Figure 7 shows the parallax effects and the solution after MPPS technique has been implemented.



Before After

Figure 7: The parallax effects.

RESULTS AND DISCUSSION

Table 1 summarises the results of the study. The results showed the advantages and disadvantages of each method. As you can see, Multiple Cameras image and resolution are sharper than CSPL and CSOL. Because of no common COP, it requires more complex stitching technique. While CSPL and CSOL suffers from blur because of the reflecting mirror. By using orthographic lens, CSOL simplify the calibration and computation.

Table 1: Summary of advantages and disadvantages of panoramic video method.

Panoramic Video	Advantages	Disadvantages
(1) Multiple Cameras	Images are more sharper than 2 and 3	No common COP
	More higher resolution than 2 and 3	Require complex stitching
	More higher vertical FOV	
(2) CSPL	Single COP	Blur because of the reflecting mirror
		Large locus of viewpoint
(3) CSOL	Single COP	Blur because of the reflecting mirror
	Calibration and computation are simplified than 2	2 < Resolution < 1

CONCLUSION

As a conclusion, multiple cameras are the best way for capturing 360-degree video without sacrifices the image resolution and quality. The major drawback of this method is no single COP. Therefore, it requires a more complex stitching method.

ACKNOWLEDGEMENTS

This project was funded by Ministry of Science and Technology (MOSTE)

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