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Full-parallax and high-quality multiview 3D image acquisition method using camera slider

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Abstract

In this paper, we propose a full-parallax and high-quality three-dimensional (3D) image acquisition method using camera slider for the real object. The proposed method uses the available fewer cameras and a camera slider, and captures the various viewpoints of the real object. Three identical cameras are mounted in the vertical direction and these cameras capture the different perspective images of the object at the same time, while the camera slides to the left and right directions horizontally. Here, we used a camera slider that allows the camera to view only the center portion of the object during sliding. Although the available fewer cameras are utilized, the hardware difference between the cameras often occurs, the additional calibration processes for color and brightness is required. In addition, through the camera calibration method, the distortion and position-depended calibration are performed. Afterwards, the pixels of the synthesized image which includes all of the viewpoint information that is rearranged according to the given multiview display specifications, at least, the high-quality multiview 3D image is generated.

1. Introduction

Three-Dimensional imaging has been developed in recent few years. 3D stereoscopic images are mostly based on stereoscopic images. However, stereoscopic images have a limited depth of feeling and limited use of special equipment such as glasses [1]. In order to solve these problems, autostereoscopic display technology has been developed which can feel stereoscopic feeling without the use of special viewing equipment [2].

The stereoscopic image for the autostereoscopic display can be acquired by two methods. The first method is to acquire images in full-parallax directions using a micro-lens array based camera. Unlike conventional 2D cameras, there has a micro-lens array in front of an image sensor and a directional ray is obtained by operating as a multi-camera by a micro-lens array. Since the optical characteristics of the micro-lens arrays are similar, depth information can be obtained without special camera alignment and calibration procedures. However, since the image is acquired on a single CCD (charge coupled device), the resolution of the viewpoint is lowered as the number of viewpoints increases [3]. The second method is to acquire data using a multiview camera. The multiview image is a set of multiple images acquired by multiple cameras at multiple viewpoints. Compared to a micro-lens array based camera, it can feel the depth feeling in a wide range, but the number of cameras required for the desired number of viewpoints is necessary for shooting and many considerations such as camera arrangement, synchronization pre-processing should be considered [4].

However, as the display technology develops, it is necessary to use an acquiring method using a multiview camera since a high resolution image can be obtained. But the conventional multiview camera method has to decide which type of array to use, so it cannot be used in a fixed position. Also, a problem occurs that requires as many cameras as the number of viewpoints.

In this paper, we propose a full-parallax and high-quality multiview image acquisition system using camera slider and implement a calibration system. The main features of our system includes: (1) Unlike previous multiview camera system, it is not fixed and it is possible to adjust the view interval and the number of viewpoints, (2) It is possible to use both the convergent method and the parallel method, (3) High-quality multiview image can be acquired using a minimum number of cameras. Finally, color and brightness calibration, lens distortion calibration, and image rectification are performed on the acquired image.

2. Full-parallax and high-quality multiview 3D image acquisition method using camera slider

The proposed method has a rotation axis as shown in Fig. 1, and three identical cameras are positioned in a vertical direction to acquire a vertical view image and move left and right through a camera slider to acquire a horizontal view image.

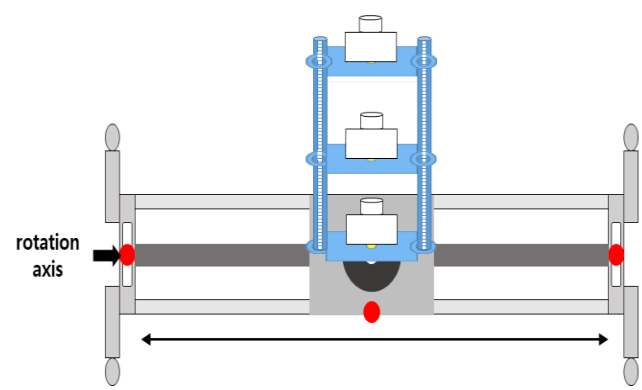

Figure 1. The proposed full-parallax and high-quality Multiview 3D image acquisition method using camera slider

In addition, it can change the camera arrangement according to the position of the rotation axis of the camera slider. When the rotation axis is centered, it can be used as a parallel arrangement as shown in Fig. 2, when the position of g rotation axis is moved away from the center, it can be used as a converging arrangement as shown in Fig. 3. Also, it is possible to move and acquire the viewpoint image in the horizontal direction at a desired interval of the user within the range of the camera slider.

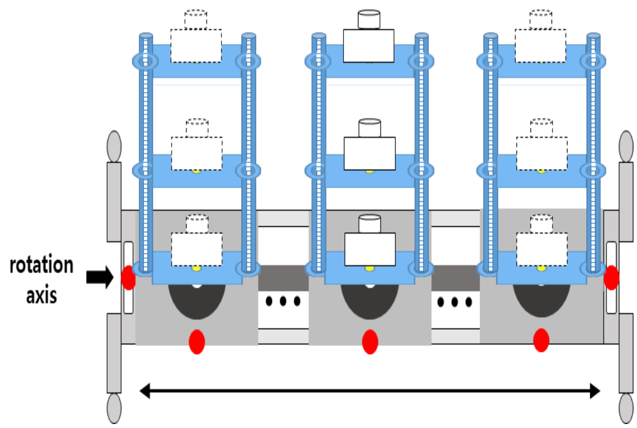

Figure 2. Using parallel arrangement

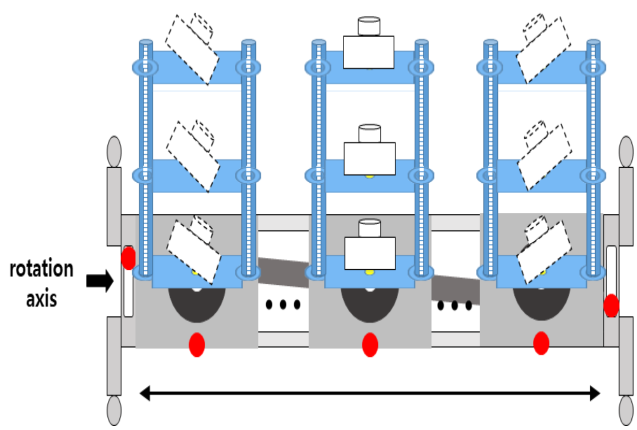

Figure 3. Using converging arrangement

3. Calibration system

The images acquired from a general multiview camera system have color and brightness differences, lens distortion, and Image alignment problems [5]. The images acquired by the proposed acquisition device also have the same problem. Therefore, we implemented a system to correct these problems. Fig. 4 shows the processing of the calibration system implemented in this paper.

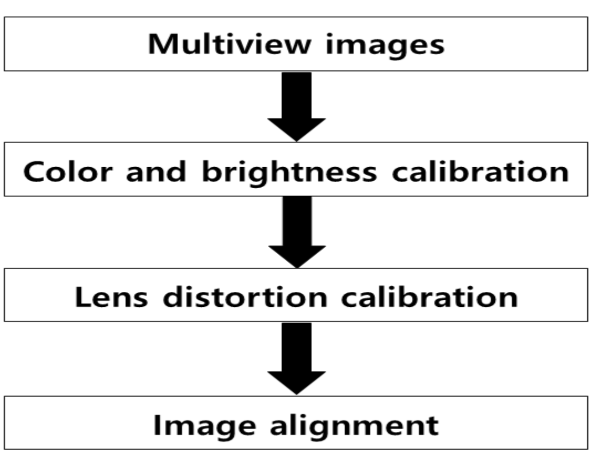

Figure 4. The procedure of image calibration process

3.1 Color and brightness calibration

Since the proposed camera acquisition system uses three cameras, there is a problem of difference in color and brightness of images acquired from each camera. Even if the same camera model is used, there may be differences in pixels due to hardware errors during camera production. The intensity of the light reaching the CCD is not uniform with respect to the CCD depending on the characteristics of the lens. The intensity of the light reaching the CCD becomes weaker toward the periphery with respect to the center of the image, which results in a non-uniform brightness value over the entire image. This difference in color and brightness increases the visual fatigue experienced by the viewer of stereoscopic images. Therefore, color and brightness calibration is required.

In this paper, color and brightness calibration images are generated and calibrated to solve them. The process of generating color and brightness calibration image (I_c) is as follows.

1. Take a picture of the same position and same direction the white background with the same color and brightness.
2. Extract the R, G, B values of each captured image.
3. Find the maximum value of the R, G, B values of each image.

$$R_{max} = \max(R(x,y)) \quad , \quad G_{max} = \max\big(G(x,y)\big) \quad , \quad B_{max} = \max(B(x,y)) \tag{1}$$

4. Find the average of the maximum values of the R, G, B channels of each image.

$$R_{avg} = \frac{R_{max1}+R_{max2}+R_{max3}}{3} \;,\; G_{avg} = \frac{G_{max1}+G_{max2}+G_{max3}}{3} \;,\; B_{avg} = \frac{B_{max1}+B_{max2}+B_{max3}}{3} \tag{2}$$

5. Create color and brightness calibration image.

$$I_c = (R_{avg} - R(x,y), G_{avg} - G(x,y), B_{avg} - B(x,y)) \tag{3}$$

By adding the generated color brightness calibration image to the R, G, B channels of the acquired view image, color and brightness calibrated images can be acquired.

3.2 Lens distortion calibration

When constructing a general multiview camera array, it is easy to think that the same characteristics are shown in the images of the respective viewpoints using several cameras of the same model. In recent CCD cameras, distortion is very small, but in the case of a camera using a special lens, distortion may occur. The image input through such a camera may be distorted due to the influence of the camera or the outside of the camera, and may appear as an image different from the real world. Even if the lens distortion of the camera is made small, calibration is necessary depending on the environmental conditions to be used. In order to remove the lens distortion from the image, the camera lens distortion coefficient must be calculated.

In this paper, the lens distortion coefficient has been calculated using the chessboard and camera calibration. Acquiring a chessboard image and calculate the position of the corner point of the chessboard has been shown in the fig. 5. Then, the lens distortion coefficient is calculated using the position of the corner point of the chess board and obtain an image with lens distortion removed using lens distortion coefficient.

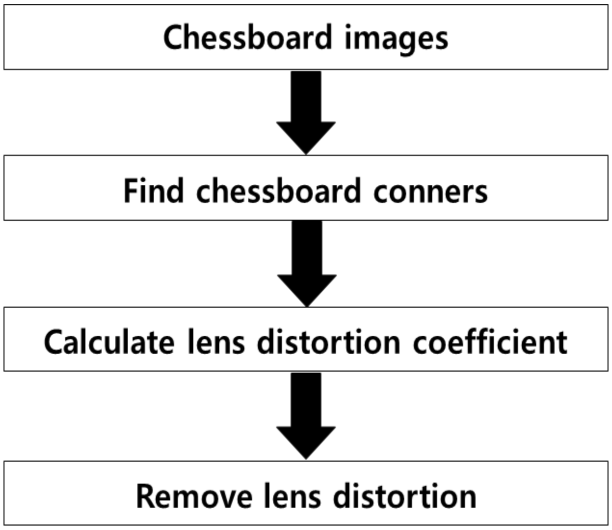

Figure 5. The process of lens distortion calibration

3.3 Image alignment

Due to the hardware problem in camera array configuration and the hardware problem in camera production, there is an error between images even in the same camera. Image alignment is to reduce the errors that occur. As shown in the fig. 6, Find feature points to use matching information between images. Then, the translation and rotation of the reference camera and the other camera are calculated and align the images.

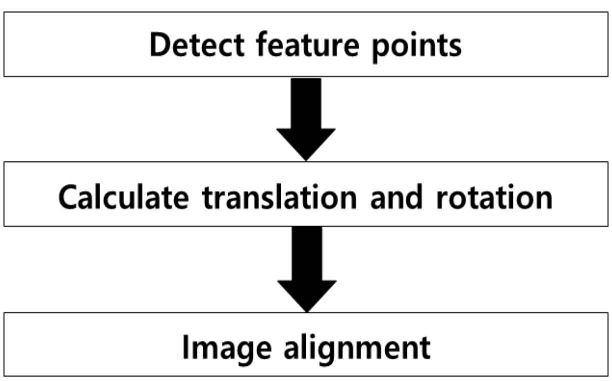

Figure 6. The process of image alignment

4. Experimental result

4.1 Experimental environment and calibration process

The experiment environment is composed of LED lighting as a general office environment. Fig. 7 shows the proposed full-parallax and high-quality multiview 3D image acquisition method using camera slider. The program for calibration is shown in Fig. 8 and is calibrated through three steps. The first is the color and brightness calibration, the second is the lens distortion calibration and finally align the image.

Figure 7. The proposed Full-parallax and high-quality multiview 3D image acquisition method using camera slider

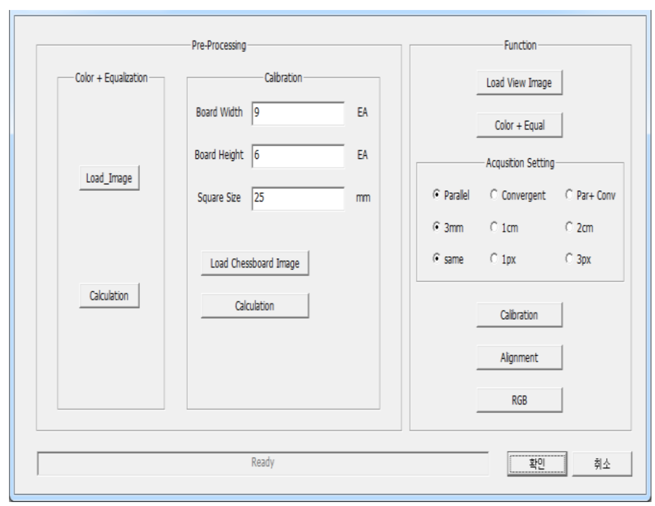

Figure 8. Calibration system software

Table 1 below shows the configured cameras and equipment.

Table 1 : Configured cameras and equipment specification

Module	Specification
Camera	Sony α6000
Camera Slider	Horusbennu GP-120Q
Camera Lens	16-50mm

Image resolution	6000×4000 px

4.2 Full-parallax and high-quality multiview 3D image acquisition

The proposed acquisition system can use the camera array method as a parallel or convergent array through the movement of the rotation axis. The fig. 9 shows the converged arrangement through the movement of the rotation axis and the convergence point is set at a distance of 2m from the camera.

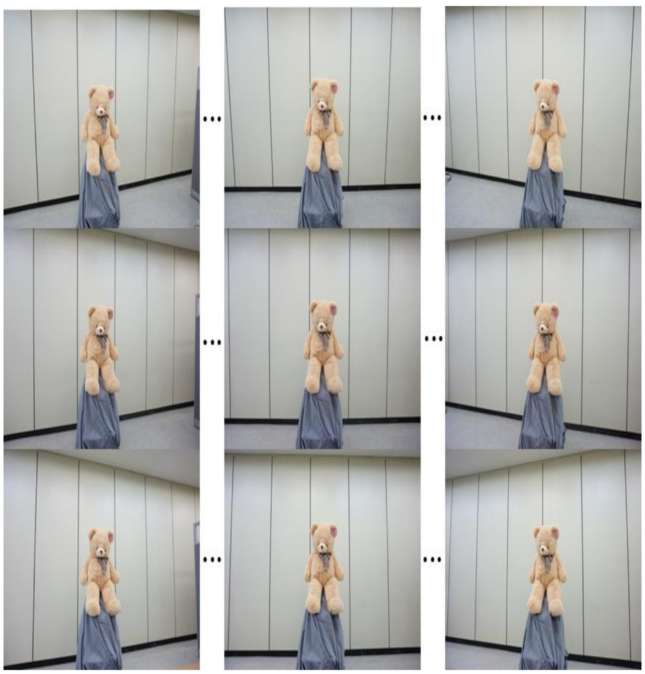

Figure 9. Image acquired by convergent array method

4.3 Color and brightness calibration

In order to calibrate the color and brightness between cameras, the images were taken so that the images of the white background looked the same direction and the same direction. As shown in the fig. 9, the color and brightness of the camera before calibration are different. Experimental results confirmed that the image obtained in Fig. 10 was calibrated as shown in Fig. 11 and Fig. 12.

Figure 10. Original 3-view Image before color and brightness Calibration

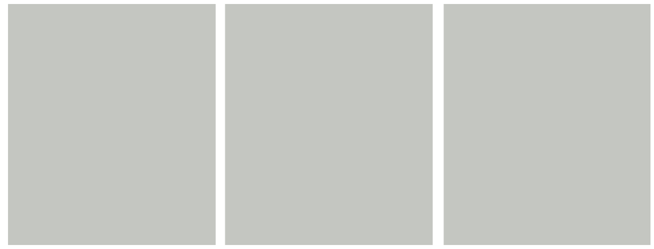

Figure 11. Calibrated 3-view image after color and brightness calibration

Figure 12. Original image(Left) and color and brightness calibrated image(Right)

4.4 Lens distortion calibration

In order to calibrate the lens distortion, the images were taken so that the images of the chessboard. The grid pattern size was set at 9×6 and the grid size was set at 2.5cm×2.5cm. The result of correcting the lens distortion is shown in the fig. 13.

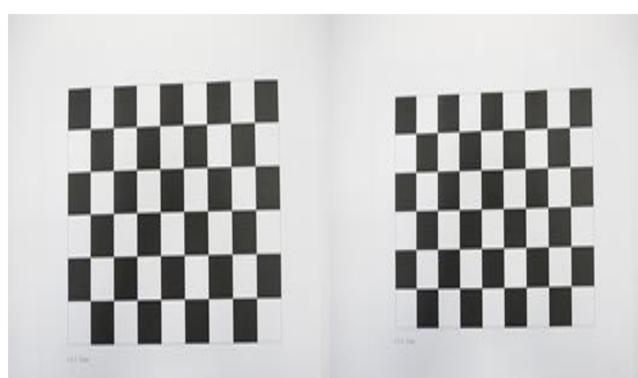

Figure 13. Original image(Left) and calibrated lens distortion image(Right)

4.5 Image alignment

In order to align the images, the images were taken so that the images of the chessboard and the feature points were found and the difference between the transition and rotation of each position was calculated. And then, the acquired image was aligned and the result is shown in Fig. 14.

Figure 14. Original 5-view image(Left) and alignment image(Right)

4.6 3D image generation result

Using the proposed acquisition system and image calibration system, images were acquired and 3D images were produced with different method of camera arrangement and number of viewpoint cameras. Fig. 15 shows the proposed system in which 35-view images are acquired in a parallel method and Fig. 16 shows 35-view images are acquired in a convergent method

Figure 15. Parallel method 35-view image

Figure 16. Convergent method 35-view image

Figure 17 shows the proposed system, in which 70-view images are acquired in a convergent method obtained by the proposed system in this paper. Experimental results confirmed that the proposed system can acquire full-parallax images with high resolution using a small number of cameras.

Figure 17. Convergent method 70-view image(Right)

5. Conclusion

In order to produce a high-resolution 3D stereoscopic image, it must be acquired using a multiview camera array. However, the conventional Multiview camera arrangement has problems such as complicated structure, a large number of cameras and difficult image processing things. In this paper, we propose a full-parallax and high-quality three-dimensional image acquisition method using camera slider for the real object. By using the proposed method, it is possible to select the parallel camera array and the convergent camera array by changing the rotation axis easily, it also confirmed that a plurality of viewpoint images can be acquired by using a small number of cameras with different intervals. In addition, we confirmed that the problem of discrepancy of each camera is solved through color and brightness calibration, lens distortion calibration, and image alignment for each image using the image calibration system.

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Author Biography

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